GUEST ARTICLE

Eye See Eye Learn

The Benefit of Comprehensive Eye Examinations for Preschoolers

BY DEBORAH A. JONES FCOptom, DipCLP, FAAO;
CATHERINE A. CHIARELLI OD, FAAO;
BARBARA E. ROBINSON OD, MPH, PhD, FAAO;
KAREN E. MACDONALD OD, FAAO

ABSTRACT

Objective: Undetected vision problems in children can lead to permanent vision loss, a condition known as amblyopia. Early detection and treatment of the causes of amblyopia may prevent this vision loss. The objective of this paper is to look for evidence that comprehensive eye examinations upon entry to junior Kindergarten are an effective way to identify and treat vision problems early.

Methods: Relevant peer-reviewed publications on amblyopia and the importance of comprehensive eye examinations were reviewed. Specific areas investigated include: the prevalence and causes of amblyopia; impact of vision problems on child development and education; impact of amblyopia and/or strabismus on quality of life; and the cost effectiveness of treating amblyopia. The validity of vision screening compared to a comprehensive eye examination was also reviewed.

Synthesis: The review suggests that without a complete eye examination many eye or vision problems remain undetected at school entry. Left uncorrected these problems negatively impact child development, education and quality of life. Reduced vision due to amblyopia also restricts future employment opportunities and increases the risk of bilateral visual impairment in adulthood. Examination procedures with high sensitivity and specificity are required to accurately detect these problems. Studies show that amblyopia treatment initiated at an early age is one of the most cost-effective of all health interventions.

Conclusion: There is good evidence in the literature that a full eye examination is critical to detect all cases of amblyopia. This and other visual problems can be detected and managed at an early age, which leads to better visual quality of life and economical outcomes. The *Eye See Eye Learn* program offers the "gold standard" of eye care.

Currently, there are many eye care initiatives underway for the paediatric and preschool population, including vision screenings and comprehensive eye examinations. Although both programs are valuable in facilitating early detection and subsequent treatment of vision problems, their relative effectiveness differs. This paper is an evidence-based literature review conducted to determine which testing strategy provides the best visual and social outcomes in the most cost effective manner. It was written with the intention of appropriately guiding the decisions of health and education policy-makers.

Introduction

Should children have a comprehensive eye examination upon entry to junior Kindergarten? This question has received much attention in the literature. This paper is intended to provide a review of the current literature reporting the benefits for children undergoing a comprehensive eye examination with an optometrist during their entry year into school. The *Eye See Eye Learn* (ESEL) program was developed to raise awareness among parents of the importance of identifying and treating vision problems early. The program provides comprehensive eye examinations by local optometrists to junior Kindergarten kids in participating school regions. This paper will report on scientific data and expert opinion as evidence that the *Eye See Eye Learn* program is of benefit to children. Papers included in this review are not limited to the visual implications of this program but also include both the short and long-term social ramifications for children.

Eye See Eye Learn Background

In 2003, the Alberta Ministry of Children's Services, the Alberta Association of Optometrists, the Alberta Public Health divisions of Capital and East Central Health Authorities, and the Elk Island Public School Board formed a partnership and created the *Eye See Eye Learn* program. As a result of the program the percentage of junior

Kindergarten children receiving an eye exam rose from 14% to 45%. Of the children examined, 12% were found to have a previously undiagnosed eye or vision problem: 6% required eyeglasses, 4% had eye coordination issues and 2.5% had amblyopia. Based on the successful outcome of the Elk Island ESEL pilot, the program was expanded to be province-wide in Alberta in 2007. Subsequently, the ESEL pilot programs began in 2008 in Saskatchewan involving the Saskatoon school board and in 2009 in Ontario involving the Hamilton school board. In both of these provinces ESEL has expanded and most recently in Ontario in 2010, government support of $200,000 per year for 5 years will allow the program to further expand. Currently, talks are underway in Manitoba and New Brunswick to adopt the ESEL program.

Visual Benefits of ESEL

The *Eye See Eye Learn* program provides comprehensive eye examinations for children entering school. This involves assessment of visual acuity, refractive error, eye coordination and eye health.

