HEALTHY VISION 2010

A Companion Document to

Healthy People 2010

Focus Area 28: Vision and Hearing

HEALTHY PEOPLE 2010

National Eye Institute

NATIONAL INSTITUTES OF HEALTH

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Introduction

Healthy People

Healthy People, an initiative of the U.S. Department of Health and Human Services, provides a framework within the public health arena to address issues relating to the health of Americans. Healthy People is updated every 10 years based on the latest research and prevalence data. The framework consists of a set of objectives designed to identify major preventable threats to health and to establish goals to reduce those threats. The two goals of *Healthy People 2010* are as follows:

- Increase quality and years of healthy life
- Eliminate health disparities among different segments of the population.

The *Healthy People 2010* objectives are categorized within 28 focus areas that touch on topics such as cancer, diabetes, and heart disease. For the first time since its inception, the Healthy People initiative contains specific objectives addressing eye health.

Vision and Eye Health

Healthy People 2010 reflects the increasing awareness of the Federal government regarding the adverse effects of vision and eye health problems on Americans' health and quality of life. The National Institutes of Health is the lead agency for the *Healthy People 2010, Focus Area 28: Vision and Hearing*. The goal is to improve the visual and hearing health of the Nation through prevention, early detection, treatment, and rehabilitation.

Vision Objectives

The 10 vision objectives resulted from a collaborative process between members of the vision community, led by the National Eye Institute (NEI). Three objectives target specific health outcomes such as reducing visual impairment due to specific eye diseases. Others target specific behavior outcomes such as increasing the use of personal protective eyewear.

The Healthy People 2010 vision objectives are as follows:

- 28-1. Increase the proportion of persons who have a dilated eye examination at appropriate intervals.
- 28-2. Increase the proportion of preschool children aged 5 years and under who receive vision screening.
- 28-3. Reduce uncorrected visual impairment due to refractive errors.
- 28-4. Reduce blindness and visual impairment in children and adolescents aged 17 years and under.
- 28-5. Reduce visual impairment due to diabetic retinopathy.
- 28-6. Reduce visual impairment due to glaucoma.
- 28-7. Reduce visual impairment due to cataract.
- 28-8. Reduce occupational eye injury.
    - 28-8a. Reduce occupational eye injuries resulting in lost work days.
    - 28-8b. Reduce occupational eye injuries treated in emergency departments.
- 28-9. Increase the use of appropriate personal protective eyewear in recreational activities and hazardous situations around the home.
    - 28-9a. Increase the use of personal protective eyewear in recreational activities and hazardous situations around the home among children 6–17 years.
    - 28-9b. Increase the use of personal protective eyewear in recreational activities and hazardous situations around the home among adults 18 years and over.
- 28-10. Increase vision rehabilitation.
    - 28-10a. Increase the use of rehabilitation services by persons with visual impairments.
    - 28-10b. Increase the use of visual and adaptive devices by persons with visual impairments.

Companion Document

This Companion Document is intended to assist state and local agencies and others interested in promoting eye health in their communities. Readers will learn the importance of eye examinations, screening and detection, treatment of eye disease, eye safety, and vision rehabilitation. The Companion Document presents the science surrounding the vision objectives to facilitate their translation into state and local eye health programs, activities, and health promotion campaigns.

Vision is an integral component and a defining element of one's quality of life. Vision impacts fundamental aspects of human development, including our ability to learn, communicate, and work. Good eye health has been shown to result in improved health overall, and may reduce the risks of disease, injury, and disability.

The need to promote and protect healthy vision encompasses the entire lifespan. Whether your focus is preschool children, adolescents, or older adults, the NEI is committed to providing materials and resources that will enable you to make vision a health priority in your community. To learn more about available resources, visit www.nei.nih.gov.

Chapter 1

Dilated Eye Exams

Objective 28-1

Increase the proportion of persons who have a dilated eye examination at appropriate intervals.

Overview

A comprehensive dilated eye examination is vital to maintaining and protecting healthy vision. This eye exam involves placing drops in the eyes to dilate, or widen, the pupils (the round opening in the center of the eye). The eye care professional uses a special magnifying lens to examine the retina (the light-sensitive tissue at the back of the eye) and optic nerve (nerves that send signals from the retina to the brain) for signs of damage and other eye problems (see figure 1-1).

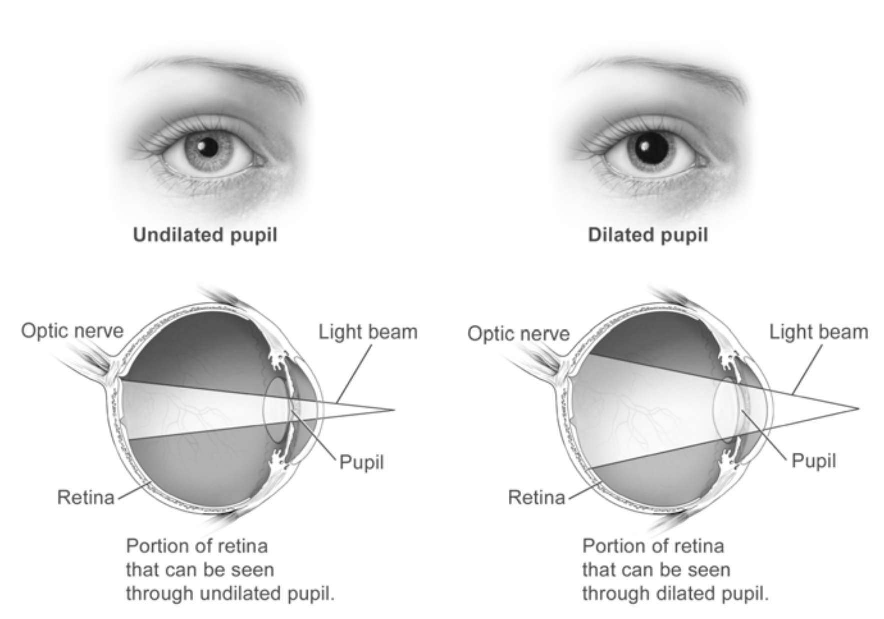

Figure 1-1: Dilation of the pupil permits a wider view of the back of the eye.

Early detection of eye disease is best achieved through a comprehensive dilated eye exam. Vision problems often develop without early symptoms or warning signs.

Therefore, an eye care professional will perform a dilated eye exam in order to detect eye diseases and conditions such as glaucoma, diabetic retinopathy, age-related macular degeneration, and cataract.

During a comprehensive dilated eye exam, an eye care professional inspects the retina and the optic nerve head. An eye care professional uses a device called an ophthalmoscope to look at the inner structure of the eye (see figure 1-2).

Figure 1-2: After the eyes are dilated, an indirect ophthalmoscope provides the eye care professional with a wider view of the retina.

Pupil dilation is part of a comprehensive eye exam. Other aspects of the exam include inspecting the outside of the eye and the eyelid, checking the pressure of the eye, observing whether the lens is clear, and testing how well the eyes work together and separately. This exam is the best way to detect eye disease, which often has no symptoms. Once detected, eye disease may be treated before vision is damaged or lost. A comprehensive dilated eye exam may also reveal signs of other conditions occurring elsewhere in the body, including high blood pressure, impending stroke, and undiagnosed diabetes.

A visit to an eye care professional for a comprehensive dilated eye exam offers the professional an opportunity to discuss lifestyle factors and eye-related issues. This discussion could be a first step toward encouraging habits that promote better health overall and healthy vision in particular.

Data

Healthy Vision 2010 Baseline Data. According to the 2002 National Health Interview Survey, 55 percent of persons 18 years and older had dilated eye exams within the past 2 years (see table 1-1). The target for Healthy People 2010 is to increase the proportion of persons who have a dilated eye exam from 55 percent to 58 percent.

Table 1-1: Percent of persons aged 18 years and older having dilated eye exams at appropriate intervals, 2002.

Adults 18 years and older	Dilated eye exams* Percentage of people
Total	**55%**
Race and ethnicity	
American Indian or Alaska Native only	54%
Asian or Pacific Islander only	DNA
Asian only	50%
Native Hawaiian or Other Pacific Islander only	DSU
Black or African American only	54%
White only	56%
2 or more races	54%
American Indian or Alaska Native; White	47%
Black or African American; White	57%
Hispanic or Latino	45%
Non Hispanic or Latino	56%
Black or African American only, not Hisp/Latino	54%
White only, not Hispanic or Latino	57%
Gender	
Female	58%
Male	52%
Education level (persons 25 years and over)	
Under 12 years	44%
12 years	55%
13 years and over	62%
Diabetes status (annual examination)	
Persons with diabetes	55%
Persons without diabetes	37%

DNA: Data have not been analyzed.

DSU: Data do not meet the criteria for statistical reliability, data quality, or confidentiality.

*Among all civilian, noninstitutionalized adults 18 years and over, those with an exam within the past 2 years were considered as meeting the objective.

Data source: National Health Interview Survey, National Center for Health Statistics, Centers for Disease Control and Prevention, 2002.

Among the different racial/ethnic groups, the highest percentage having dilated eye exams occurred among mixed race persons (Black or African American and White) and White persons 18 years and older, followed by Blacks or African

Americans, American Indians or Alaska Natives, and Asian only. Hispanics/Latinos reported having dilated eye exams less often (see table 1-1). Persons with diabetes were more likely to have had a dilated eye exam (55%) than persons without diabetes (37%).

Issues

Examination Frequency and Timing

There is no overall agreement about how often adults who are not at high risk for eye disease should have comprehensive dilated eye exams. Professional recommendations on the frequency of examinations are slightly different between eye care organizations.[1,2]

For healthy adults who do not have specific risk factors, the recommended times to get comprehensive eye examinations are shown in table 1-2.

Table 1-2: Comprehensive eye exam frequency recommendation for healthy adults.

American Optometric Association[3]		American Academy of Opthalmology[4]	
Age	**When to get an exam**	**Age**	**When to get an exam**
18–40	Every 2 to 3 years	20–39	Once between these ages
41–60	Every 2 years	40–64	Every 2 to 4 years
Over 60	Annually	Over 64	Every 1 to 2 years

Both optometrists and ophthalmologists recommend more frequent comprehensive dilated eye exams for adults at risk for eye disease. The National Eye Institute recommends that patients with diabetes receive comprehensive dilated eye examinations at least once every year. People at risk for glaucoma should have a comprehensive dilated eye examination at least once every 2 years. People who have specific eye conditions may need different eye examination schedules, especially to follow up with treatment. This schedule is determined by their eye care professional.

Public and Patient Awareness

When researchers studied patients at a clinic in Baltimore, Maryland, who had not undergone an eye examination in 2 or more years, more than 25 percent of these patients had at least one eye disease and were unaware of it. When researchers asked the patients why they had not seen an eye care professional, about 28 percent reported considering an eye examination unnecessary, 11 percent lacked money or insurance, and 8 percent said obtaining regular eye examinations was inconvenient.[3]

Effective eye health education programs can help the public come to value and understand the importance of regular eye exams. More Americans need to be encouraged to seek comprehensive dilated eye examinations as part of routine health care (see figure 1-3).

Figure 1-3: Educating a patient about the importance of regular comprehensive dilated eye examinations to prevent vision loss.

At-risk populations are a first priority for eye health education. These higher risk populations include the following:

- Older Americans who have increased risk of age-related eye disease such as glaucoma, cataract, and age-related macular degeneration.
- African Americans and Mexican Americans at higher risk for glaucoma.
- Hispanics/Latinos, African Americans, American Indians, and Alaska Natives at greater risk for diabetes.
- People with a family history of eye disease.

In 2002, the Centers for Medicare & Medicaid Services began providing an annual dilated eye exam for people with Medicare who were at higher risk for eye diseases, including glaucoma. In 2006, the list of those covered was expanded to include Hispanics aged 65 and older.

Medicare covers annual glaucoma screening for the following persons considered to be at high risk for this disease:

- People with diabetes
- African Americans aged 50 and older
- Hispanics aged 65 and older
- Those with a family history of glaucoma.

Conclusions

Getting regular, comprehensive dilated eye exams is the best way to prevent vision loss. Symptoms of eye disease often do not usually appear until vision is lost. Therefore, early detection and timely treatment of eye disease are essential to prevent visual impairment. Lost vision cannot be restored.

Increasing the proportion of persons who have a comprehensive dilated eye exam at appropriate intervals is an objective of Healthy Vision 2010. Eye health education programs for the public can assist in overcoming barriers to obtaining appropriate care for one's eyesight. Education programs can help overcome the lack of awareness about the importance of maintaining eye health, and can inform the public about the recommended frequency of comprehensive dilated eye examinations and the availability of eye care services.

References

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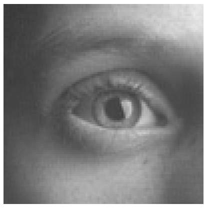

Chapter 2

Preschool Vision Screening

Objective 28-2

Increase the proportion of preschool children aged 5 years and under who receive vision screening.

Overview

Children 5 years and younger can be affected by eye and vision problems. Visual impairment caused by refractive errors, amblyopia, and/or strabismus is a common condition among young children, affecting up to 20 percent of all preschoolers.[1]

Screening may be a cost-effective way of identifying children in need of further vision care; however, studies have found that less than 22 percent of preschool children are screened for vision problems.[2,3] One study showed that only 37 percent of pediatricians perform visual acuity testing at 3 years of age,[4] and as many as 60 percent do not perform preschool vision screening.[5,6]

Although young children are at risk for vision problems, there are barriers to screening children under the age of 3 years. For example, infants and toddlers do not complain of vision problems.[2,7,8] The child who "cannot see well" and the child who "does not perform well" on visual acuity tests are difficult to differentiate.[9] However, the Vision in Preschoolers (VIP) Study, described below, demonstrated that more than 98 percent of 3-, 4-, and 5-year-olds were testable.

A vision screening is a quick, simple public health strategy to detect children with, or at risk for, selected vision problems, but it does not provide a diagnosis or treatment. While vision screening can be performed by an eye care professional, it is typically done by a nurse or trained layperson.

Vision in Preschoolers Study

The National Eye Institute funded the Vision in Preschoolers Study to evaluate whether vision screening tests can successfully identify preschool-aged children who would benefit most from a comprehensive eye examination. The study focused on three criteria for success:

- Testability: the ability to administer the tests to high numbers of 3- to 5-year-olds.
- Sensitivity: the ability to correctly identify a high proportion of children with vision disorders.
- Specificity: the ability to correctly identify as normal a high proportion of children with no vision disorders.

In phase I of the VIP study, 2,588 children were first screened by a licensed eye care professional who had been trained and certified to administer the vision screening tests. The children were then given a comprehensive eye examination using standardized diagnostic procedures and tests (referred to as a "Gold Standard Eye Examination") by an optometrist or ophthalmologist who did not know the results of the child's prior screening test.[10] Results from the comprehensive eye examinations were used to classify children with respect to four targeted conditions: amblyopia, strabismus, significant refractive errors, and unexplained reduced visual acuity.

The results of phase I revealed that commonly used screening tests vary widely in performance when administered by licensed eye care professionals (optometrists and ophthalmologists) experienced in working with children. A striking finding was the overall superiority of noncycloplegic retinoscopy, the Retinomax Autorefractor, SureSight Vision Screener, and Lea Symbols in detecting children who have one or more of the targeted conditions, as well as the most severe of these conditions. Not only were these tests accurate in picking up high refractive errors, but they were also effective in detecting strabismus and strabismic amblyopia. In agreement with previous reports based on other populations, examination of VIP children revealed that both strabismus and strabismic amblyopia were frequently associated with the presence of significant refractive errors.

Overall, the study results suggest that 98 percent of 3- to 5-year-olds were testable and even at a high level of specificity (over-referral rates for normal children of 10%), the best tests detected two-thirds of children having one or more of the targeted conditions.[10]

Phase II of the VIP study compared the performance of specially trained nurse screeners and lay screeners in administering some of the best screening tests identified during phase I to 1,452 children. The results of phase II of the VIP study indicate that both nurse screeners and lay screeners achieved similar sensitivity for detecting children in need of a comprehensive eye exam. Two of the best-performing tools for vision screening of preschool children (Retinomax Autorefractor and SureSight Vision Screener) are as effective when used by nurse or lay screeners as they are when used by optometrists and ophthalmologists. The Linear Lea Symbols was one of the most effective screening tools when used by optometrists and ophthalmologists, but was somewhat less effective when used by nurse and lay screeners. However, lay screeners' performance improved when the test distance was reduced from 10 to 5 ft and the test format was modified from linear presentation to single, crowded symbols.[11]

Common Visual Impairments

Vision screening is used to detect the three types of visual impairment that most frequently affect young children:

- Refractive errors
- Amblyopia
- Strabismus.

These visual impairments are discussed in detail below.

Refractive Errors

Refractive errors occur when the curve of the cornea (the clear, dome-shaped surface that covers the front of the eye) is irregularly shaped, either too steep or too flat. When the cornea is of normal shape and curvature, it bends, or refracts, light on the retina with precision. However, when the curve of the cornea is irregularly shaped, the cornea bends light imperfectly on the retina. This irregular curvature affects good vision.

Preschool-aged children diagnosed with refractive errors are most often farsighted (hyperopic), which means they may have difficulty seeing nearby objects clearly. The incidence of farsightedness in children decreases as children mature. In one study, 20 percent of preschool children in the study group were farsighted.[1] In another, 3 percent were nearsighted, or myopic.[12] Early detection and treatment of refractive errors may prevent amblyopia and strabismus.[1]

More information about refractive errors can be found in Chapter 3: Refractive Errors.

Amblyopia

Amblyopia, or "lazy eye," generally occurs in early childhood and is one of the most treatable causes of vision loss in children. The prevalence of amblyopia in the general population remains approximately 2 to 3 percent.[2,13] Most children with amblyopia are asymptomatic, but this condition can often be corrected if detected and treated in early childhood.[2] The impact of childhood amblyopia can have long-lasting effects, as it is the leading cause of monocular vision loss in people aged 20 to 70 years.[2]

From birth, the visual system of the brain develops by forming a single picture from images received from both eyes. However, when amblyopia is present, signals sent to the brain from the two eyes differ. The brain forms a picture from the clearer image. The areas of the brain associated with the stronger eye, which sends the clearer picture, develop soundly. Brain areas supporting the weaker eye do not. Over time, the brain simply stops processing the image from the weaker eye, causing increasingly poor vision or even blindness in that eye.

Treatment for amblyopia usually has two steps. First, the underlying eye problem, such as refractive errors and/or strabismus (misalignment of the eyes), must be corrected to allow the image created by the weaker eye to be as clear as possible. Second, the amblyopia itself is treated, often by placing a patch over the better eye. Generally, the younger the child, the better the chance of a successful outcome.[2] Patching forces the brain to use images from the amblyopic eye for all vision (see figure 2-1). A variety of clinical factors[14,15] determine how long each day and for how many days the patch is worn. A recent study showed that patching for 2 hours a day over 4 months had a

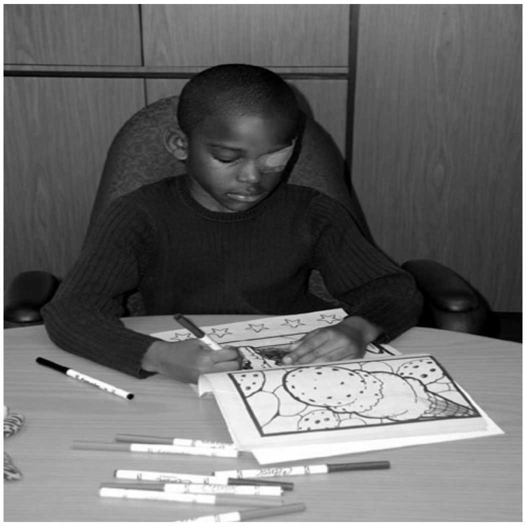

Figure 2-1: A child with amblyopia wearing an adhesive eye patch over his better eye.

slight advantage over patching for 6 hours a day over 4 months.[16] Another treatment strategy involves using prescription eye drops that blur vision in the better eye; this treatment may be as effective as patching in children with moderate amblyopia.[17] Treatments prescribed and monitored by an eye care professional can potentially reduce or correct the visual impairment caused by amblyopia.

Glasses are frequently prescribed to correct refractive errors in the amblyopic eye. Glasses also protect the better eye from potential injury. Children with amblyopia are at a markedly increased risk (16 times) of losing vision in the better eye when compared with nonamblyopic children of the same age.[18]

Strabismus

Misalignment of the eyes, or strabismus, occurs when the muscles that move the eye and/or the systems that control those muscles work improperly. Usually, one eye points toward the object of interest and the other may point in a different direction. Strabismus causes the brain to receive an image from one eye that shows the desired view, while the image from the wandering eye projects a different view. Common terms for strabismus include crossed eyes and wandering eyes. Strabismus is not the same condition as amblyopia.

Strabismus occurs in about 3 to 4 percent of children under 6 years of age.[4] In most cases of strabismus in children, the cause is unknown, but low birth weight[19] increases the risk of strabismus. Children with cerebral palsy or Down syndrome also have higher rates of strabismus.[20]

The eye care professional will conduct an eye examination if a child is suspected of having strabismus. The child may be asked to look through a series of prisms to determine the extent of misalignment, and the eye movements will be tested to determine the degree of abnormal function of the extraocular muscles.[21,22]

Data

Healthy Vision 2010 Baseline Data. Baseline data from the National Health Interview Survey collected in 2002 indicate that 36 percent of children under 5 years of age received at least one vision screening (see table 2-1). The target for Objective 28-2 of Healthy People 2010 is to increase the proportion of preschool children under age 5 years who receive vision screening from 36 percent to 52 percent.

Table 2-1: Percent of children aged 5 years and under who received vision screening by race/ethnicity, gender, family income groups, and disability status, 2002.

Children aged 5 years and under	Vision screening Percentage of people
Total	36%
Race and ethnicity	
American Indian or Alaska Native only	DSU
Asian or Pacific Islander only	DNA
Asian only	31%
Native Hawaiian or Other Pacific Islander only	DSU
Black or African American only	43%
White only	35%
2 or more races	48%
American Indian or Alaska Native; White	DSU
Black or African American; White	51%
Hispanic or Latino	33%
Non Hispanic or Latino	37%
Black or African American only, not Hisp/Latino	43%
White only, not Hispanic or Latino	36%
Gender	
Female	35%
Male	38%
Family income level	
Poor	35%
Near poor	38%
Middle/high income	36%
Disability Status	
Persons with disabilities	64%
Persons without disabilities	35%

DNA: Data have not been analyzed.

DSU: Data do not meet the criteria for statistical reliability, data quality, or confidentiality.

Data source: National Health Interview Survey, National Center for Health Statistics, Centers for Disease Control and Prevention, 2002.

As shown in table 2-1, baseline data show some variability in the numbers of preschool children receiving vision screenings, according to defined subgroups. Mixed race children are more likely to have had at least one preschool vision screening. Children with disabilities are also more likely to have had at least one preschool vision screening. Young children who have visual impairments may have greater difficulty learning and may not be able to participate safely in organized sports and recreational activities. Not seeing well puts children at increased risk of injury due to accidents. Children's psychosocial development can also be affected by visual impairments.[23]

Issues

Vision Screening Guidelines

The American Optometric Association recommends that an optometrist perform a comprehensive eye examination for preschool-aged children at age 3, before first grade, and every 2 years thereafter.[23]

The American Academy of Ophthalmology recommends that all preschool-aged children receive eye and vision screenings. The screenings may be performed by primary care doctors, nurses, or appropriately trained health professionals.[24] When any vision problem is detected through the brief screening exam, the child should be referred to an ophthalmologist for followup examination and care.

The U.S. Preventive Services Task Force (USPSTF) recommends screening to detect amblyopia, strabismus, and defects in visual acuity in children younger than age 5. The USPSTF found fair evidence of the following:

- Screening tests have reasonable accuracy in identifying strabismus, amblyopia, and refractive errors in children with these conditions.
- More intensive screening compared with usual screening leads to improved visual acuity.
- Treatment of strabismus and amblyopia can improve visual acuity and reduce long-term amblyopia.[25]

Screening before entering school is a high priority among suggested clinical preventive services.[26] Thirty-three states and the District of Columbia have vision screening guidelines for school screenings supported by state law or regulatory policy.[1,27] Fifteen of these states require the screening of at least some preschool children. Most often, these screenings are undertaken by state departments of public health and education, or jointly by both departments.[25]

The American Academy of Pediatrics, in association with the American Association of Certified Orthoptists, the American Association for Pediatric Ophthalmology and Strabismus, and the American Academy of Ophthalmology, issued a comprehensive policy statement and joint eye evaluation guidelines. According to this policy statement, the following vision screenings should be performed at all well-child visits[8] (see table 2-2).

Table 2-2: Procedures for eye evaluation.*

Birth to 3 years of age	3 years and older
1. Ocular history	Items 1 through 6, plus:
2. Vision assessment	7. Age-appropriate visual acuity measurement
3. External inspection of the eyes and lids	8. Attempt at ophthalmoscopy
4. Ocular motility assessment	
5. Pupil examination	
6. Red reflex examination	

*Committee on Practice and Ambulatory Medicine, Section on Ophthalmology. American Association of Certified Orthoptists; American Association for Pediatric Ophthalmology and Strabismus; American Academy of Ophthalmology. Eye examination in infants, children, and young adults by pediatricians. *Pediatrics* 2003 Apr;111(4 Pt 1)(4):902-7.

In the event that a child is unable to cooperate, a second attempt should be made 4 to 6 months later. For children 4 years and older, a second attempt should be made in 1 month.[9]

Programs seeking guidance should become familiar with the results from Phases I and II of the VIP Study. The scientifically rigorous VIP Study established the following:

1. The best vision screening tests for use with preschool-aged children when administered by licensed eye care professionals include the following:
    - Noncycloplegic Retinoscopy
    - Retinomax Autorefractor
    - SureSight Vision Screener
    - Linear Crowded Lea Symbols Visual Acuity Test at 10 feet.
2. The best tests are appropriate for use with 3- to 5-year-old children because child testability is high (greater than or equal to 98%).
3. Test/tester- and age-specific referral criteria for 3- to 5-year old children can be determined.
4. A maximum test/tester sensitivity for detecting one or more targeted vision disorders with specificity set at 90 percent can be determined.
5. Similar performances (child testability and screening test sensitivity with specificity set at 90%) can be achieved by pediatric nurses and lay screeners trained according to standardized preschool vision screening procedures.

6. The best vision screening tests for use with preschool-aged children when administered by trained nurses and lay screeners are the following:

   - Retinomax Autorefractor
   - SureSight Vision Screener
   - Single Crowded Lea Symbols Visual Acuity Test at 5 feet (lay screeners only).[10,11]

Many early intervention programs such as HeadStart[28] and Early and Periodic Screening, Diagnosis, and Treatment[29] require vision screenings with timely referral and treatment. A wide variety of personnel perform these school- and community-based screenings.[29] In many cases, school nurses perform the screenings. Voluntary health and community service organizations use trained lay people to screen large numbers of children in school and community settings each year.

Improvement in vision screening is needed in four areas:

1. Adoption of the best preschool vision screening tests.
2. Adoption of test/tester- and age-specific referral criteria to maximize the detection of preschool-aged children with, or at risk for, amblyopia, strabismus, and/or refractive errors.
3. Widespread implementation of preschool vision screening programs by trained lay people using the best tests, thus increasing the number of young children screened.
4. Improving followup care for those children whose screening reveals possible vision problems.

Factors that probably contribute to primary care providers' inattentiveness to vision screening of young children include a lack of confidence in the accuracy of the results, inconsistent and confusing guidelines from various organizations for screening and referral, poorly trained screeners, and a misunderstanding of the window of opportunity for treating amblyopia.[2,5,30,31]

Vision Screening Techniques

Both primary care physicians who provide screenings[24,25] and school- and community-based screening programs[27] often rely on tests of visual acuity, color vision, and eye alignment.

Visual acuity testing measures the sharpness of central vision. These tests are primarily intended to detect significant refractive errors. The most commonly used visual acuity tests are any of several eye charts with letters, pictures, or symbols (see figure 2-2 below). Between the ages of 3 and 5 years, visual acuity can be screened using simple recognition charts including the HOTV test and the Lea Symbols chart (shown below). After age 5, standard visual acuity charts such as the Snellen Acuity Chart can generally be added to the screening.

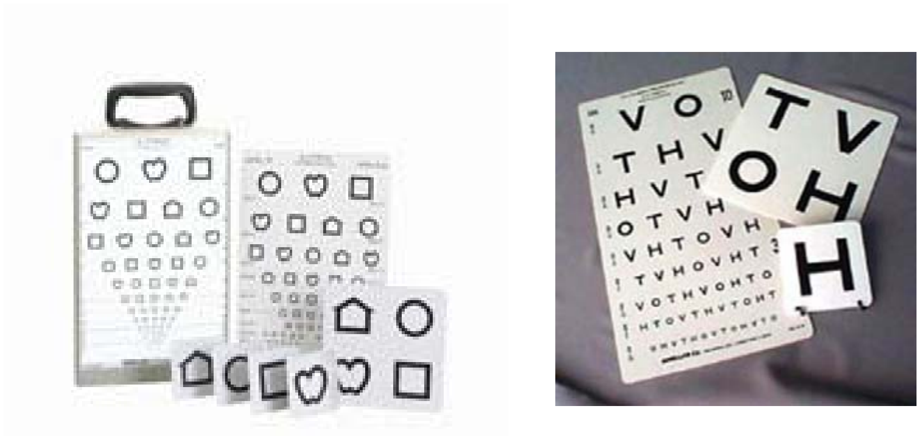

Figure 2-2: Distance visual acuity charts for preschool children.
LEA Symbols are shown on the left and HOTV Symbols on the right.

Parents' observations about the child's ocular history are also listed as being very valuable to the pediatrician. Questions parents can answer include the following:

- Does your child seem to see well?
- Does your child hold objects close to his or her face when trying to focus?
- Do your child's eyes appear straight or do they seem to cross, drift, or seem lazy?
- Do your child's eyes appear unusual?
- Do your child's eyelids droop or does one eyelid tend to close?
- Has your child's eye(s) ever been injured?

Public Education

Parents play a key role in getting eye care for their children. However, one study showed that mothers were unaware of the recommended schedule for vision screening and were unaware that checkups were available.[32] Public education programs help to inform parents about the potential for children's eye problems and the need for appropriate care. Such programs may focus on the prevalence of refractive errors, amblyopia, and strabismus in children.

One study demonstrated that educating teachers in spotting vision problems resulted in significantly more students being identified as having vision problems. The teachers were given a 40-minute in-service lecture and a brochure.[33] Another study showed that even training pediatricians and family practitioners in vision screening techniques increased screening frequency.[5]

In all cases, the results of vision assessments, visual acuity measurements, and eye evaluations, along with instructions for followup care, should be clearly communicated to parents.[8]

Conclusions

Vision impairment and blindness affect up to 20 percent of preschool children. Vision disabilities due to refractive errors, amblyopia, strabismus, or other eye conditions can be mitigated by preschool vision screening. However, 60 percent of pediatricians do not perform preschool vision screening. Although various eye care providers and health agencies have issued guidelines regarding vision screening, less than 22 percent of children are screened for vision problems.

Public education programs can help parents make informed decisions about maintaining the eye health of their children. These programs can also educate teachers and pediatricians about the prevalence of childhood eye disease, stress the importance of vision screenings, and emphasize the need for followup after vision screening, when recommended.

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Chapter 3

Refractive Errors

Objective 28-3

Reduce uncorrected visual impairment due to refractive errors.

Overview

Refractive errors are the most common of all vision problems. Millions of Americans have correctable visual impairment due to refractive errors. Prescription lenses (glasses and contact lenses) and corrective surgery are all standard treatments for this condition. Many Americans have uncorrected refractive errors because they do not realize that proper diagnosis and treatment could result in vision improvement. Eye examinations are essential for detecting vision problems.