It could be argued that if a child has no vision problems at all then it really makes little difference whether they have a vision screening or a full examination. However the argument becomes very significant when children with vision problems are considered. Undetected vision problems can lead to permanent vision loss (amblyopia).

There have been many definitions of amblyopia in textbooks and in publications. One of the more simple statements originated from Von Graefe who described amblyopia as the condition "in which the observer sees nothing and the patient very little" cited by Grounds.[1] Amblyopia typically develops when the image in one or both eyes is blurred or obscured and is a significant cause of unilateral vision loss, and is one of the most common causes of persistent unilateral vision impairment in adulthood. Prevalence has been estimated to be between 2% and 5% in children[2-4] and between 0.35% and 3.2% in adults.[5-7]

Amblyopia occurs in childhood and, if treated while the visual system is still maturing, may be reversible resulting in normal vision. There are many causes, the two most common are strabismus and anisometropia (a difference in refractive error between the two eyes). In a population sample of 3-6 year olds with amblyopia, 38% was found to be associated with strabismus and 37% with anisometropia.[8] This is significantly different to a cohort of children, younger than three years-of-age, in which strabismus is the primary cause of amblyopia (82%).[9] Children with strabismus tend to be referred to an eye care professional at an earlier age as parents and/or family physicians at routine health checks often detect strabismus. Another common cause of amblyopia is uncorrected astigmatism or uncorrected high refractive error of any kind.[10]

The main steps in the diagnosis of amblyopia are: measurement of vision in each eye; measurement of refractive error; evaluation of eye alignment and movement; examination of the health of the eyes to rule out pathology (eye disease); and rechecking the vision with eyeglasses, as required. These steps can only be accurately carried out by a trained eye care professional and are the components of a full eye examination.

In most cases amblyopia occurs in one eye only so that even severe amblyopia may go unnoticed by the child or their caregiver. In everyday life unilateral amblyopia results in poor depth perception. Reduced depth perception has an adverse effect on many tasks for young children that involve good hand-eye coordination, such as penmanship and dexterity with scissors.[11,12] Children with reduced depth perception can be challenged by ball sports and do not perceive the effects of modern 3-D movies.

Amblyopia is a preventable and treatable condition. There are many forms of treatment for amblyopia. The type of amblyopia dictates the treatment modality. For amblyopia related to a large refractive error, eyeglasses may be all that is required. The results of a comparative case series indicated that children aged five to seven years with astigmatism who had been provided with spectacles prior to Kindergarten showed significantly better corrected visual acuity than did children of similar ages who had not received their glasses prior to entering Kindergarten.[13]

Amblyopia that is not fully treated with eyeglasses alone, and amblyopia that is related to strabismus, is treated by occlusion (patching) of the non-amblyopic eye. This

usually is done a few hours per day for several months. After amblyopia treatment is complete, some children also need vision training or surgery to correct strabismus.

The evidence that early detection of amblyopia is vital to the success of treatment is compelling. It is well documented that younger children respond better to treatment than older children and although there is evidence that amblyopia can be treated even in adult years there is little evidence to suggest that normal visual acuity may be achievable.

A recently published study looked at the effect of age on response to amblyopia treatment in children. The results of the study demonstrated that children aged 7-13 years were significantly less responsive to treatment compared with younger subjects (aged three to seven years). Older children did show improvement in vision with treatment but the amount of improvement was less than in the younger children. There is a greater chance of obtaining normal vision in an eye with amblyopia if treatment is initiated before the age of seven.[14]

The Canadian Association of Optometrists recommends that a child's first eye examination be at six months-of-age and then again at three years. There is good evidence to support this recommendation. It can be shown from Ontario Health Insurance Plan (OHIP) evidence that children are not having their eyes examined and in fact less than 25% of children in Ontario have an annual eye examination by an optometrist.

Many authors have suggested pre-school vision screening or eye examinations would be beneficial in order to detect and treat amblyopia. Holmes in 2006 stated, "Based on the current evidence, if one screening session is used, screening at school entry could be the most reasonable time."[15] The *Eye See Eye Learn* program provides full comprehensive eye examinations at school entry age for all children.

Developmental Benefits of ESEL

The impact of uncorrected vision problems may be seen in many areas of child development. Effects on the development of motor skills, behaviour and attention, learning skills and reading ability, and general quality-of-life, have been studied extensively. The goal of ESEL is to identify and treat vision problems in early childhood, thus minimizing such secondary consequences.

Motor skills are influenced by visual input. Amblyopia causes reduced vision and eye coordination, and can affect the development of motor skills. Children with amblyopia demonstrate reduced fine motor skills, especially for tasks requiring speed and accuracy. This is especially characteristic of children with amblyopia related to strabismus.[16]

Children with amblyopia also demonstrate reduced reach-to-grasp performance.[17] The importance of accurate eye coordination in developing precise hand-eye coordination increases, as children grow older. The successful treatment of amblyopia can improve hand action control.[17] Children with uncorrected vision problems may demonstrate behavioural, emotional or attention problems when confronted with visual tasks.[18] Increases in misconduct, hyperactivity and aggressiveness have been reported.[19] This is of special significance in children with learning difficulties, who may be unable to effectively communicate their visual symptoms.[20]

Children with symptomatic convergence insufficiency and/or weak accommodation have been shown to have higher scores on surveys of their behaviour related to deficiencies in school performance (including inattention, avoidance, opposition, hyperactivity).[21,22]

Educational Benefits of ESEL

Vision is considered the most important sense for learning and it is estimated that 80% of what children learn in primary grades is gained through visual input.[23] Students spend 30-60% of the school day on sustained reading, writing and other near point tasks. Uncorrected vision problems can create strain or distraction during these activities, forcing children to work harder to perform well.[18]

The relationship between visual function and academic performance has been highlighted in a policy statement from the American Optometric Association (AOA) / American Academy of Optometry (AAO),[24] in which it is

stated that identification and treatment of vision problems enhances learning potential.

Early vision evaluation should be part of a multi-disciplinary approach to ensuring that children reach their full learning potential.[25-27] Most professionals agree that, although vision problems are not the single cause of learning difficulties in most cases, they can be a relevant factor that influences a child's ability to perform required academic tasks and to use vision to access the curriculum effectively.[25-27]

There are numerous publications that report on how vision problems affect academic achievement. These are summarized below:

- Reduced visual acuity, especially at near, has been reported to be more common in children with learning difficulties.[28,29]
- Hyperopia has been shown to be strongly linked with reduced literacy skills.[29-33] Correction of hyperopia has been shown to result in improved reading achievement.[31-33]
- Anisometropia also has been demonstrated to be more common in children with poor reading skills[29,33]
- Eye coordination skills allow accurate, efficient and comfortable input of visual information. Weakness in eye coordination skills results in discomfort, reduced concentration and slower processing speed.[29,34-36]
- Weakness in eye coordination skills also may interfere with phonetic or eidetic decoding and spelling.[37,38] In different studies, reading deficiencies have been correlated with unstable eye coordination,[18,44,45] poor eye movements,[46-49] reduced vergence,[28,29,34,39-42] reduced accommodation[28,43-47] and reduced depth perception.[41]
- In preschool children, reduced depth perception and reduced accommodation were found to be predictors of reading performance in Kindergarten and Grade One.[48]
- The number of people suffering from amblyopia who complete higher university degrees is considerably fewer than those without amblyopia.[49]

Quality of Life Benefits of ESEL

A number of studies have investigated the impact of amblyopia and/or strabismus on Quality-of-Life (QoL). Different QoL surveys have been administered to children with these conditions, their caregivers, adults who were treated for these conditions in childhood, and adults with residual amblyopia and/or strabismus.[11,19,49-56]

For individuals with amblyopia, many QoL issues are related to the impact of treatment (i.e. patching therapy) rather than the condition itself. Individuals may develop low self-esteem and a negative self-image,[51,54] and may experience feelings of depression, frustration, embarrassment,[54,55] or shame.[19] Many become distressed about their appearance[59] and worry about losing their eyesight in the future.[28] Children with amblyopia are 37% more likely to be the object of bullying or discrimination.[19,52,55] They often perceive a lower social acceptance[51] and sometimes avoid social events[55] because of how they feel about their condition. Amblyopia treatment impacts family life, causing increased stress and anxiety for the caregiver and altering the caregiver-child relationship and other family relationships.[19] This highlights the importance of early intervention, since early identification and treatment of amblyopia are associated with shorter treatment times and more successful outcomes. In addition, the social consequences of amblyopia treatment may have less impact on younger children.[52]