Refractive errors occur when the curve of the cornea (the clear, dome-shaped surface that covers the front of the eye) is irregularly shaped—either too steep or too flat. When the cornea is of normal shape and curvature, it bends, or refracts, light on the retina with precision. However, when the curve of the cornea is irregularly shaped, the cornea bends light imperfectly on the retina. This irregular curvature affects good vision. There are four kinds of refractive errors: hyperopia, myopia, astigmatism, and presbyopia.

Farsightedness, or hyperopia, results from an eye that is too short. Distant objects are clear, and close-up objects appear blurry. With farsightedness, images focus on a point beyond the retina.

Nearsightedness, or myopia, occurs when the cornea is curved too much, or if the eye is too long. Faraway objects will appear blurry because they are focused in front of the retina. Nearsightedness affects more than 25 percent of all adult Americans.

Astigmatism is a condition in which the uneven curvature of the cornea blurs and distorts both distant and near objects. A normal cornea is round, with even curves from side to side and top to bottom. With astigmatism, the cornea is shaped more like the back of a spoon, curved more in one direction than in another. This distortion causes light rays to have more than one focal point and focus on two separate areas of the retina, distorting the visual image. Two-thirds of Americans with nearsightedness also have astigmatism.

Presbyopia causes the eye to lose the ability to change focus in order to see nearby objects clearly. Many people with mild presbyopia find they can focus on reading material held no closer than the length of an arm. Eventually, the distance required for proper focus becomes too great to read small print. Presbyopia affects most people as they age. As the eye ages, the lens becomes less flexible, making the lens less able to focus on nearby objects. Almost all Americans will experience some degree of presbyopia by age 60.[1]

Farsightedness and nearsightedness are opposites, and only one of these conditions can be present in an eye. However, either farsightedness or nearsightedness may happen in an eye that also has astigmatism or presbyopia.

Data

In the United States in general, persons aged 40 and older are the most likely to have refractive errors (see table 3-1). Data recently published by the Eye Diseases Prevalence Research Group provide the most recent authoritative estimates of the prevalence of this condition among adults.[2]

Table 3-1: Estimated prevalence of refractive errors in the U.S. population aged 40 and older by race/ethnicity and sex.

	U.S. population (Millions)	Myopia* (%)	Hyperopia** (%)
Total Population (Over 40)	119.4	25.4	9.9
Women	63.7	26.2	11.3
Men	55.7	24.6	8.2
Non-Hispanic White	92.8	27.7	11.0
Non-Hispanic Black	11.8	15.1	5.1
Hispanic	8.9	18.6	6.3
Other	5.9	21.5	6.9

*Myopia was defined as a refraction of -1 diopters or less negative.

**Hyperopia was defined as a refraction of +3 diopters or more positive.

Source: Tables 3 and 4, Eye Diseases Prevalence Research Group. The prevalence of refractive errors in the United States, Western Europe, and Australia. *Arch Ophthalmol* 2004 Apr;122: pp. 501, 502.

Percentages were calculated based on U.S. Census 2000 population estimates.

Data were not presented separately for Asian Americans and/or American Indians/Alaska Natives, although data from specific research studies are reported below.

Healthy Vision 2010 Baseline Data. The 1999–2000 National Health and Nutrition Examination Survey estimates that 110.7 persons per 1,000 aged 12 and older have uncorrected visual impairment due to refractive errors (see table 3-2). The target for Healthy People 2010 is to reduce the prevalence of uncorrected visual impairment due to refractive errors by 16.1 percent, from 110.7 to 92.9 per 1,000 persons aged 12 years and older by the year 2010. As shown in table 3-2, uncorrected visual impairment due to refractive errors is more prevalent among Mexican Americans than among Blacks or African Americans or Whites only, and among those whose family income level is "poor" than among those whose family income level is "middle/high income." Persons aged 12 to 19 and those 60 years and older also have more uncorrected visual impairment due to refractive errors than among those persons aged 20 to 59 years.

Table 3-2: Uncorrected visual impairment due to refractive errors in persons 12 years and older, 1999–2000.

Persons 12 years and older	Uncorrected visual impairment due to refractive errors Rate per 1,000
Total	**110.7**
Race and ethnicity	
American Indian or Alaska Native only	DSU
Asian or Pacific Islander only	DSU
Asian only	DSU
Native Hawaiian or Other Pacific Islander only	DSU
Black or African American only	DNA
White only	DNA
2 or more races	DNA
American Indian or Alaska Native; White	DNA
Black or African American; White	DNA
Hispanic or Latino	
Mexican American	175.0
Not Hispanic or Latino	DNA
Black or African American only, not Hispanic or Latino	147.8
White only, not Hispanic or Latino	93.0
Gender	
Female	123.1
Male	97.6
Family Income Level	
Poor	169.0
Near Poor	132.4
Middle/high income	85.0
Diabetes status	
Persons with diabetes (within the past year)	144.2
Persons without diabetes (within the past year)	110.5

Table 3-2: Continued

Persons 12 years and older	Uncorrected visual impairments due to refractive errors Rate per 1,000
Age Groups	
Persons aged 12 to 19 years	155.9
Persons aged 20 to 39 years	96.6
Persons aged 40 to 59 years	84.3
Persons aged 60 years and older	145.7

DNA: Data have not been analyzed.

DNC: Data for specific population are not collected.

DSU: Data do not meet the criteria for statistical reliability, data quality, or confidentiality.

Source: 2002 National Health Interview Survey, National Center for Health Statistics, Centers for Disease Control and Prevention.

A study designed to establish the baseline prevalence of refractive errors in a population of children from four racial/ethnic groups measured 2,523 children between the ages of 5 and 17 to determine their level of refractive error and ocular development (Collaborative Longitudinal Evaluation of Ethnicity and Refractive Error Study Guide [CLEERE study]).[3] While this study focused considerable effort on managing the differences in definitions of refractive errors across research studies and reports, definitions were adopted for the purposes of the study, and prevalences, as identified below, were established.

Table 3-3: Prevalence of refractive errors in the U.S. population ages 5–17.

	Myopia*	Hyperopia*	Astigmatism*
Population Overall (Children 5–17)	9.2%	12.8%	28.4%
African Americans	6.6	6.4	20.0
Asians	18.5	6.3	33.6
Hispanics	13.2	12.7	36.9
Whites	4.4	19.3	26.4

* Myopia (-0.75 diopters or worse), hyperopia (+1.25 diopters or worse), astigmatism (1.00 diopters) difference between the two meridians.

Source: Kleinsten RN, Jones LA, Hullett S, Kwon S, Lee RJ, Friedman NE, Manny RE, Mutti DO, Yu JA, Zadnik K. Collaborative Longitudinal Evaluation of Ethnicity and Refractive Error Study Group. Refractive error and ethnicity in children. *Arch Ophthalmol* 2003 Aug;121(8):1141-7, p. 1144.

The study established that the differences in prevalence among racial/ethnic groups are significant, after controlling for gender and age (see table 3-3). The authors concluded that "there are a large number of children who are handicapped visually in their everyday classroom, recreational, and other activities. These uncorrected refractive errors have the potential to make learning more difficult and to reduce or self-limit the choices that children make in their daily activities." The study identifies this level of uncorrected vision problems in children as a public health problem that needs resources and policies in order for administrators to address and alleviate it.[3]

Data from the Los Angeles Latino Eye Study suggest that the prevalence of visual impairment and blindness is high among urban Latinos aged 40 and older, primarily of Mexican ancestry. The overall prevalence of visual impairment for this population was 3 percent, using study-specific definitions of visual impairment. The rate of impairment and blindness was higher among older and female Latinos.[4]

Studies show that visual impairment due to refractive errors is high among some American Indian tribes and Alaska Natives. A study of Sioux Indian adults and children found that 87 percent needed refractive correction and 24 percent had some form of eye disease.[5] In another study, moderate-to-high amounts of astigmatism were found among the Sioux in South Dakota.[6] In a study of more than 1,500 Inuits/Eskimos, researchers found that nearly 45 percent had nearsightedness and more than 10 percent had farsightedness.[7] In a study of Yupik Eskimos, the prevalence of nearsightedness was 68 percent, a rate among the highest reported for a general population anywhere in the world.[8]

Refraction and Correction

Most of the vision problems caused by nearsightedness, farsightedness, astigmatism, and presbyopia can be easily corrected. Practice guidelines from both the American Optometric Association and the American Academy of Ophthalmology recommend that an analysis of refractive errors be a component of a comprehensive dilated eye exam.[9,10]

The degree of refractive error in an eye is measured in units called diopters. Diopters measure the degree to which light rays are bent by a lens. The severity of error is usually described in terms of the power of a lens needed to correct it. For example, +5.00 diopters of farsightedness is more severe than +2.50 diopters of farsightedness.

Eye care professionals use several methods to measure the degree of refractive error and prescribe the right correction. For adults and older children, eye care professionals generally test the patient's vision with a series of lenses. They ask the patient to identify objects through the lenses to indicate which lenses allow the best vision correction. Usually, these lenses are in a device called a phoropter, a machine used to detect refractive errors (see figure 3-1). Lenses may also be placed in a trial lens frame (see figure 3-2).

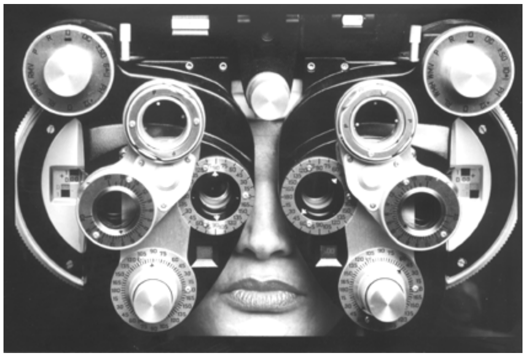

Figure 3-1: A phoropter is a machine used to detect refractive errors.

Figure 3-2: An eye care professional determines a patient's eyeglass prescription.

Eye care professionals sometimes begin an examination by using an autorefractor. This device measures refractive errors with no input from the patient. The device allows for initial estimates of the refractive errors, which are then refined during the lens selection procedure.

Prescription eyeglasses and contact lenses are the most common forms of vision correction. More than 150 million Americans use corrective eyewear, spending more than $15 billion on eyewear each year.[3] Refractive surgeries are becoming an increasingly popular option for reducing or eliminating refractive errors.[11,12]

Issues

Uncorrected Refractive Errors and Visual Impairment

Uncorrected refractive errors commonly cause visual impairment, and small degrees of refractive errors can cause vision problems. For instance, -2.00 diopters of nearsightedness might worsen a person's distance visual acuity (the clarity or sharpness of vision) from 20/20 to 20/80.

The term 20/20 vision is used to express normal visual acuity measured at a distance of 20 feet. If you have 20/20 vision, you can see clearly at 20 feet what should normally be seen at that distance. If you have 20/100 vision, it means that you must be as close as 20 feet to see what a person with normal vision can see at 100 feet. Having 20/20 vision does not necessarily mean having perfect vision. A measurement of 20/20 vision only indicates the sharpness or clarity of vision at a distance. Most states require a distance visual acuity of 20/40 to obtain an unrestricted driver's license.

Refractive correction is widely available. However, a surprisingly large number of Americans do not have adequate refractive correction. In one study of nearly 4,000 adults, researchers found they could improve vision in more than one-third of the people with better refractive correction.[13] Many people with uncorrected refractive errors have reduced visual acuity that may qualify as visual impairment (generally acuity of 20/50 or worse).

Some racial/ethnic populations appear more likely to have visual impairment from uncorrected refractive errors. In a study of more than 4,700 Mexican Americans aged 40 and older, 8.2 percent had reduced visual acuity even with their current eyeglasses.[14] Of these, 91 percent were able to read one or more additional lines of an eye chart after they were given better correction following a refractive exam. A study of more than 5,000 African Americans and Whites in Baltimore, Maryland, found that half of those with impaired vision improved after receiving a new correction.[15]

Several additional populations also appear more likely to have visual impairment from uncorrected refractive errors. A study of more than 700 nursing home residents in Baltimore revealed high rates of blindness (17%) and visual impairment (18.8%). The study also showed that the right amount of refractive correction could have solved partial blindness in one-fifth of the residents and visual impairment in more than one-third of them.[16] Likewise, more than one-half of veterans visiting a Veterans Administration hospital needed improved refractive correction.[17]

In a study of 5,851 children aged 9–15 in Manhattan, nearly 28 percent (1,614 students) needed glasses, but only 10 percent of that group already had them.[18] This study points to a huge need to identify and service children who could be adequately treated by providing eyeglasses. The study estimates that glasses could be provided to approximately 1 million children in this age group in the United States.

A study was conducted to develop a national estimate for the proportion of school-age children in the United States with corrective lenses (glasses or contact lenses), and to analyze the association between having corrective lenses and factors typically associated with the use of other preventive care services. These factors included age, gender, race/ethnicity, family income, and health insurance status. Using data from the Medical Expenditure Panel survey (1988), the national estimate study demonstrated that about 25 percent of school-age children between 6 and 18 years wear corrective lenses. Girls were more likely than boys to have glasses. Income, gender, and race/ethnicity, depending on insurance status, were associated with having corrective lenses.[19]

Screening and Detection

Only an eye care professional can diagnose refractive errors and prescribe corrective treatments. Screening programs help identify people with vision problems, and can refer them for professional eye care. School-based vision screening programs may help find uncorrected vision problems in older children.

Community-based adult vision screening programs promote the importance of both public education and the detection of uncorrected refractive errors. Screening programs for working-age adults may find a large number of people with uncorrected presbyopia or inadequate correction for nearsightedness. Screening programs that produce referrals resulting in visits to eye care doctors can lead to the correction of vision problems and the detection of eye disease. Referrals also help to reinforce the importance of periodic professional eye care. Older Americans, especially nursing home residents, have an increased need for the screening and treatment of uncorrected refractive errors.[16]

Conclusions

Even with extensive corrective and diagnostic technology, refractive error remains the most common vision problem. Several types of treatments for correcting this condition are widely available, including prescription eyeglasses, contact lenses, and refractive surgery.

Public education programs that promote routine eye care help increase awareness and may reduce the impact of uncorrected refractive errors. Screening programs targeting those ages when vision problems commonly occur, such as nearsightedness development in school-aged children or presbyopia development in middle-aged adults, can help encourage those in need of refractive correction to seek professional eye care. Some vulnerable populations, such as nursing home residents, who disproportionately suffer from visual impairment due to refractive errors, could benefit from targeted education, screening, and treatment programs.

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Chapter 4

Blindness and Visual Impairment in Children and Adolescents

Objective 28-4

Reduce blindness and visual impairment in children and adolescents aged 17 years and under.

Overview

Eye conditions that begin in childhood have the potential to create vision impairment that lasts a lifetime. The potential for compromising or limiting daily activities and interfering with independent living is substantial. Vision problems that affect children and adolescents from ages 6 to 17 are addressed in this chapter. Issues of eye health affecting children aged 5 and under are presented in Chapter 2: Preschool Vision Screening.

Vision Problems in Children and Adolescents

Children and adolescents face common vision problems such as refractive errors and are at greater risk for eye injury.

Specific vision problems that may affect children and adolescents are the following:

- Refractive errors (for more detail see Chapter 3: Refractive Errors)
- Retinopathy of prematurity (ROP)
- Glaucoma and congenital cataract (for more detail see Chapter 6: Glaucoma and Chapter 7: Cataract)
- Retinoblastoma
- Eye injury (for more detail see Chapter 9: Home and Recreational Eye Safety).

Each of these items is addressed below.

Refractive errors occur when the curve of the cornea is irregularly shaped. This irregular curvature can result in nearsightedness, farsightedness, or astigmatism.