Untreated amblyopia affects the ability to complete daily tasks. In one study, 55% of individuals with amblyopia reported that it affected their performance in school, 48% reported that it interferred with their work and 50% felt that it influenced their general lifestyle.[61] Reduced vision due to amblyopia also restricts certain employment opportunities that have specific vision standards, such as the armed forces.[11]

Individuals with amblyopia also are at greater risk for future vision loss. They are more prone to ocular injury and have an increased five-year incident risk of visual loss in the better eye.[49]

Overall, persons with amblyopia have a lifetime risk of vision loss that is almost double that for persons without amblyopia (18% vs 10%), and typically suffer a longer duration of bilateral visual impairment in their lifetime.[57,58]

A survey in the UK in 2002 found that only 35% of people who lost the vision in their non-amblyopic eye were able to continue in paid employment.[59] The early identification and treatment of amblyopia in childhood can prevent such tragic visual impairment in adulthood.

Individuals with strabismus also report significant QoL concerns.[19,52,60-64] They report discomfort when driving, difficulty maintaining eye contact, and anxiety about their appearance and social acceptance. This may affect emotional self-esteem and personal relationships. This highlights the need for early identification and treatment of strabismus, to avoid life-long consequences.

Advantages of ESEL over other Children's Vision Programs

Children deserve our best effort to help them maximize their vision, general development, education and quality of life by accurately identifying and treating vision problems early.

ESEL is a program offering full eye examinations in an optometrist's office, unlike a vision screening which is an assessment of specific aspects of visual function carried out in a location of convenience. This distinction is critical as there are many implicit advantages to having the child visit the optometrist's office. At the optometrist's office the assessment is carried out by a team of professionals comprised of the optometrist and trained support staff, while at a vision screening the tests are often performed by lay volunteers. An optometrist evaluates all aspects of vision and eye health. Vision screenings often isolate single tests such as visual acuity and depth perception tests or incorporate automated testers that can give false readings that are difficult for screeners to interpret. On-site, at the optometrist's office, specialized instrumentation is available to aid in the accurate evaluation of a young patient. Vision screenings, by definition, necessitate portability, which implies significant limitations to what testing can be performed – many essential tests are simply not possible.

Although vision screenings have been effective at raising awareness for the need for paediatric visual assessments by a convenient mechanism, there are numerous reports in the literature that point to validity problems. In a 1992-4 study, 3,434 Oxford County preschoolers in Ontario underwent a vision screening. Of the 1,017 preschoolers who failed the screening only 384 (38%) actually were found to have a vision problem.[65] In this study the sensitivity (ability to accurately identify children with vision problems) and specificity (ability to accurately identify children without vision problems) were both low (60.4% and 79.7%) so the vision screening did not do a good job of identifying children with and without vision problems. When a vision problem is detected during a vision screening there is no guarantee that follow-up care will be sought. It has been shown that 40% of children who fail an initial vision screening do not receive the appropriate follow-up care.[66]

The Enhanced Vision Screening Program (EVSP) assessed the negative predictive value (percentage of children who pass the screening who do not have any vision problems) in vision screenings involving 11,734 children and reached a similar conclusion.[67] The main goal of these vision screenings was to detect amblyopia, strabismus and high refractive error. Of the children who passed the screening, 200 were randomly selected to undergo the "gold standard" – a strictly defined eye examination. The results showed a negative predictive value of 97.6% and the authors conclude:

'Because the negative predictive value of the EVSP is not 100%, some children with amblyopia, strabismus or refractive errors are missed…parents should be aware of this.'

The Vision in Preschoolers Study (VIP study) was a multiphased, multi-centre, interdisciplinary, clinical study to evaluate the accuracy of screening tests used to identify preschool-aged children in need of further evaluation for vision disorders.[68] The gold standard against which the screenings were tested was a comprehensive eye examination (100% sensitivity and specificity). In the phase II conclusions it was noted that:

'The best performing tests had high testability whether performed by trained eye care professionals, nurses or lay screeners but detection of strabismus was improved by the use of cover test by doctors…'

And from the Preschool Vision Screening: Rationale, Methodology and Outcome, came:

'*The relatively low prevalence of amblyopia makes it difficult to achieve a high screening yield in terms of predictive value…unless a 'supertest' can be devised, with very high sensitivity and specificity, health policy decisions will be required to determine which of these two characteristics should be emphasized.*'

As indicated by these authors, vision screenings often fail to correctly identify the 2-5% of children with amblyopia and in the process give false reassurances to parents that their child's vision is normal. A comprehensive eye examination with an optometrist could be considered to be the "*supertest*".

Cost Effectiveness of ESEL

While there has not been a direct analysis of the cost-effectiveness of ESEL the benefit of such a program may be inferred from the literature. The cost-effectiveness of screening and treatment of amblyopia has been examined in the United States and in Europe.

A cost-benefit analysis of five vision screening programs in the United States showed that the greater the sensitivity of the screening method the more beneficial the program.[69] This study also found that the highest net benefit was for children three to four years-of-age. A study in Germany calculated that the cost-effectiveness of vision screening in children three years-of-age was 727 euros per case detected.[70] The measure of effectiveness was determined by the number of newly diagnosed cases of amblyopia as well as cases of strabismus and refractive errors likely to cause amblyopia.

Optometrists in Ontario provide a "gold standard" eye examination that will provide better case finding than the methods described in either of these two papers.

Systematic reviews of the effectiveness of screening preschool children for amblyopia have reported insufficient evidence due to lack of randomized controlled trials conducted in this area.[71,72] However other reviews have noted that treatment of strabismus and amblyopia can improve visual outcomes. The U.S. Preventive Services Task Force (USPSTF) states that it is important to detect amblyopia, strabismus and defects in visual acuity in children younger than 5 years-of-age.[73]

Studies based on U.S. and German data concluded that treatment for amblyopia is likely to be very cost effective.[74,75] In both studies the cost effectiveness was based on Quality-Adjusted Life-Years (QALYs). The U.S. study showed that amblyopia therapy initiated at four years-of-age, including both surgical and nonsurgical treatment, yields a $/QALY gained of $2,281.[74] The authors state that "interventions with a $/QALY gained of <$20,000 are especially cost-effective".

The study based on German data found that treatment for amblyopia starting at three years of age was more favourable than many other health care interventions.[75] They found the incremental cost effectiveness ratio of treatment was 2,369 euros/QALY. It is interesting that although each study used a different model for analysis both found similar results.

Conclusion

In conclusion there is good evidence in the literature that a full eye examination at school entry age is beneficial. Amblyopia and other visual problems can be detected and managed at an early age, which leads to better visual, quality-of-life and economical outcomes. The *Eye See Eye Learn* program offers the "gold standard" of eye care.

Author Affiliations

Deborah A. Jones FCOptom, DipCLP, FAAO *Lecturer, School of Optometry, University of Waterloo*

Catherine Chiarelli OD, FAAO *Vision Institute of Canada*

Barbara Robinson OD, MPH, PhD, FAAO *Associate Professor, School of Optometry, University of Waterloo*

Karen MacDonald OD, FAAO *Children's Vision Committee Chair, Ontario Association of Optometrists*

References

1. Barnard N. Edgar D. Pediatric Eye Care: Blackwell Science; 1995.
2. Robaei D, Rose K, Ojaimi E, Kifley A, Huynh S, Mitchell P. Visual acuity and the causes of visual loss in a population-based sample of 6-year-old Australian children. Ophthalmology. Jul 2005;112(7):1275-1282.
3. Thompson JR, Woodruff G, Hiscox FA, Strong N, Minshull C. The incidence and prevalence of amblyopia detected in childhood. Public Health. Nov 1991;105(6):455-462.
4. Ross E MA, Stead S. Prevalence of amblyopia in grade 1 schoolchildren

in Saskatoon. Can J Public Health. 1997;68:491-493.