A recent study of school-aged children showed that overall, nearsightedness is more common (10.1%) than farsightedness (8.6%). Nearsightedness, also known as myopia, occurs when objects close by can be seen clearly, while distant objects appear blurred. Farsightedness, or hyperopia, occurs when distant objects can be seen clearly, but nearby objects appear blurred. In this study, age had a significant effect on refractive errors, with children becoming less farsighted as they aged. Children aged 6 to 7 were more farsighted than children aged 9 to 14.[1]

Another study demonstrated that between 3 and 6 percent of all early school-aged children (kindergarten to second grade) have refractive errors, either farsightedness, nearsightedness, or complications related to astigmatism. [2,3]

School-aged children from many American Indian tribes display a high prevalence of astigmatism. Unfortunately, astigmatism often goes undetected and untreated in young American Indian children.[4]

Asian and Pacific Islander children may be at higher risk for nearsightedness than White, Hispanic, or African American children of the same age.[5] A study conducted in Southern California finds this result for children aged 5 to 7 years. By adolescence, nearsightedness becomes much more common in all children. About one-quarter of children aged 12 to 17 years have juvenile nearsightedness.[6]

Retinopathy of prematurity affects premature infants. In these infants, the blood vessels that supply the retina are incompletely formed and are immature at birth. [7] Severe forms of ROP cause major vision impairment.

Glaucoma involves an increase in the fluid pressure within the eye. Congenital glaucoma usually develops within the first few years of life. Cataract, which is a clouding of the lens of the eye, usually occurs in conjunction with other eye or health conditions. Cataract may also be genetic.[8]

Retinoblastoma, although a rare condition, can threaten an infant's or child's eyesight, and can even be life-threatening. It causes the pupil (round opening in the center of the eye) to appear white as a tumor fills the eye. If left untreated, more tumors can develop, which can ultimately spread to the brain. Chemotherapy, radiation therapy, and/or surgical removal of the affected eye may be required for treatment of this eye disease.

For children, eye injuries most often occur as a result of accidents involving toys or household products, or during sporting activities. Vision loss due to injury is almost entirely preventable.

Data

Healthy Vision 2010 Baseline Data. Estimates of the number of children and adolescents with blindness and visual impairment are available from the 2003 National Health Interview Survey. Twenty-four children and adolescents per 1,000 aged 17 years and under were blind or visually impaired (see table 4-1). The target for Healthy People 2010 is to reduce this prevalence statistic by 25 percent, from 24 to 18 per 1,000 children and adolescents by the year 2010.

A review of the data presented in table 4-1 shows that the presence of disabilities is by far the most heavily associated condition related to prevalence of blindness and visual impairment (92 children per 1,000, as compared to 24 children per 1,000, overall). Data are also presented for race/ethnicity, gender, and family income level. Prevalence is elevated for Black or African American only children, not Hispanic/Latino children. Male children and adolescents have slightly higher rates of visual impairment and blindness than females. Children and adolescents whose family incomes were classified as poor or near poor had a higher prevalence of blindness and visual impairment than their middle- to high-income counterparts.

Table 4-1: Prevalence of Blindness and Visual Impairment in Children and Adolescents, 1997.

Children and adolescents aged 17 years and under (1997)	Blindness and visual impairment Rate per 1,000
Total	24
Race and ethnicity	
American Indian or Alaska Native	DSU
Asian or Pacific Islander	DSU
Asian	DSU
Native Hawaiian or other Pacific Islander	DSU
Black or African American	26
White	24
2 or more races	DNC
American Indian or Alaska Native; White	DNC
Black or African American; White	DNC
Hispanic or Latino	21
Not Hispanic or Latino	25
Black or African American	27
White	25
Gender	
Female	24
Male	25
Family income level	
Poor	34
Near poor	28
Middle/high income	20
Disability status	
Persons with disabilities	92
Persons without disabilities	19

DNC: Data for specific population are not collected.

DSU: Data do not meet the criteria for statistical reliability, data quality, or confidentiality.

Source: 1997 National Health Interview Survey, National Center for Health Statistics, Centers for Disease Control and Prevention.

Issues

Several major causes of blindness and vision loss in children and adolescents have no effective treatment. However, scientists now understand much more about the causes of inherited conditions (including retinitis pigmentosa and related hereditary retinal degenerations). Gene-based therapies for these conditions offer hope for future preventive strategies. The National Eye Institute views genetic research as important science for understanding congenital eye disease, and addresses gene-based therapy in its strategic plan, "Vision Research: A National Plan."[9]

Early detection of incurable eye conditions in children is still important, whether or not effective treatments are currently known. Since children who suffer from untreatable visual impairment may face a lifetime of special needs, early detection of their conditions will ensure they receive appropriate vision rehabilitation services (for more detail see Chapter 10: Vision Rehabilitation). In cases like retinitis pigmentosa, children can have good vision for many years before signs of their condition develop. Retinitis pigmentosa is a progressive degeneration of the retina that affects night vision and peripheral (side) vision. Early detection helps prepare these children for their eventual visual impairment. Early exposure to adaptive devices and vision rehabilitation services can enhance a young person's life by making the adjustment to their visual impairment earlier, and possibly, easier.

Many of the eye conditions affecting children and adolescents require early detection and prompt treatment for normal childhood development, or for successful prevention of progressive visual impairment and blindness.

Reduced visual acuity (the clarity or sharpness of vision) due specifically to astigmatism has been shown to have a negative effect on school performance. However, examinations for astigmatism are often not included in many vision screening guidelines for use in schools. Vision screening instead often emphasizes testing for visual acuity and eye misalignment.

The American Academy of Ophthalmology recommends an eye screening by a primary care physician at birth and at regular intervals in childhood thereafter. Preschool children (ages 3–4) should have an eye screening by a primary care physician, state vision screening society, and/or eye care professional. For school-aged children, the American Academy of Ophthalmology recommends an eye screening during "routine school checks or after the appearance of symptoms."[10]

The American Optometric Association recommends a comprehensive examination at age 3, followed by another examination before first grade. The asymptomatic/risk-free child should continue to have comprehensive eye and vision examinations every 2 years thereafter. Symptomatic/at-risk children may need to have examinations more frequently at the discretion of their doctor of optometry.[11]

Conclusions

Children and adolescents can face many threats to their eye health. The best defenses against potential vision loss are early detection and prompt treatment, when available. Eye examinations at appropriate intervals help to ensure early detection and treatment of children's eye conditions. Children and adolescents with severe visual impairments benefit from early detection and referral for vision rehabilitation and counseling, and the implementation of adaptive measures.

Health educators and professionals can encourage parents to take an active role in obtaining eye care for their children. Many parents are not likely to be aware of the need for eye examinations for their children and adolescents. Public education programs for parents can enhance awareness of the potential for children to develop common and/or serious vision problems and can inform parents about the need for appropriate eye examinations.

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Chapter 5

Diabetic Retinopathy

Objective 28-5

Reduce visual impairment due to diabetic retinopathy.

Overview

Diabetes is a disease in which the body does not produce or properly use insulin. Insulin is a hormone that is needed to convert sugar, starches, and other food into energy needed for daily life. While the exact cause of diabetes is unknown, both genetics and environmental factors such as obesity and lack of exercise appear to play roles.[1] Diabetes causes a host of health complications, many of which lead to heart disease, stroke, lower extremity amputation, and visual impairment.

More than 200,000 people die each year of complications related to diabetes. Diabetes is the sixth major cause of death in the United States.[2] More than 20 million Americans have diabetes, and one in three people with diabetes do not know they have the disease.[1]

There are two primary types of diabetes: type 1 and type 2. Type 1 most often appears during childhood or adolescence. Type 2 most often appears after age 40 and affects as many as 95 percent of people with diabetes. However, type 2 diabetes is no longer a disease that strikes only adults. It is now increasingly diagnosed in children and teenagers.

Diabetic retinopathy is a complication of diabetes and a leading cause of blindness. There are no symptoms in the early stages of diabetic retinopathy. It occurs when diabetes damages the tiny blood vessels inside the retina, the light-sensitive tissue at the back of the eye (see figure 5-1). A healthy retina is necessary for good vision.

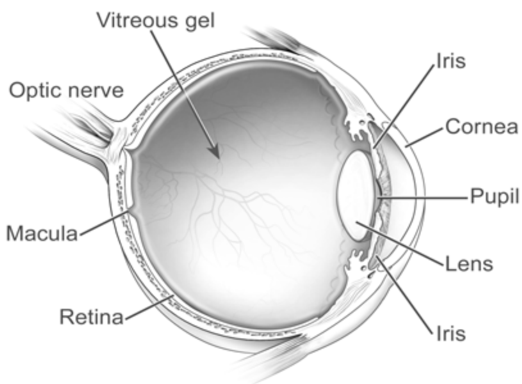

Figure 5-1: A cross-sectional diagram of the eye.

Detection

The American Diabetes Association, the Centers for Disease Control and Prevention, the American Academy of Ophthalmology, the American Optometric Association, and the American College of Physicians recommend that a yearly dilated eye exam be used to detect and evaluate diabetic retinopathy.[3,4,5,6,7] A comprehensive dilated eye exam involves placing drops in the eye that enlarge the pupils (the round opening in the center of the iris). This procedure allows the eye care professional to see the inside of the eye and examine it for signs of retinopathy. The National Eye Institute recommends that persons with diabetes get a comprehensive dilated eye exam at least once a year, and that pregnant women with diabetes get a comprehensive dilated eye exam as early as possible. Women with diabetes who become pregnant should have a comprehensive dilated eye exam in the first trimester and close followup throughout pregnancy and 1-year postpartum.[7]

Eye care professionals will look for early signs of retinopathy, such as leaking blood vessels; retinal swelling, such as macular edema; pale, fatty deposits in the retina; damaged nerve tissue; and changes in the blood vessels. Researchers are beginning to evaluate high-quality digital imaging systems for detecting diabetic retinopathy.[8]

In some cases of diabetic retinopathy, a procedure called fluorescein angiography may be performed where a special dye is injected into a vein in the arm. The dye is photographed or digitally recorded as it passes through the blood vessels of the retina. This procedure allows the eye care professional to find areas of new blood-vessel growth and detect leaking vessels.

Data

The prevalence of diabetic retinopathy in persons with diabetes is high. During the first two decades of having diabetes, nearly all patients with type 1 diabetes and more than 60 percent with type 2 diabetes have retinopathy.[9,10] It is estimated that 40.8 percent of adults aged 40 and older with diabetes have diabetic retinopathy and 8.2 percent have advanced, vision-threatening retinopathy. More than 4 million (3.4%) Americans aged 40 and older have some form of diabetic retinopathy (see table 5-1). This number is projected to reach 6.1 million by the year 2020.[11]

Table 5-1: Estimated prevalence of diabetic retinopathy in the United States in persons 40 years and older, by gender and race/ethnicity.

	U.S. population aged 40 and older (millions)	Prevalence of diabetic retinopathy per 100 persons
Total	**119.4**	**3.4***
Women	63.7	3.3
Men	55.7	3.6
Non-Hispanic White	92.8	3.2
Non-Hispanic Black	11.8	4.0
Hispanic	8.9	5.3

*Estimates for prevalence of diabetic retinopathy in the total U.S. population are based on Census 2000 population estimates and include estimates for other races (Asian, American Indian, Alaska Native, Native Hawaiian, other Pacific Islander, and any other race) and those designating more than one race on the Census 2000 form.

Source: Adapted from Table 5, Estimated Prevalence of Diabetic Retinopathy in the United States, by Age, Gender, and Race/Ethnicity. The Eye Diseases Prevalence Research Group. The prevalence of diabetic retinopathy among adults in the United States. *Arch Ophthalmol* 2004 Apr;122(4):552-563, p. 559.

The prevalence of diabetic retinopathy increases, on average, across successive age groups, however, lower prevalence rates of diabetic retinopathy have been observed in the oldest age group (75 years and older) when compared with those aged 65 to 74 years. Higher rates of diabetic retinopathy in Hispanics/Latinos and African Americans as compared to Whites have been observed in the general population. These differences most likely contribute to higher rates of diabetes in these racial/ethnic groups. No gender differences have been reported between any racial/ethnic groups for diabetic retinopathy.[12]

Healthy Vision 2010 Baseline Data. According to the 2002 National Health Interview Survey, nearly 46 per 1,000 persons 18 years and older with diabetes have visual impairment due to diabetic retinopathy (see table 5-2). The target for Healthy People 2010 is to reduce visual impairment due to diabetic retinopathy by 10.9 percent, from 45.9 to 40.9 per 1,000 persons aged 18 years and older. As shown in table 5-2, Hispanics/Latinos are substantially more likely to be visually impaired from diabetic retinopathy when compared to other racial/ethnic groups.

Table 5-2: Visual impairment due to diabetic retinopathy in adults 18 years and older by race/ethnicity, gender, and education level, 2002.

Persons 18 years and older with diabetes	Visual impairment due to diabetic retinopathy Rate per 1,000
Total	**45.9**
Race and ethnicity	
American Indian or Alaska Native only	DSU
Asian or Pacific Islander only	DSU
Asian only	DSU
Native Hawaiian or Other Pacific Islander only	DSU
Black or African American only	DNA
White only	46.7
2 or more races	DSU
American Indian or Alaska Native; White	DSU
Black or African American; White	DSU
Hispanic or Latino	73.3
Non Hispanic or Latino	41.9
Black or African American only, not Hisp/Latino	DSU
White only, not Hispanic or Latino	41.0
Gender	
Female	46.8
Male	46.6
Education level (persons 25 years and over)	
Under 12 years	58.9
12 years	44.9
13 years and over	47.4

DNA: Data have not been analyzed.

DSU: Data do not meet the criteria for statistical reliability, data quality, or confidentiality.

Source: 2002 National Health Interview Survey, National Center for Health Statistics, Centers for Disease Control and Prevention.

Prevalence rates for diabetes are higher among racial and ethnic minorities than the general population. African Americans, Hispanics/Latinos, American Indians, and Alaska Natives aged 20 years and older are 1.5 times or more likely to have diagnosed diabetes than their White counterparts.[12] Studies have found that the prevalence and severity of diabetic retinopathy are greater in African Americans with type 2 diabetes than in non-Hispanic Whites.[13,14,15]

Data from the Los Angeles Latino Eye Study (LALES) suggest that the prevalence of diabetic retinopathy is high among Latinos, primarily of Mexican ancestry. Researchers also found that Latinos appear to have a higher rate of more severe vision-threatening diabetic retinopathy than non-Hispanic Whites. Data from LALES revealed that 6 percent of people with diabetes were visually impaired, and more than 8 percent needed laser treatment to prevent vision loss.[16] Researchers have also suggested that Mexican Americans with low income (annual income less than $20,000) experience a higher rate of proliferative retinopathy.[17]

Diabetic retinopathy poses a serious health threat to American Indian and Alaska Native populations.[18,19,20,21,22,23] One study showed a 49 percent prevalence of diabetic retinopathy in Oklahoma Indians.[24,25] Pima Indians, the most widely studied American Indian group,[26] also have higher rates of diabetic retinopathy.[27]

Treatment

Fortunately, early detection and timely treatment of diabetic retinopathy significantly lower the risk of vision loss. Advanced stages of retinopathy are treated with laser surgery (see figure 5-2). This procedure is called scatter laser treatment and helps shrink the abnormal blood vessels.

Figure 5-2: A patient receives laser treatment for diabetic retinopathy.

People with advanced retinopathy have a 90 percent chance of keeping their remaining vision when they are treated before the retina is severely damaged.[28] Early treatment produces better visual outcomes. Although treatments are very successful, they do not cure the disease.

Issues

Disease Management

The longer someone has diabetes, the more likely he or she will develop diabetic retinopathy. Between 40 to 45 percent of those with diagnosed diabetes have some degree of retinopathy. Research shows that carefully controlling blood-sugar levels can decrease the risk of developing advanced diabetic retinopathy. The Diabetes Control and Complications Trial found that therapy that strictly controlled sugar levels in people with type 1 diabetes reduced the risk for retinopathy by 76 percent. The study also revealed that better control of blood-sugar levels slows the onset and progression of retinopathy and lessens the need for laser surgery for severe retinopathy.[29] The United Kingdom Prospective Diabetes Study further established that improved blood glucose and blood pressure control can prevent or delay the progression of diabetic retinopathy in patients with diabetes.[30]

Diabetes education is the cornerstone of care for all people with diabetes.[31] People with diabetes play a key role in managing their disease. Patient education programs help people with diabetes better understand the disease and how they can effectively be involved in their own care to delay and control its complications.