5. Rosman M, Wong TY, Koh CL, Tan DT. Prevalence and causes of amblyopia in a population-based study of young adult men in Singapore. Am J Ophthalmol. Sep 2005;140(3):551-552.
6. Brown SA, Weih LM, Fu CL, Dimitrov P, Taylor HR, McCarty CA. Prevalence of amblyopia and associated refractive errors in an adult population in Victoria, Australia. Ophthalmic Epidemiol. Dec 2000;7(4):249-258.
7. Attebo K, Mitchell P, Cumming R, Smith W, Jolly N, Sparkes R. Prevalence and causes of amblyopia in an adult population. Ophthalmology. Jan 1998;105(1):154-159.
8. PEDIG. The clinical profile of moderate amblyopia in children younger than 7 years. Arch Ophthamol. 2002;120(3):281-287.
9. Birch EE, Holmes JM. The clinical profile of amblyopia in children younger than 3 years of age. J Aapos. Dec 2010;14(6):494-497.
10. Harvey EM, Dobson V, Miller JM. Prevalence of high astigmatism, eyeglass wear, and poor visual acuity among Native American grade school children. Optom Vis Sci. Apr 2006;83(4):206-212.
11. Webber AL, Wood J. Amblyopia: prevalence, natural history, functional effects and treatment. Clin Exp Optom. Nov 2005;88(6):365-375.
12. Fielder AR, Moseley MJ. Does stereopsis matter in humans? Eye (Lond). 1996;10 (Pt 2):233-238.
13. Dobson V, Clifford-Donaldson CE, Green TK, Miller JM, Harvey EM. Optical treatment reduces amblyopia in astigmatic children who receive spectacles before kindergarten. Ophthalmology. May 2009;116(5):1002-1008.
14. Holmes JM, Lazar EL, Melia BM, et al. Effect of Age on Response to Amblyopia Treatment in Children. Arch Ophthalmol. Jul 11 2011.
15. Holmes JM, Clarke MP. Amblyopia. Lancet. Apr 22 2006;367(9519):1343-1351.
16. Webber AL, Wood JM, Gole GA, Brown B. The effect of amblyopia on fine motor skills in children. Invest Ophthalmol Vis Sci. Feb 2008;49(2): 594-603.
17. Suttle CM, Melmoth DR, Finlay AL, Sloper JJ, Grant S. Eye-hand coordination skills in children with and without amblyopia. Invest Ophthalmol Vis Sci. Mar 2011;52(3):1851-1864.
18. Goldstand S, Koslowe KC, Parush S. Vision, visual-information processing, and academic performance among seventh-grade schoolchildren: a more significant relationship than we thought? Am J Occup Ther. Jul-Aug 2005;59(4):377-389.
19. Koklanis K, Abel LA, Aroni R. Psychosocial impact of amblyopia and its treatment: a multidisciplinary study. Clin Experiment Ophthalmol. Nov 2006;34(8):743-750.
20. Pilling R. Learning disability: challenging behaviour. Br J Ophthalmol. Oct 2008;92(10):1436.
21. Rouse M, Borsting E, Mitchell GL, et al. Academic behaviors in children with convergence insufficiency with and without parent-reported ADHD. Optom Vis Sci. Oct 2009;86(10):1169-1177.
22. Borsting E, Rouse M, Chu R. Measuring ADHD behaviors in children with symptomatic accommodative dysfunction or convergence insufficiency: a preliminary study. Optometry. Oct 2005;76(10):588-592.
23. Moore J. The visual system and engagement in occupation. . Journal of Occupationsal Science: Australia. 1996;3(1):16-17.
24. American Academy of Optometry AOA. Vision, Learning and Dyslexia. A joint organizational policy statement. Optometry and Vision Science 1997;74(10):868-870.
25. Solan HA. Dyslexia and learning disabilities: epilogue. Optom Vis Sci. May 1993;70(5):392-393.
26. Levine MD. Reading disability: do the eyes have it? Pediatrics. Jun 1984;73(6):869-870.
27. Handler SM, Fierson WM, Section on O. Learning disabilities, dyslexia, and vision. Pediatrics. Mar 2011;127(3):e818-856.
28. Grisham D, Powers M, Riles P. Visual skills of poor readers in high school. Optometry. Oct 2007;78(10):542-549.
29. Garzia RP, Nicholson SB. Visual function and reading disability: an optometric viewpoint. J Am Optom Assoc. Feb 1990;61(2):88-97.
30. Williams WR, Latif AH, Hannington L, Watkins DR. Hyperopia and educational attainment in a primary school cohort. Arch Dis Child. Feb 2005;90(2):150-153.
31. Association APH. Policy statment Improving early Childhood Eyecare. 2001.
32. American Academy of Pediatrics Committee on Practice and Ambulatory Medicine: Vision screening and eye examination in children. Pediatrics. Jun 1986;77(6):918-919.
33. Grisham JD, Simons HD. Refractive error and the reading process: a literature analysis. J Am Optom Assoc. Jan 1986;57(1):44-55.
34. Williams G. New opportunities in vision therapy. Optometry. Dec 2009;80(12):717-720.
35. Rawstron JA, Burley CD, Elder MJ. A systematic review of the applicability and efficacy of eye exercises. J Pediatr Ophthalmol Strabismus. Mar-Apr 2005;42(2):82-88.
36. Satyan HS. Management of children with reading difficulties: a multidisciplinary approach. J Learn Disabil. Oct 1980;13(8):435-439.
37. Cornelissen P, Bradley L, Fowler S, Stein J. Covering one eye affects how some children read. Dev Med Child Neurol. Apr 1992;34(4):296-304.
38. Cornelissen P, Bradley L, Fowler S, Stein J. What children see affects how they spell. Dev Med Child Neurol. Aug 1994;36(8):716-726.
39. Ygge J, Lennerstrand G. Visual impairment and dyslexia in childhood. Curr Opin Ophthalmol. Oct 1997;8(5):40-44.
40. Kirkby JA, Webster LA, Blythe HI, Liversedge SP. Binocular coordination during reading and non-reading tasks. Psychol Bull. Sep 2008;134(5):742-763.
41. Palomo-Alvarez C, Puell MC. Binocular function in school children with reading difficulties. Graefes Arch Clin Exp Ophthalmol. Jun 2010;248(6):885-892.
42. Buzzelli AR. Stereopsis, accommodative and vergence facility: do they relate to dyslexia? Optom Vis Sci. Nov 1991;68(11):842-846.
43. Evans BJ. The underachieving child. Ophthalmic Physiol Opt. Mar 1998;18(2):153-159.
44. Kaye G. Vision and learning to read. Clin Exp Optom. Mar 2002;85(2):111.
45. Palomo-Alvarez C, Puell MC. Accommodative function in school children with reading difficulties. Graefes Arch Clin Exp Ophthalmol. Dec 2008;246(12):1769-1774.
46. Maples WC. Visual factors that significantly impact academic performance. Optometry. Jan 2003;74(1):35-49.