Comprehensive Dilated Eye Exams

Diabetic retinopathy often has few visual symptoms until vision is lost. It is important to identify and treat patients early in the disease since screening and timely laser therapy can greatly reduce the incidence of vision loss from diabetic retinopathy.[9,10,32,33] To achieve this goal, patients with diabetes should be routinely evaluated to detect treatable disease.[9]

Although effective treatment is available, the number of patients with diabetes referred by their primary care physicians for eye care is far below the guidelines of the American Diabetes Association and the American Academy of Ophthalmology.[33] The National Eye Institute recommends that everyone with diabetes have a comprehensive dilated eye exam at least once a year. For people with diabetic retinopathy, increased exam frequency may be necessary. Several studies have found that patient education improves rates of eye examinations.[3,34]

Emerging Trend: Children, Adolescents, and Diabetic Retinopathy

Over the past decade, researchers have identified an emerging epidemic of type 2 diabetes among children and adolescents. American Indian, Hispanic/Latino, and African American youth are especially affected.[34,35] This increase parallels the recent rise in childhood obesity. Researchers believe genetic, environmental, and lifestyle factors may account for the dramatic increase in the number of African American and Mexican American children with diabetes as compared with White children.[34,35]

The early onset of diabetes indicates increased numbers of adolescents and young adults who either have or will develop diabetic retinopathy. Health care professionals and researchers are now identifying children as young as 8 years of age with type 2 diabetes—increasing the likelihood they will develop retinopathy at some point during their lives.[35]

Conclusions

Diabetes is one of the most significant health problems facing our Nation. It imposes an enormous burden on public health and is a serious threat to healthy vision. This threat is particularly significant for minority populations such as African Americans, American Indians, Alaska Natives, and Hispanics/Latinos. Increasing numbers of children and adolescents are also affected. Patient education about the disease is critical for people with diabetes. Studies have shown the importance of improved blood glucose, blood pressure, and blood cholesterol control in preventing or slowing the progression of diabetic retinopathy. People with diabetes are urged to get a comprehensive dilated eye exam at least once a year to prevent or delay the onset of vision loss.

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Chapter 6

Glaucoma

Objective 28-6

Reduce visual impairment due to glaucoma.

Overview

Glaucoma is an eye disease in which the normal fluid pressure inside the eyes slowly rises, damaging the optic nerve. At first, glaucoma displays no symptoms. However, as the disease progresses, people with glaucoma will slowly lose their peripheral vision. Glaucoma is a leading cause of blindness and visual impairment for Americans, especially older persons, affecting as many as 2.2 million people nationwide. Glaucoma is one of the leading causes of blindness among African Americans.[1] An additional 2 million people who have glaucoma are unaware that this eye disease is weakening or impairing their vision.[2] This chapter will reference only open-angle glaucoma, the most common form of the disease.

Glaucoma damages the optic nerve, the network of fibers that carries visual information from the eye to the brain (see figure 6-1).

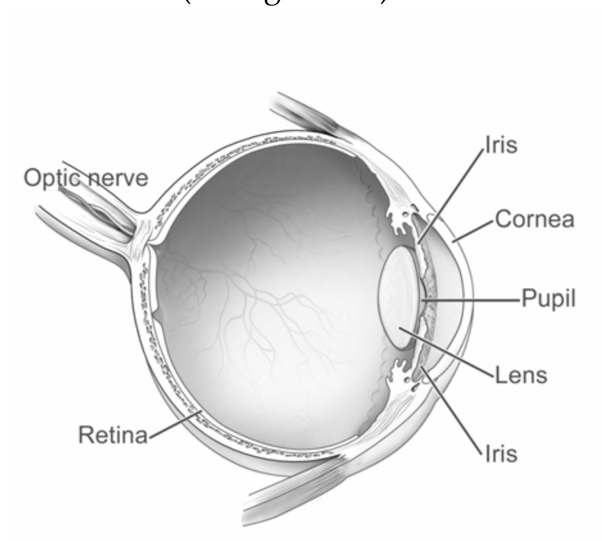

Figure 6-1: A cross-sectional diagram of the eye, showing the optic nerve at the back (left side of diagram).

Over time, more nerve cells in the eye die, and the area of vision loss grows. However, vision loss may be subtle and may increase slowly. Many people do not notice this vision loss as it is progressing. A person with glaucoma in its advanced stages sees only objects in the center of the visual field. Some people may even lose their central vision.

Glaucoma is often associated with an increase of fluid pressure within the eye. This fluid, known as aqueous humor, fills the front portion of the inner eye. The eye continuously makes this fluid that circulates around the structures at the front of the eye, and then the fluid drains out. The drain for aqueous humor is located where the inside of the cornea (surface of the eye) and the iris (colored part of the eye) meet (see figure 6-2).

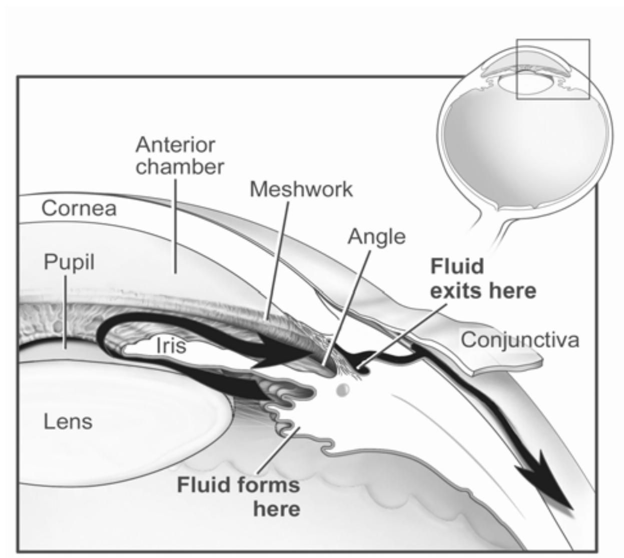

Figure 6-2: In glaucoma, fluid drains too slowly out of the eye. As the fluid builds up, the pressure inside the eye rises. Unless this pressure is controlled, it may cause damage to the optic nerve and other parts of the eye, and loss of vision.

Pressure within the eye depends upon a balance between fluid production and drainage. The drainage system may become less efficient as we age. Increased eye pressure caused by the less efficient drainage system may directly damage the optic nerve by causing changes in the optic nerve cells, or may block the blood supply to the nerves.

The specific amount of pressure required to cause damage to the optic nerve is unclear. In fact, nerve damage occurs in some instances even though measured eye pressure appears to be in the normal range.[3]

Open-angle glaucoma is responsible for most of the vision loss due to glaucoma. Other, less common forms of glaucoma include closed-angle (acute) glaucoma, secondary glaucoma, low-tension or normal-tension glaucoma, congenital glaucoma, and postsurgical glaucoma.

Detection

Anyone can develop glaucoma; however, some groups face a higher risk than others. Age, race, and heredity represent risk factors for glaucoma. Older people are more likely to have glaucoma. African Americans develop glaucoma more often than other racial/ethnic groups, and are likely to develop the disease at a younger age.[4,5,6] Latinos in Los Angeles with a predominantly Mexican ancestry have rates of open-angle glaucoma comparable to those of African Americans and significantly higher than those seen in non-Hispanic Whites.[7] Family history of glaucoma is a risk factor, especially for people with a parent or sibling who has the disease.[8]

Eye care professionals rely on several tests to suggest or confirm the presence of glaucoma. However, no single test or symptom indicates glaucoma with certainty, and only rare forms of glaucoma have any early symptoms at all. Signs of glaucoma include damage to the optic nerve, loss of visual field, and increased eye pressure.

Eye pressure is measured by a procedure known as tonometry (see figure 6-3). Pressure is measured and reported in units of millimeters of mercury, or mmHg. Normal eye pressure can range from approximately 10 to 21 mmHg. People with increased eye pressure that is above this range do not necessarily have glaucoma. Since most people’s eye pressure changes over the course of the day, several measurements may be necessary to confirm the presence of consistent increased eye pressure.

Figure 6-3: An eye care professional uses a tonometer to measure eye pressure.

Gonioscopy is a technique used to inspect the drainage angle of the eye. After numbing the eye, an eye care professional places a special lens on the surface of the eye to allow the angle to be viewed clearly.

Eye care professionals also perform a procedure called perimetry to evaluate the visual field, especially if there are indications that glaucoma may be present. Perimetry tests the vision in the entire field of view to determine whether any areas are damaged, particularly peripheral vision.

None of the above-mentioned procedures have proven to be completely accurate and none are routinely performed by all eye care professionals.

The National Eye Institute is supporting research studies to help scientists better answer the following questions:

- Who is likely to get glaucoma?
- When should people who show increased eye pressure (elevated fluid pressure within the eye) be treated?
- Which treatment is the best one when glaucoma is first diagnosed?

Data

Several population-based studies have estimated the number of people with glaucoma in the United States.[4,6,7,9,10,11,12,13] More recently, the Eye Diseases Prevalence Research Group estimated the prevalence of open-angle glaucoma in Americans aged 40 and older to be 1.86 percent[6] (see table 6-1). This estimate is based on combined data from several population-based studies that used a standard definition and a clinical exam to diagnose the presence of open-angle glaucoma.

Table 6-1: Estimated prevalence of open-angle glaucoma in the United States in persons 40 years and older by gender and race/ethnicity.

	U.S. population aged 40 and older (millions)	Prevalence of glaucoma per 100 persons
Total	**119.4**	**1.86***
Women	63.7	2.19
Men	55.7	1.48
Non-Hispanic White	92.8	1.69
Non-Hispanic Black	11.8	3.37
Hispanic	8.9	1.50

*Estimates for prevalence of open-angle glaucoma in the total U.S. population are based on Census 2000 population estimates and include estimates for other races (Asian, American Indian, Alaska Native, Native Hawaiian, other Pacific Islander, and any other race) and those designating more than one race on the Census 2000 form.

Source: Adapted from Table 4, Estimated Prevalence of Glaucoma in the United States by Age, Gender, and Race. The Eye Diseases Prevalence Research Group. Prevalence of open-angle glaucoma among adults in the United States. *Arch Ophthalmol* 2004 Apr;122(4):532-8, p. 536.

Applied to population figures from the 2000 Census, the prevalence rate of 1.86 percent suggests that about 2.22 million people in the United States have glaucoma. By 2020, researchers estimate this number will grow to more than 3 million.[4,6] Recent studies confirmed that the rate of glaucoma increases with age, and that African Americans have higher rates of the disease than Whites or Hispanics/Latinos. African Americans are almost three times as likely to develop visual impairment due to glaucoma than other racial/ethnic groups[6] (see table 6-1).

Results from the Los Angeles Latino Eye Study, which was designed to estimate age- and gender-specific prevalence of open-angle glaucoma in adult Latinos, suggest that the prevalence of open-angle glaucoma is high among Latinos of Mexican ancestry. Results also reveal an absence of gender-related differences, but did find that older Latinos have a higher prevalence of open-angle glaucoma than younger Latinos.[7]

The prevalence of glaucoma is also high for Alaska Natives (Eskimos/Inuits). The prevalence of closed-angle, or acute, glaucoma has been reported to be as high as 8 percent among Alaska Natives, compared to 0.1 percent among Whites. The reasons for this elevated prevalence have not yet been fully understood or explained, but some researchers believe that genetic predisposition to a shallow anterior chamber of the eye (the space behind the cornea and in front of the iris) causes higher incidence of glaucoma for Alaska Natives.[12,13,14] Among Asians, the prevalence of closed-angle glaucoma is intermediate between Whites and Alaska Natives.[12]

Researchers found no major statistical differences between the sexes, although a recent study found that African American and Hispanic/Latino women had somewhat higher rates of glaucoma than their male counterparts. However, these differences were not statistically significant.[6]

Healthy Vision 2010 Baseline Data. The 2002 National Health Interview Survey estimates that 13.5 adults per 1,000 aged 45 and older are visually impaired due to glaucoma (see table 6-2). This estimate is based on those persons who self-reported having glaucoma and having trouble seeing even with corrective lenses. The target for Healthy People 2010 is to reduce the prevalence of visual impairment due to glaucoma by 20.7 percent, from 13.5 to 10.7 per 1,000 adults by the year 2010.

Table 6-2: Visual impairment due to glaucoma in adults 45 years and older by race/ethnicity, gender, education level, and diabetes status, 2002.

Adults 45 years and older	Visual impairment due to glaucoma Rate per 1,000
Total	13.5
Race and ethnicity	
American Indian or Alaska Native only	DSU
Asian or Pacific Islander only	DNA
Asian only	DSU
Native Hawaiian or Other Pacific Islander only	DSU
Black or African American only	38.0
White only	10.9
2 or more races	DSU
American Indian or Alaska Native; White	DSU
Black or African American; White	DSU
Hispanic or Latino	13.5
Non Hispanic or Latino	13.6
Black or African American only, not Hisp/Latino	38.4
White only, not Hispanic or Latino	10.8
Gender	
Female	15.3
Male	11.2
Education level (person 25 years and over)	
Under 12 years	21.4
12 years	11.2
13 years and over	11.8
Diabetes status	
Persons with diabetes (within the past year: 55.0%)	29.1
Persons without diabetes (within the past year: 37.0%)	10.8

DNA: Data have not been analyzed.

DSU: Data do not meet the criteria for statistical reliability, data quality, or confidentiality.

Source: 2002 National Health Interview Survey, National Center for Health Statistics, Centers for Disease Control and Prevention.

As shown in table 6-2, women are somewhat more likely than men to develop visual impairment as a result of glaucoma. African Americans are substantially more likely to be visually impaired from glaucoma when compared to other racial/ethnic groups. Baseline data also indicate that persons with diabetes have higher rates of visual impairment due to glaucoma.

Treatment

All current therapies for glaucoma focus on reducing eye pressure. Glaucoma treatments include medicines, laser trabeculoplasty, conventional surgery, or a combination of any of these. While these treatments may save remaining vision, they do not restore sight already lost to glaucoma.

In recent years, several clinical trials have clearly demonstrated the effectiveness of lowering eye pressure. The Collaborative Initial Glaucoma Treatment Study has shown that both medical and surgical treatments to lower eye pressure do effectively slow visual field loss.[15] Treatments to lower eye pressure also help to limit the effect glaucoma has on reducing one's quality of life.[16] The Early Manifest Glaucoma Trial found that reducing the eye pressure of people in the early stages of glaucoma may delay the progression of the disease.[17] The Ocular Hypertension Treatment Study found that treatment to lower eye pressure might delay and perhaps prevent the development of glaucoma in people who have only increased eye pressure as a symptom.[18]

Medications are often the first treatment option for glaucoma. Many medications, in the form of eye drops or pills, effectively lower eye pressure. These medications reduce the amount of aqueous humor or improve its drainage.

Laser treatment has been shown to also be effective as medication for the initial treatment of glaucoma.[19] In this procedure, a laser makes evenly spaced burns that stretch the drainage holes so that the aqueous humor can drain more efficiently.

When medication and/or laser surgery do not lower eye pressure, eye care professionals will often perform conventional surgery. A surgical procedure called filtering surgery makes a new drainage path. Drainage implant surgery is often prescribed for patients whose filtering surgery has failed. In the drainage implant surgery, an eye care professional inserts a small tube that drains the aqueous humor.