47. Shin HS, Park SC, Park CM. Relationship between accommodative and vergence dysfunctions and academic achievement for primary school children. Ophthalmic Physiol Opt. Nov 2009;29(6):615-624.
48. Solan HA. Visual deficits and dyslexia. J Learn Disabil. Jul-Aug 1999;32(4):282-283.
49. Chua B, Mitchell P. Consequences of amblyopia on education, occupation, and long term vision loss. Br J Ophthalmol. Sep 2004;88(9):1119-1121.
50. Carlton J, Kaltenthaler E. Amblyopia and quality of life: a systematic review. Eye (Lond). Apr 2011;25(4):403-413.
51. Webber AL, Wood JM, Gole GA, Brown B. Effect of amblyopia on self-esteem in children. Optom Vis Sci. Nov 2008;85(11):1074-1081.
52. Williams C, Harrad R. Amblyopia: contemporary clinical issues. Strabismus. Mar 2006;14(1):43-50.
53. Damji KF. Vision screening programs in children. Can Fam Physician. May 1988;34:1133-1139.
54. Packwood EA, Cruz OA, Rychwalski PJ, Keech RV. The psychosocial effects of amblyopia study. J Aapos. Feb 1999;3(1):15-17.
55. Sabri K, Knapp CM, Thompson JR, Gottlob I. The VF-14 and psychological impact of amblyopia and strabismus. Invest Ophthalmol Vis Sci. Oct 2006;47(10):4386-4392.
56. Rahi JS, Cumberland PM, Peckham CS. Does amblyopia affect educational, health, and social outcomes? Findings from 1958 British birth cohort. Bmj. Apr 8 2006;332(7545):820-825.
57. Nilsso J. The negative impact of amblyopia from a population perspective: untreated amblyopia almost doubles the lifetime risk of bilateral visual impairment. Br J Ophthalmol. Nov 2007;91(11):1417-1418.
58. van Leeuwen R, Eijkemans MJ, Vingerling JR, Hofman A, de Jong PT, Simonsz HJ. Risk of bilateral visual impairment in individuals with amblyopia: the Rotterdam study. Br J Ophthalmol. Nov 2007;91(11):1450-1451.
59. Rahi J, Logan S, Timms C, Russell-Eggitt I, Taylor D. Risk, causes, and outcomes of visual impairment after loss of vision in the non-amblyopic eye: a population-based study. Lancet. Aug 24 2002;360(9333):597-602.
60. Hatt SR, Leske DA, Kirgis PA, Bradley EA, Holmes JM. The effects of strabismus on quality of life in adults. Am J Ophthalmol. Nov 2007;144(5):643-647.
61. Durnian JM, Owen ME, Marsh IB. The psychosocial aspects of strabismus: correlation between the AS-20 and DAS59 quality-of-life questionnaires. J Aapos. Oct 2009;13(5):477-480.
62. Hatt SR, Leske DA, Adams WE, Kirgis PA, Bradley EA, Holmes JM. Quality of life in intermittent exotropia: child and parent concerns. Arch Ophthalmol. Nov 2008;126(11):1525-1529.
63. Hatt SR, Leske DA, Yamada T, Bradley EA, Cole SR, Holmes JM. Development and initial validation of quality-of-life questionnaires for intermittent exotropia. Ophthalmology. Jan 2010;117(1):163-168 e161.
64. Hatt SR, Leske DA, Holmes JM. Comparison of quality-of-life instruments in childhood intermittent exotropia. J Aapos. Jun 2010;14(3):221-226.
65. Robinson B, Bobier WR, Martin E, Bryant L. Measurement of the validity of a preschool vision screening program. Am J Public Health. Feb 1999;89(2):193-198.
66. Donahue SP, Johnson TM, Leonard-Martin TC. Screening for amblyogenic factors using a volunteer lay network and the MTI photoscreener. Initial results from 15,000 preschool children in a statewide effort. Ophthalmology. Sep 2000;107(9):1637-1644; discussion 1645-1636.
67. De Becker I, MacPherson HJ, LaRoche GR, et al. Negative predictive value of a population-based preschool vision screening program. Ophthalmology. Jun 1992;99(6):998-1003.
68. Kulp MT. Findings from the Vision in Preschoolers (VIP) Study. Optom Vis Sci. Jun 2009;86(6):619-623.
69. Joish VN, Malone DC, Miller JM. A cost-benefit analysis of vision screening methods for preschoolers and school-age children. J Aapos. Aug 2003;7(4):283-290.
70. Konig HH, Barry JC, Leidl R, Zrenner E. Cost-effectiveness of orthoptic screening in kindergarten: a decision-analytic model. Strabismus. Jun 2000;8(2):79-90.
71. Schmucker C, Grosselfinger R, Riemsma R, et al. Effectiveness of screening preschool children for amblyopia: a systematic review. BMC Ophthalmol. 2009;9:3.
72. Powell C, Porooshani H, Bohorquez MC, Richardson S. Screening for amblyopia in childhood. Cochrane Database Syst Rev. 2005(3):CD005020.
73. Force UPST. Screening for Visual Impairment in Children Youger than 5 years: Recommendation Statement. Ann Fam Med. 2004;2:263-266.
74. Membreno JH, Brown MM, Brown GC, Sharma S, Beauchamp GR. A cost-utility analysis of therapy for amblyopia. Ophthalmology. Dec 2002;109(12):2265-2271.
75. Konig HH, Barry JC. Cost effectiveness of treatment for amblyopia: an analysis based on a probabilistic Markov model. Br J Ophthalmol. May 2004;88(5):606-612.