Researchers have identified a potential tool to examine the role of different cells on the drainage path, opening the way for possible glaucoma gene therapy in the future.[20]

Issues

Public Awareness

Two million people with glaucoma are unaware they have the disease.[1,2,4] In fact, many people do not know what glaucoma is.[21] Some studies have shown that older adults have heard of glaucoma, but many do not know much about the disease.[22] Some groups that are predisposed to the disease seem least likely to be familiar with it, including African Americans, Hispanics/Latinos, and those persons who have not obtained education beyond high school.[22]

Screening and Examination

Screening for glaucoma in at-risk populations has taken place for decades. For many years, eye care professionals used tonometry as a screening test for glaucoma, but scientists later found it was a poor predictor of the disease.[23,24] Tonometry will miss about half of all patients with glaucoma because they will not have increased eye pressure at the time of the test.[22]

According to the National Eye Institute, tonometry by itself is not sufficient for an accurate diagnosis of glaucoma because of individual variations in what constitutes "normal" pressure. Getting regular comprehensive dilated eye examinations is the best strategy for detecting glaucoma. The National Eye Institute recommends that people at risk for glaucoma should have a comprehensive dilated eye exam at least once every 2 years. The comprehensive dilated eye exam allows the eye care professional to inspect the retina (the light-sensitive tissue at the back of the eye) and optic nerve. (For more detail, see Chapter 1: Dilated Eye Exams.) An eye care professional may also take a picture of the inside of the eye to record how the optic nerve looks. Ophthalmoscopy and fundus photography are two common procedures eye care professionals use to identify optic nerve damage.

Access to Care

In 2002, the Centers for Medicare & Medicaid Services began providing an annual dilated eye exam for people with Medicare who were at higher risk for eye diseases, including glaucoma. Medicare covers annual glaucoma screening for the following persons considered to be at high risk for this disease:

- People with diabetes
- African Americans aged 50 and older

- Hispanics aged 65 and older
- Those with a family history of glaucoma.

Patient Compliance

For most people with glaucoma, controlling the disease requires the consistent use of eye-drop medications that reduce eye pressure in order to delay the onset of glaucoma. Managing glaucoma, like most illnesses, requires compliance with prescribed treatment plans and adherence to medication schedules. Patient compliance with glaucoma treatment is a common problem in managing the disease.[25,26] Failure to comply with treatment contributes to the progression of vision loss in the patient.[27] Factors influencing compliance include the type of drug prescribed,[28] frequency of dosage,[29,30] inconvenience of dosing regimen,[30] affordability of medication,[29] and the need to take other medications.[29] The most common problem cited by patients is forgetfulness.[30,31] The problem may also be related to glaucoma patients, who often have a limited understanding of their disease.[32]

Patient education can improve understanding of glaucoma among people under treatment for the disease.[32] Helping people to comply with their glaucoma medication schedule is an important and essential goal of glaucoma patient education.[33] Researchers recommend clear communication among patients, eye care professionals,[30] nurses,[34] and pharmacists[35] as a step toward encouraging adherence to treatment and prevention of further vision loss.

Conclusions

Glaucoma can result in complete vision loss, often without noticeable symptoms. Of the estimated 2.2 million Americans who have glaucoma, many fail to receive treatment because they are unaware of the presence of the disease. A comprehensive eye examination through dilated pupils is the best way to detect glaucoma.

A major message of glaucoma awareness should be that the disease has no symptoms, since many Americans visit health care professionals only after physical symptoms are observed. To help reduce the risk of vision loss from glaucoma, people must seek examinations to test for glaucoma before they begin to lose their vision, as this symptom indicates an advanced stage of the disease. Public education should promote getting regular comprehensive dilated eye examinations, especially for populations at higher risk, and should endeavor to increase awareness of glaucoma.

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Chapter 7

Cataract

Objective 28-7

Reduce visual impairment due to cataract.

Overview

Cataract is a clouding of the naturally clear lens of the eye and is the leading cause of treatable blindness in the world.[1,2,3] A cataract can occur in one or both eyes. It cannot spread from one eye to the other.

The lens is near the front of the eye, just behind the iris, which is the colored part of the eye (see figure 7-1). Light enters the eye and passes through the lens. The lens focuses light to produce a clear image on the retina, light-sensitive tissue at the back of the eye. The lens constantly changes focus, adjusting to the light that passes through it, allowing a clear view of near or distant objects. Normally, the lens of the eye comprises a variety of proteins carefully arranged to be clear and flexible. However, eye disease, injury, or the normal aging process can often cause a loss of lens transparency, making it opaque. When the lens becomes opaque and interferes with vision, this condition is called a cataract.

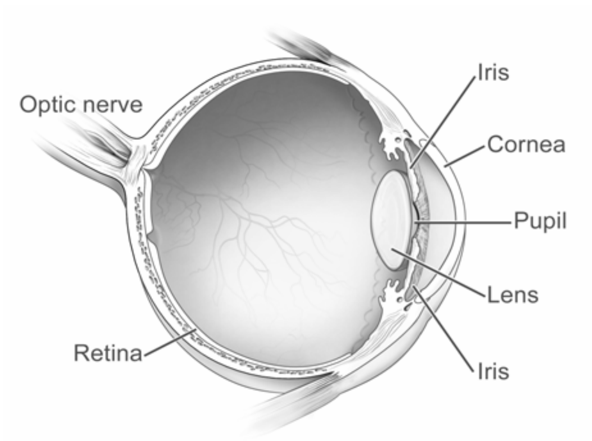

Figure 7-1: A cross-sectional diagram of the eye.

An estimated 20.5 million (17.2%) Americans aged 40 and older have cataract in either eye. By 2020, the estimated number of people with cataract is expected to rise to more than 30 million.[1] While cataract can affect people of all ages, the disease most often affects older adults.

There are three major types of cataract. Nuclear cataract, which is the most common type, appears in the innermost portion of the lens. Cortical cataract develops in the middle layers of the lens, known as the cortex. Posterior subcapsular cataract appears near the surface of the backside of the lens. It is possible for more than one type of cataract to appear in the same lens.

Modifiable risk factors associated with the development of age-related cataract are as follows:[4,5]

- Exposure to ultraviolet light from the sun and other sources[6,7]
- Lifestyle factors such as smoking,[8,9,10] alcohol consumption,[11] and obesity[12]
- Medical issues including diabetes[12] and corticosteroid use[13,14]
- Family history of cataract.[15,16]

A cataract often grows slowly and may be unnoticeable at first. Usual symptoms of cataract include cloudy or blurred vision, reduced night vision, impaired depth perception, dulled color perception, problems with reading, and frequent eyeglass prescription changes.

Many people with cataract complain of haze or glare, especially under bright lights. They may experience blur that cannot be improved with refractive correction. Eventually, vision becomes completely obscured in the area covered by the cataract.

Like all visual impairments, cataract can have adverse effects on the quality of life. People with cataract report increased problems with the activities of daily living, employment, and recreational activities. Older drivers with cataract are more likely to restrict their driving habits and are 2.5 times more likely to have been the cause of an auto accident within the past 5 years.[17] Cataract surgery may, however, reduce subsequent auto accidents for older adults.[18]

Detection

The detection of cataract requires a thorough evaluation as part of a comprehensive dilated eye examination (see figure 7-2).

Figure 7-2: An eye care professional uses a slit-lamp biomicroscope to view the inside of the eye during a comprehensive dilated eye exam.

Dilating the eye for a comprehensive exam involves placing drops on the eye that allow the pupil to dilate, or widen. The pupil (the round opening in the center of the iris) then opens widely, allowing the eye care professional a better view of the inside of the eye.

When an eye care professional suspects the presence of cataract, additional tests may be administered. Tests such as glare acuity[19,20] and contrast sensitivity[21,22] measure aspects of visual function that cannot be measured by traditional eye charts and that reflect areas often impaired by cataract.

Data

Several population-based studies have evaluated the prevalence of cataract in various populations.[23,24,25,26,27,28,29] The most recent estimates provided by the Eye Diseases Prevalence Research Group (2004), indicate that 17.2 percent of Americans aged 40 and older have cataract in one or both eyes[1] (see table 7-1). Based on U.S. Census estimates for the population in 2020, the number of persons with cataract will rise from 20.5 million in 2000 to 30.1 million, an increase of 50 percent. This increase is largely due to the aging population and increased life expectancy.

Table 7-1: Estimated prevalence of cataract in the United States in persons 40 years and older by gender and race/ethnicity.

	U.S. population aged 40 and older (millions)	Prevalence of cataract per 100 persons
Total	**119.4**	**17.2***
Women	63.7	20.0
Men	55.7	13.9
Non-Hispanic White	92.8	18.5
Non-Hispanic Black	11.8	12.2

*Estimates for prevalence of cataract in the total U.S. population are based on Census 2000 population estimates and include estimates for Hispanic persons and other races (Asian, American Indian, Alaska Native, Native Hawaiian, other Pacific Islander, and any other race/ethnicity) and those designating more than one race on the 2000 U.S. Census form.

Source: Adapted from Table 4, Estimated Prevalence of Cataract in the United States by Age, Gender, and Race/Ethnicity. The Eye Diseases Prevalence Research Group. Prevalence of cataract and pseudophakia/aphakia among adults in the United States. *Arch Ophthalmol* 2004 Apr;122(4):487-94, p. 491.

These study data also reveal that women are more likely to have cataract than men. The age-adjusted prevalence of cataract did not differ between African Americans and Whites for women, but the rate among men was significantly higher for Whites than African Americans.

Results of the Los Angeles Latino Eye Study (LALES) of ocular disease in Latinos 40 years and older, primarily of Mexican ancestry, reveal that there was a significantly higher prevalence of all lens changes in this population, and any type of lens opacity in older Latinos. Although only 3 percent of Latinos in their 40s had all lens changes, the prevalence increased to more than 80 percent in Latinos aged 80 and older. Mixed opacities, followed by nuclear opacities, were most likely to be associated with visual impairment among Latinos in the LALES. Nuclear opacities were more prevalent in females.[28]

Although cataract is more commonly viewed as an age-related eye disease, it may also cause visual impairment in infants. Researchers recently estimated the prevalence of infantile cataract to be 3.0 to 4.5 per 10,000 births.[29]

Healthy Vision 2010 Baseline Data. According to the 2002 National Health Interview Survey, nearly 119 Americans per 1,000 aged 65 years and older have a visual impairment due to cataract (see table 7-2). The target for Healthy People 2010 is to reduce the prevalence of visual impairment due to cataract in adults 65 years and older by 23.5 percent, to 91.4 per 1,000 by 2010.

Table 7-2: Visual impairment due to cataract in adults 65 years and older by race/ethnicity, gender, education level, and diabetes status, 2002.

Adults 65 years and older	Visual Impairment Due to Cataract Rate per 1,000
Total	118.8
Race and ethnicity	
American Indian or Alaska Native only	DSU
Asian or Pacific Islander only	DNA
Asian only	DSU
Native Hawaiian or Other Pacific Islander only	DSU
Black or African American only	126.7
White only	120.3
2 or more races	DSU
American Indian or Alaska Native; White	DSU
Black or African American; White	DSU
Hispanic or Latino	91.5
Non Hispanic or Latino	120.7
Black or African American only, not Hisp/Latino	127.2
White only, not Hispanic or Latino	122.2
Gender	
Female	130.9
Male	102.2
Education level (persons 25 years and over)	
Under 12 years	147.2
12 years	103.1
13 years and over	114.0
Diabetes status	
Persons with diabetes	181.9
Persons without diabetes	106.8

DNA: Data have not been analyzed.

DSU: Data do not meet the criteria for statistical reliability, data quality, or confidentiality.

Source: 2002 National Health Interview Survey, National Center for Health Statistics, Centers for Disease Control and Prevention.

As shown in table 7-2, people aged 65 and older with diabetes are substantially more likely to have visual impairment due to cataract than those without diabetes. While data are not available for all racial/ethnic groups, Hispanics/Latinos aged 65 and older are less likely to be visually impaired from cataract, while African Americans aged 65 years and older are somewhat more likely to be visually impaired from cataract when compared to other racial/ethnic groups in this age range. People with less than a high school level of education have higher rates of visual impairment due to cataract than do people who graduated high school.

Treatment

Cataract surgery is very common in the United States. There are two types of cataract surgery:

- Phacoemulsification or phaco. For this surgery, a small incision is made on the side of the cornea—the clear, dome-shaped surface that covers the front of the eye. The eye care professional will insert a tiny probe into the eye. This device emits ultrasound waves that soften and break up the lens so that it can be removed by suction. Most cataract surgery today is done by phacoemulsification, also called "small incision cataract surgery."
- Extracapsular surgery. For this surgery, a longer incision is made on the side of the cornea and the cloudy core of the lens is removed in one piece. The rest of the lens is removed by suction. The lens capsule is left intact.

After the natural lens is removed by phacoemulsification or extracapsular surgery, it is often replaced by an artificial lens, called an intraocular lens (IOL). This lens is clear plastic that requires no care and becomes a permanent part of the eye. Light is focused clearly by the IOL onto the retina, improving the patient's vision. Some people cannot have an IOL because of another eye disease or problem during surgery. For these patients, a soft contact lens, or glasses may be suggested.[3]

A 2003 study of the effect of cataract surgery examined self-reported visual difficulties. The study results demonstrated that when surgery and no-surgery choices to cataract extraction were compared, the Activities of Daily Vision Scale (ADVS) and tests for visual acuity, contrast sensitivity, and disability glare improved from baseline to one-year post surgery. The study showed that at baseline, patients who elected to have surgery reported having more difficulty in visual tasks than those who did not elect to have surgery. At post-surgery, the treatment group showed improvements in ADVS scores and reported less difficulty with visual tasks. They also reported an improvement in visual acuity and contrast sensitivity, as well as a reduction in disability glare. The no-surgery group reported no change or worsening at the 1-year followup.[30]

Technological advances have greatly changed the experience of cataract surgery for the patient. The surgical treatment for cataract is now faster, more effective, and more comfortable. Cataract extraction is an elective procedure. The timing of cataract surgery is largely a matter of patient choice in consultation with the eye care professional. Patients should consider the risks and benefits of the surgery. The decision to decline or postpone the surgery is valid and this will not usually affect the final outcome. Most patients go home a couple of hours after surgery and resume their normal activities in a matter of days.

Issues

Prevention of Cataract

Few preventive measures for cataract are known. Pharmaceutical therapies that prevent cataract have been investigated, but have had limited success to date.[31] Researchers believe, however, that even a modest delay in the onset of age-related cataract would be worthwhile. Reducing exposure to modifiable risk factors for cataract may help to reduce the prevalence of the condition.

Research has demonstrated that former smokers have a reduced risk of cataract when compared to current smokers.[32] Smoking cessation has also been shown to reduce the risk of other serious eye diseases, including age-related macular degeneration and diabetic retinopathy.

Scientists are also looking into the potential effects of nutrition, including antioxidants (vitamins A, C, and E), polyunsaturated fat, and high amounts of protein in preventing the development of cataract.[2] In a 2003 study, smokers who used the dietary supplement beta-carotene appeared to reduce their risk for developing cataract by 25 percent.[33]

Studies show that exposure to bright sunlight may increase the risk of developing cataract. Sunglasses that block ultraviolet rays and broad-brimmed hats that shade the eyes are recommended by the American Optometric Association, the American Academy of Ophthalmology, and Prevent Blindness America. These measures can help reduce the risk of cataract.[2,3,34]

Public Awareness

Eye care professionals and educators believe that cataract education efforts should focus on getting people to avoid risk factors such as smoking and alcohol consumption, and should promote the use of ultraviolet-ray protection for outdoor activities. Messages about the availability of cataract treatment, Medicare's coverage of cataract surgery, and the high success rate of surgery in improving vision[35] may help to encourage those with cataract to seek care. Public awareness of the need for regular comprehensive dilated eye examinations is essential.[36]

Conclusions

Cataract is a leading cause of treatable vision loss in the United States.[1] It is sometimes overlooked as a public health issue because of the wide availability of effective surgical treatment in the United States. At the same time, no known medical treatment prevents cataract. Managing risk factors may help reduce the prevalence of vision loss from the disease. Public education and screening efforts to promote regular comprehensive dilated eye exams and emphasize the availability and high success rate of cataract treatment may encourage people to seek care.

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Chapter 8

Occupational Eye Injury

Objective 28-8

Reduce occupational eye injury.

a. Reduce occupational eye injuries resulting in lost work days.

b. Reduce occupational eye injuries treated in emergency departments.

Overview

Each day more than 2,000 American workers receive some form of medical treatment because of eye injuries sustained at work.[1] In 2000, emergency rooms at U.S. hospitals treated nearly 300,000 eye injuries that occurred on the job.[2] The Bureau of Labor Statistics (BLS), part of the U.S. Department of Labor, estimates that in 2004, about 37,000 occupational eye injuries resulted in 1 or more days away from work. The majority (74%) of these eye injuries occurred in workers less than 45 years of age.[3]

Types of Occupational Eye Injury

Workers in construction, manufacturing, natural resources, and mining have the highest rates of eye injuries involving days away from work.[3]

American workers are exposed daily to a variety of potential eye hazards.

- Scrap materials, waste, and windblown dust*:* Flying material particles such as grit, plastic bits, or metal flakes can fly into your eye, causing irritation or a scratch on the cornea.
- Impact*:* Falling or misdirected objects, or collisions with objects swinging from a fixed position, like tree limbs, ropes, chains, lumber, or tools can damage eyes.
- Chemicals: Hazardous chemicals splash into the eyes, damaging them.
- Welding light: Ultraviolet light from welding torches can cause radiation burns to eyes and surrounding tissue of welders, helpers, and bystanders.

- Infections: Fertilizers, waste, body fluids, human remains, and bacteria can cause eye infections.
- Eyestrain: Glare, poor lighting, and inadequate rest can cause eye fatigue, soreness, and headaches.

Data

Healthy People 2010 Baseline Data. Data on the prevalence of occupational eye injuries have been collected from two sources:

- National Electronic Injury Surveillance System (NEISS), National Institute for Occupational Safety and Health (NIOSH) of the Centers for Disease Control and Prevention. NIOSH collects data on the number of eye injuries treated in emergency departments through the NEISS in collaboration with the U.S. Consumer Product Safety Commission.
- Annual Survey of Occupational Injuries and Illnesses (ASOII), U.S. Department of Labor, Bureau of Labor Statistics. This survey provides data on the number of occupational eye injuries that result in lost work days.

In 2003, 4.8 per 10,000 full-time workers in private industry lost workdays resulting from eye injuries sustained on the job. The Healthy People 2010 occupational eye injury target proposes reducing the rate of eye injuries resulting in lost work days by 29.2 percent, to 3.4 per 10,000 full-time workers by 2010.

Also in 2000, on average, 21 per 10,000 full-time workers were treated in hospital emergency departments for occupational eye injuries. Eye injury rates sustained by women and men differ, with nearly 9 per 10,000 full-time female workers sustaining eye injuries on the job, and 30 per 10,000 full-time male workers undergoing occupational eye injuries requiring emergency room treatment (see table 8-1). The Healthy People 2010 occupational eye injury target is reducing the rate of occupational eye injuries treated in emergency departments by 30 percent, to 14.7 per 10,000 full-time workers.

Table 8-1: **Occupational eye injuries treated in emergency departments, 2000.**

Occupational eye injuries treated in emergency departments	Per 10,000 full-time workers
Total	**21.0**
Gender	
Female	8.9
Male	30.0

Source: National Electronic Injury Surveillance System, U.S. Consumer Product Safety Commission, National Institute for Occupational Safety and Health.

Reported prevalence data vary widely according to the source. A problem central to accurate and consistent prevalence and incidence data for occupational eye injuries involves differing methodologies and definition criteria of eye injury, which make it difficult to compare prevalence and incidence rates among eye injury studies and data.[4] The variable definition of "recordable injury" is not uniform across data sources. Another factor affecting accurate incidence data is that many eye injuries go unrecorded and undocumented.

In addition to NEISS and ASOII, the United States Eye Injury Registry (USEIR) collects information from ophthalmologists on a voluntary basis. The USEIR data sources, however, are limited in scope, do not reflect the total incidences of worksite eye injuries, and cannot be extrapolated as a basis for prevalence data. The data collected from these sources may also not reflect treatment provided by other eye care and health care professionals.

National Institute for Occupational Safety and Health

NIOSH collects information on work-related injuries and illnesses treated in emergency departments through the National Electronic Injury Surveillance System, based on a national probability sample of hospitals in the United States and its territories. Patient and incident data are collected from each NEISS hospital for every work-related emergency visit without restriction by type of industry, employment category, or other occupational factors. In 2000, the most recent year figures are available, nearly 300,000 people were treated at U.S. hospital emergency rooms for occupation-related eye injuries.

U.S. Department of Labor, Bureau of Labor Statistics

The BLS conducts the Annual Survey of Occupational Injuries and Illnesses. This survey provides workplace injury information reported by industries. In 2004, the survey documented 36,680 eye injuries that occurred in the workplace that resulted in

1 or more days away from work. Eye injuries represented about 3 percent of the total number of injuries that year, which topped 1.2 million. Contact with objects and/or equipment caused more than 26,000 eye injuries. Exposure to harmful substances or environments caused nearly 9,000 eye injuries.[3]

The United States Eye Injury Registry

The USEIR collects voluntary information from ophthalmologists in participating states. Not all serious eye injuries are captured, and caution must be used in extrapolating these large case-series results to the Nation as a whole. The data collected from these sources may also not reflect treatment provided by eye care professionals in private practice, nurses, physician's assistants, primary care clinics, remote rural health centers, or community health centers in urban, underserved areas. Nevertheless, the registry documents more than 10,000 seriously injured eyes and helps to determine strategies for the prevention, treatment, and rehabilitation of eye injury. In a 1998 limited-case series, the USEIR reported that of nearly 9,000 people treated for very serious eye injuries, more than 20 percent sustained work-related injuries. About 96 percent of those injured at work were male, and workers in the construction industry sustained the most eye injuries. The majority of severe injuries to the eye were sustained by workers who were not wearing eye protection.[5]

Special Populations

In 2004, about 2,500 African Americans and 6,000 Hispanics/Latinos sustained eye injuries that occurred in the workplace that resulted in 1 or more days away from work.[3] However, among minority and racial/ethnic populations, the prevalence of work-related eye injuries is difficult to estimate, as complete data are not available.

A number of smaller studies looked at eye injury rates in particular sectors of the economy and within particular population groups. Autoworkers sustained as much as 18 percent of all occupational eye injuries, according to 1998 research on injuries among members of United Auto Workers at the Chrysler Corporation. Only one-quarter of the workers had been using some form of eye protection at the time of injury, and nearly one-third of resulting injuries prevented workers from resuming their normal duties for at least 1 day.[6] Among people over age 75, researchers found a "late peak" in the incidence of eye injury. Researchers speculate that this peak is related to the higher risk of injury in older adults.[7,8]

Protective Eyewear

Simple improvements in workplace conditions and the use of the proper safety eyewear can greatly reduce the number of eye injuries. In occupational settings, protective eyewear primarily includes safety glasses, safety goggles, face shields, welding helmets, and full-face respirators. Wearing the right protective eyewear for the job can protect employees from dust, debris, and scrap materials; impact; hazardous chemicals; and welding light.

Safety glasses are designed to withstand impact from common workplace hazards and to provide the minimum level of protection required in the workplace.

Safety goggles are stronger than safety glasses and are used for protection from high impacts, particles, chemical splashes, and welding light.

Face shields are used for higher impact tasks and protect the wearer's face and eyes from hazards such as critical chemicals and blood-borne materials.

Welding helmets protect the user from the intensity of welding light, which can cause severe burns to the eye and surrounding tissue. Different welding tasks require filter lenses with appropriate protective shade numbers.

Safety glasses or goggles should be worn under face shields and welding helmets. For those workers who do wear eye protection, many may wear the wrong kind of protective device for the task being performed.[9]

The most popular safety lens is the clear polycarbonate lens, accounting for more than 85 percent of all safety spectacles sold. This lens provides maximum visual acuity and color recognition. This polycarbonate safety lens is also capable of filtering out more than 99.9 percent of hazardous ultraviolet light. Its most common use is for general eye protection from impact in manufacturing, construction, and mining. Clear lenses are available in safety spectacles, goggles, and face shields.

Other specially colored or tinted lenses are appropriate for protection in certain environmental conditions.[10] These lenses may provide either a safety or visual improvement function. Safety functions include protection from hazardous optical radiation, and visual improvement includes reduction of glare, elimination of annoying light, enhancement of view of work environment, and provision of comfort.

Prescriptive Eyewear

Standard prescriptive eyeglasses do not provide adequate eye protection, but having sharp vision is important to preventing occupational eye injuries. Getting a comprehensive dilated eye examination can help identify vision problems that can interfere with your safety, so they can be corrected.

For some time, contact lenses have been routinely banned in industrial workplaces where hazards from chemicals, optical radiation, and particles have existed. However, researchers no longer believe these blanket restrictions on wearing contact lenses are necessary. The American Optometric Association[11], Prevent Blindness America, the American Chemical Society, and other groups have released new guidelines permitting contact lens use in industrial environments.[12] The Occupational Safety and Health Administration (OSHA) stated in a final ruling of the 29 Code of Federal Regulations (CFR) Part 1910 that contact lenses do not pose additional hazards to the wearer. However, contact lenses are not eye protective devices and if eye hazards are present, appropriate eye protection must be worn instead of, or in conjunction with, contact lenses.[13]

If an eye injury occurs, first-aid treatment for contact lens wearers should never be delayed while attempting to remove the lens.[12] Employers should also establish policies concerning the use of contact lenses, taking into account existing hazards and the visual requirements of the employee.

Regulatory Agencies

Occupational Safety and Health Administration

The basic requirements for eye protection in the workplace are set by the Occupational Safety and Health Administration, part of the U.S. Department of Labor, in the Code of Federal Regulations. Section 29 CFR 1910.133(a)(1)–(5) states the following:

- The employer shall ensure that each affected employee uses appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation.
- The employer shall ensure that each affected employee uses eye protection that provides side protection when there is a hazard from flying objects. Detachable side protectors (e.g., clip-on or slide-on side shields) meeting the pertinent requirements of this section are acceptable.

- The employer shall ensure that each affected employee who wears prescription lenses while engaged in operations that involve eye hazards wears eye protection that incorporates the prescription in its design, or wears eye protection that can be worn over the prescription lenses without disturbing the proper position of the prescription lenses or the protective lenses.
- Eye and face personal protective eyewear shall be distinctly marked to facilitate identification of the manufacturer.
- The employer shall ensure that each affected employee uses equipment with filter lenses that have a shade number appropriate for the work being performed for protection from injurious light radiation.[14]

American National Standards Institute

The American National Standards Institute (ANSI) administers and coordinates the U.S. voluntary standardization and conformity assessment system. ANSI also sets voluntary standards for the functionality of protective eye equipment. In 2003, ANSI adopted new basic-impact and high-impact lens performance standards. In order to conform to the new ANSI lens standards, manufacturers will need to either retest or develop new protective eyewear, safety professionals will need to reexamine job tasks and reassess employees' needs, and workers will need to determine whether the basic-impact or high-impact protective wear is suited to the task they are scheduled to perform.[15]

Issues

Eye Injury in Industry

Eye injuries occur in all industries, but workers in construction, manufacturing, mining, and agricultural have the highest rates of eye injuries on the job.[4]

Construction

In a 2001 study of construction workers treated in urban emergency departments over 8 years, researchers found that employers frequently required eye protection for all tasks or high-risk tasks. While many workers reported wearing eye protection regularly, most did not wear eye protection with top and side shields. Research suggests that increased use of goggles or full shields may have prevented two-thirds of the injuries reported.[16]

Of the more than 3,300 construction worker injuries reviewed in the study, 11 percent were eye injuries that had been treated. Welders, plumbers, insulators, painters/glaziers, supervisors, and electricians had the highest proportion of injuries. Nearly half of the diagnoses were abrasions, followed by foreign objects or splashes in the eye, conjunctivitis, and burns.[16]

In a review of compensation claims for construction workers in Washington state for a 6-year period, researchers found that eye injuries were responsible for 12 percent of all claims, exceeded only by back and finger injuries. Many medical and paid lost-time costs relating to eye injuries were associated with injuries sustained while hammering.[16]

Welders and bystanders watching welding tasks being performed are at the highest risk for eye injury. The U.S. Consumer Product Safety Commission estimated that 10,800 non-work-related eye injuries related to welding are treated each year in hospital emergency rooms. Most types of welding give off radiation that can burn the eye, and bystanders are often among those injured. Eye injuries from welding do not require much more than a second to occur.[17]

Agriculture

Farmworkers face a number of eye hazards. Compounding the problem is that emergency medical care is often not readily accessible. Serious eye injuries for the farm worker can negatively impact his or her livelihood.

In the mid-1990s, farm-related eye injuries across five Midwestern states accounted for 8.2 percent of all farm injuries.[18] Researchers found that, nationally, 17,895 farm workers lost work time due to eye injuries.[19] In 1995, a survey placed the number of eye injuries per 1,000 farm household members at 8.1, or 10 percent of all agricultural injuries in Minnesota in the early 1990s. Most farm workers in the survey did not wear eye protection. Of those who worked with extremely hazardous liquid fertilizer under pressure, 35 percent said they either never or only occasionally wore goggles, and 44 percent said they never or only occasionally checked the water supply in their field emergency water tank, a standard safety precaution.[20]

One of the major eye risks on farms is handling pesticides and herbicides. The U.S. Environmental Protection Agency requires farm operators to adopt preventive measures when workers handle pesticides, including providing personal protective equipment to be used as indicated on pesticide labels, and providing an emergency water supply.[20]

Military

With the exposure of the face in combat and the susceptibility of the eye to small particles and fragments, the incidence of eye injuries has increased with each succeeding war compared to injuries sustained by other body parts.[21] In World Wars I and II, eye injuries were estimated to be 2 percent of all battle casualties. The percentage of military personnel who suffered eye injuries increased 2.8–4.1 percent in the Korean conflict, 5–9 percent in Vietnam, and 13 percent in Desert Shield and Desert Storm.[21,22,23]

A longitudinal study was conducted to assess ground (nonaviation) eye injuries sustained in the Army, Navy, and Air Force for 11 years (FY 1988 through FY 1998). The data show that the average military employee who sustained an eye injury was not wearing eye protection when injured. The authors recommended protective vision conservation education to reduce the number and cost of injuries. Persons who sustain eye injury when not wearing eye protection lose, on average, more days of work at a higher cost than those who wear eye protection.[24]

Primary prevention of injury to military personnel through the use of polycarbonate protective eyewear could have prevented many wartime ocular injuries.[25,26] However, few soldiers used the provided eye armor. Reasons for noncompliance included environmental conditions such as deployment or nondeployment activities, organizational attitudes toward eye protection programs, community influence, soldiers' knowledge and perceptions of such injuries, and belief in the efficacy of eye armor.[23]

Chemical Exposure and Burns

Chemical injuries to the eye occur frequently and can cause a range of damage, from mild irritation to loss of vision, and sometimes loss of the eye. Damage can be caused by solid, liquid, powder, or aerosol chemicals.

For chemical burns, prevention is key and, in the workplace, is primarily the responsibility of employers. Prevention strategies include providing adequate eye washes and shower stations where chemicals are used, providing adequate protective eye equipment to prevent splash injuries, posting emergency instructions and contact information for poison centers, coordinating safe and proper chemical storage, and providing worker training on proper eye irrigation. Irrigation of the eye at the site of the injury offers the greatest opportunity to reduce eye damage from surface exposure to chemicals.[27]

Effectiveness of Eye Protection

Few studies have evaluated the effectiveness of interventions designed to prevent work-related eye injuries. However, researchers recently reviewed the effectiveness of eye protection and environmental controls in the workplace, as well as behavioral interventions aimed at increasing usage of eye protection.[28] Researchers reviewed seven individual studies, one of which reported a 75 percent reduction in injuries requiring medical attention and a 230 percent reduction in disabling eye injuries 4 years after the initiation of a prevention program. Researchers found that policy changes, coupled with a broader program focused on eye safety, might be effective in changing behaviors and reducing eye injuries in manufacturing settings.[28]

In one survey of 2,000 mechanical contractors, most employers reported that motivating employees to wear eye protection was their biggest challenge. Others reported successes from supplying comfortable, high-quality, stylish safety glasses that included such features as antifog coatings and shaded lenses. Nearly all contractors provided eye-protection training.[29]

A key prevention issue is whether the type of eye protection worn is adequate for the task performed. Although eye injuries are common work-related injuries, there is limited scientific literature about the effectiveness of preventive interventions, including the use of protective equipment and the education of workers.[28] To see whether prevention programs work, company-specific rates must be evaluated before and after implementation of eye injury prevention programs.[29]

Employer and Employee Education

Employers and employees should prepare for eye injuries. Eye safety should receive continuing attention in workplace educational programs regarding safe work practices and safety rules. Following are several steps both employers and employees can take to minimize potential eye hazards:

- Conduct a hazard assessment to identify potential eye hazards such as hanging or protruding objects.
- Remove eye hazards from the worksite.
- Provide the appropriate protective eyewear for your employees and require them to wear it.
- See an eye care professional for all eye injuries.

- Know basic eye injury first-aid.
- Wash out minor dust in the eye at the eyewash station.
- Flush chemical splashes immediately and continue while the injured worker is transported to medical help.
- Leave nails, wire, slivers, and other fragments in the eye alone and take the worker to an emergency department immediately.
- Seek medical treatment immediately for severe blows to the eye.

Conclusions

Employers and workers need to be aware of the risks to sight, particularly in high-risk industries such as construction, manufacturing, and mining. The combination of removing or minimizing eye safety hazards and the wearing of proper safety eye protection can prevent many eye injuries.

Prevention strategies may include the following:

- Conducting an eye hazard evaluation of the worksite.
- Removing eye hazards by using engineering controls, when possible.
- Requiring employers to have the appropriate safety eye protection at the worksite. Eye protection should be marked with ANSI Z87.
- Requiring workers to use safety eye protection at all times. Employers should also enforce its use.

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Chapter 9

Home and Recreational Eye Safety

Objective 28-9

Increase the use of appropriate personal protective eyewear.

a. **Increase the use of personal protective eyewear in recreational activities and hazardous situations around the home among children 6–17 years.**

b. **Increase the use of personal protective eyewear in recreational activities and hazardous situations around the home among adults 18 years and over.**

Overview

Nearly 2.5 million eye injuries occur each year in the United States. Eye injuries are a leading cause of visual impairment in one eye (monocular), and ranks second only to cataract as the most common cause of visual impairment overall.[1] Nearly half of all eye injuries occur at home, and more than one-quarter occur during sporting and recreational activities, or on streets and highways.

Between 40,000 and 60,000 patients are diagnosed with trauma-related visual impairment every year, and about 40 percent of all cases of monocular visual impairment are caused by trauma to the eye. Over a lifetime, about 1,400 of every 100,000 people sustain an eye injury.[2]

Eyewear protection is becoming increasingly available and is often mandatory in the workplace. Many safety experts now consider the home and places of recreational activity the second and third most dangerous environments in which eye injuries occur each year. Legislation mandating the use of safety equipment has helped reduce the incidence of eye injuries, especially in recreational activities, such as the use of fireworks. Eye injuries from motor vehicle accidents have also dropped dramatically following legislation requiring the use of seat belts and the development and implementation of airbags.[3]

Data

The magnitude of eye injuries is difficult to estimate nationally because of differing definitions of "home-related injury." Numerous reports demonstrate that eye trauma in the home accounts for as much as half of all eye injuries.[4] The U.S. Eye Injury Registry (USEIR) cites home injuries, sports-related eye injuries, and eye injuries occurring on streets and highways as being responsible for more than two-thirds of the eye injuries in its database.[5]

The USEIR collects voluntary information on severe eye injuries from ophthalmologists in more than 40 states, and the data include reports from the U.S. Military Eye Injury Registry. The USEIR does not reflect all serious eye injuries, and caution must be used in extrapolating or projecting these large-case series results to the entire Nation. Nevertheless, the registry documents more than 10,000 seriously injured eyes and helps to determine strategies for the prevention, treatment, and rehabilitation of eye injuries.

USEIR data show that blunt objects caused nearly one-third of reported injuries. The types of blunt objects that caused injuries are as follows, in decreasing order: rocks, fists, baseballs, lumber, and fishing weights. Sharp objects such as sticks, knives, scissors, and screwdrivers caused less than one-quarter of eye injuries. Motor vehicle accidents accounted for nearly one-tenth of all injuries to eyes. Gunshots, nails, air guns, fireworks, and falls followed in frequency of injury.

In terms of populations affected, African Americans suffer eye injuries at disproportionately higher rates than other groups. In a study in the early 1990s, researchers found high rates of eye trauma in an urban neighborhood of Baltimore. The study showed that African American men were three times more likely than White men to have visual impairment from eye trauma. Researchers noted that the medical consequences of eye injuries in African Americans were more severe than in others. Although the authors did not ascertain the reasons for the higher rates, followup reviews have noted socioeconomic status and exposure to violence as factors.[6]

Children and adolescents account for a disproportionate share of eye trauma. Non-penetrating eye injuries account for three-quarters of injuries to children's eyes.[7] These injuries occur in more than one-third of all children under the age of 15. Boys between 11 and 15 years old are most vulnerable; they are injured between three and five times more frequently than girls.

Researchers have reported that children aged 15 years and younger comprise more than one-third of all hospital admissions for eye injuries. Most of these injuries are related to sports and projectiles, including toys, guns, darts, sticks, stones, and air guns.[8]

The home has many dangers that often go unnoticed. Accidents involving common household products cause 125,000 eye injuries each year. Ninety percent of these eye injuries can be prevented through understanding safety practices and using proper eye protection.[9]

Healthy Vision 2010 Baseline Data. Estimates of the number of children (aged 6–17 years) and adults (18 years and older) who report using protective eyewear always or most of the time at home are available from the 2002 National Health Interview Survey (see tables 9-1 and 9-2, respectively). In 2002, 15 percent of children and 33 percent of adults reported wearing eye protection always or most of the time when participating in sports, hobbies, or other activities that can cause eye injuries. Activities include baseball, basketball, soccer, and lawn mowing.

The Healthy People 2010 target for increasing the use of protective eyewear in recreational activities and hazardous situations around the home in children, aged 6–17 years, is 20 percent. For adults aged 18 years and older, the target for 2010 is to increase protective eyewear use to 37 percent.

Table 9-1: Use of protective eyewear at home always or most of the time among children aged 6–17 years, 2002.

Use of protective eyewear at home	Children (6–17 years)
(Always or most of the time)	15%
Race and ethnicity	
American Indian or Alaska Native only	DSU
Asian or Pacific Islander only	DNA
Asian only	DSU
Native Hawaiian or Other Pacific Islander only	DSU
Black or African American only	13%
White only	15%
2 or more races	DSU
American Indian or Alaska Native; White	DSU
Black or African American; White	DSU
Hispanic or Latino	19%
Non Hispanic or Latino	14%
Black or African American only, not Hisp/Latino	13%
White only, not Hispanic or Latino	14%
Gender	
Female	11%
Male	17%
Family income level	
Poor	15%
Near poor	12%
Middle/high income	14%

DSU: Data do not meet the criteria for statistical reliability, data quality, or confidentiality.

DNA: Data have not been analyzed.

Source: National Health Interview Survey, National Center for Health Statistics, Centers for Disease Control and Prevention.

As shown in table 9-1, slightly more male than female children reported using protective eyewear in recreational activities and hazardous situations around the home.

Among adults 18 years and older, 33 percent said they used protective eyewear always or most of the time when participating in sports, hobbies, or other activities that can cause eye injuries. These activities include baseball, basketball, lawn mowing, woodworking, or working with chemicals. Adult males are more likely than adult females to report using protective eyewear at home (see table 9-2 on the following page).

Table 9-2: Use of protective eyewear at home always or most of the time among adults aged 18 years and older, 2002.

Use of protective eyewear at home	Adults (18 years and older)
(Always or most of the time)	33%
Race and ethnicity	
American Indian or Alaska Native only	DSU
Asian or Pacific Islander only	DNA
Asian only	25%
Native Hawaiian or Other Pacific Islander only	DSU
Black or African American only	30%
White only	34%
2 or more races	34%
American Indian or Alaska Native; White	33%
Black or African American; White	DSU
Hispanic or Latino	36%
Non Hispanic or Latino	33%
Black or African American only, not Hisp/Latino	29%
White only, not Hispanic or Latino	34%
Gender	
Female	26%
Male	36%
Education level	
Under 12 years	34%
12 years	36%
13 years and over	37%

DNA: Data have not been analyzed.

DSU: Data do not meet the criteria for statistical reliability, data quality, or confidentiality.

Source: National Health Interview Survey, National Center for Health Statistics, Centers for Disease Control and Prevention.

Issues

Consumer Product-Related Eye Injuries

According to a comprehensive study of consumer product-related eye injuries, more than 250,000 of these types of injuries were treated in U.S. hospital emergency rooms each year in the early 1990s.[10] In 2003, an estimated 216,690 product-related eye injuries were treated, with 115,782 being household related and 12,122 being sports or athletic equipment related.[11]

In 1991, a national probability sample survey determined that about 500 different products caused consumer product-related eye injuries. The leading cause was contact lenses (26,490 emergency room visits in 1991), followed by welding equipment, hair curlers or curling irons, and workshop power grinders. Baseball-related trauma accidents accounted for nearly 5,000 visits to emergency rooms, and less familiar causes of injuries such as bleaches and car batteries exceeded baseball- and basketball-related trauma. One-half of all injuries occurred in patients between the ages of 25 and 64.[10]

A discussion of various eye injury hazards is presented below.

Air Guns

It is estimated that more than 1,300 eye injuries related to air guns are seen per year in emergency departments in the United States.[12] Teenagers and children account for about 80 percent of all nonfatal air gun-related injuries. While most injuries were the result of unintentional shootings, at least 10 percent of them were from interpersonal or self-directed violence.[13] Injuries to the eye from air guns is often drastic, with many requiring removal of the eye.[12]

States began passing legislation regulating air-gun possession and use nearly 20 years ago. In 2000, 48 states had laws that restricted possession or use of air guns, and provision or sale to children.[14]

A study conducted in the mid-1990s compared children who had used but had not been injured by air guns, and children who were injured by air guns. The children who had been injured were 24 times more likely to have been without adult supervision when the injury occurred, 12 times more likely to have been at a friend's home rather than their own, and five times more likely to have been indoors. The researchers suggest that unsupervised access to air guns and their unstructured use are the primary risk factors for this type of eye injury.[12]

Paintball

Paintball has recently risen in popularity as a sport, and eye injuries associated with the use of paintball pellets is also rising in frequency. Blunt eye trauma caused by paint pellets can result in severe eye injuries and permanent vision loss.

Using the National Electronic Injury Surveillance System, a study was conducted to review non-fatal injury data for paintball game-related injury cases from 1997 to 2001. Results revealed that an estimated 11,998 persons >=7 years with paintball game-related injuries were treated in emergency departments during this timeframe, with an annual average rate of 4.5 per 10,000 participants. Nearly 60 percent of all injured persons >=7 years were treated for paintball pellet wounds of which most were to the eye.[15]

Obtaining proper training, enforcing rules, and educating participants about staying safe by wearing protective eyewear when engaged in the paintball activities may reduce the likelihood of eye injuries from this sport.[15,16,17]

Bungee Cords

Eye injuries due to the use of home bungee cords have risen. Such injuries are expected to rise with the ever-increasing popularity of sports such as skiing, bicycling, and windsurfing. These sports require equipment that people often attach to vehicles and trailers with bungee cords.[18]

The elastic recoil of a bungee cord generates tremendous force under certain conditions, capable of producing severe blunt and penetrating eye trauma. More than one-half of patients who sustain an eye injury related to a bungee cord require hospitalization for surgical treatment, and one-third of patients who sustain bungee-cord-related eye injuries require medical management of resulting increased eye pressure.[18]

Decorative Contact Lenses

The U.S. Food and Drug Administration (FDA) issued product warnings to the public in 2002 after reports of cases in which corneal transplants were required to save the eyesight of people injured by non-corrective decorative contact lenses. Decorative contact lenses change the appearance of the eye and have become popular fashion accessories in recent years, especially among the young. Although the number of people who incur eye injuries each year from decorative lenses has not been adequately documented, these lenses can cause corneal ulcers, which can rapidly lead to vision-threatening infections and other eye injuries.[19]

The warning from the FDA about this product urges consumers not to wear cosmetic contact lenses unless they are properly prescribed and fitted by a qualified eye care professional. Indeed, all contact lenses, cosmetic or otherwise, are FDA-regulated products that require a prescription for their sale and training in their proper care.[20]

Fireworks

Fireworks are a major source of preventable serious eye injuries. The eye is one of the most common organs involved in fireworks-related injuries.[21] Between June and July 2002, the U.S. Consumer Product Safety Commission reported there were more fireworks-related eye injuries (1,200) than fireworks-related injuries to the head, face, or ear.[22,23]

In the United States, fireworks have been reported to cause more than 10,000 hospital emergency room visits each year, with 20 percent of them for injuries that involve the eye. Only 40 percent of all such injuries are treated in emergency rooms, which suggests that a majority of information about eye injuries related to fireworks is missing.[21]

Most fireworks-related eye injuries result from bottle rockets and roman candles, and those injured are likely to be male, under age 14, and unsupervised by an adult. Between 28 and 58 percent of fireworks-related eye injuries affect bystanders, not the fireworks user.[21]

Because of the differences in state and local laws regulating the use of fireworks, incidence of injuries—more specifically of eye injuries—varies from region to region. Local customs of the population can also make a difference. Overall, states with strict regulations have a 50 times lower rate of injuries compared to states allowing most consumer fireworks. The rate of fireworks-related injuries is seven times higher in the less restrictive states.[21]

Gardening and Lawn Care

Each year, power lawn trimmers cause more than 1,500 eye injuries, according to the American Optometric Association (AOA). Tree or bush branches can cause painful scratches to the eye; fertilizers and weed killers can cause burns or eye irritations. The AOA recommends wearing safety goggles that meet the American National Standards Institute (ANSI) Z87.1 standards. These goggles are made of polycarbonate, a plastic that is one of the strongest lens materials available. Since ordinary prescription glasses, contact lenses, and sunglasses do not provide adequate protection in eye-hazardous situations, safety goggles should be worn over them.[24] Wearing a polycarbonate face shield over safety goggles can also increase protection against facial and eye injuries.

Lasers

The use of lasers continues to grow in research, health care, communications, the military, education, and industry. Laser pointer sales have grown dramatically over the past decade. Growth in this industry may be because manufacturers of hand-held laser pointers began marketing these devices as toys in the 1990s. In December 1997, the FDA issued a warning that was aimed primarily at parents and school officials about the possibility of eye injuries to children from the devices after two reports of misuse and subsequent eye injuries.[25]

The AOA suggests that even momentary exposure to laser pointers can cause discomfort and temporary visual impairment such as glare, flashblindness, and afterimages. These effects, however, do not generally cause permanent physical damage.[26] The AOA issued warnings concerning laser pointers, stating that “the light energy that some laser pointers deliver into the eye may be more damaging than staring directly into the sun.”[26] The Laser Institute of America warns about the potential misuse of laser pointers and has suggested that additional regulations for such devices be implemented to further limit the power they can emit.[27]

Motor Vehicles

Motor vehicle accidents account for 9 to 12 percent of all eye injuries (penetrating and nonpenetrating, combined).[28] In one study, researchers found that requiring the use of seatbelts resulted in a more than 50 percent reduction in the incidence of penetrating eye injuries in a 24-week time period.

Data on the relationship of airbags to eye injuries conflict. In the late 1980s, airbags gained widespread popularity as an effective means of reducing severe injury and death in motor vehicle accidents. Airbags have been required in all automobiles made after 1998. Since 1991, however, numerous reports have cited the deployment of air bags as a cause of eye injuries. The question of whether these eye injuries were caused by the accident itself, the airbag, or a combination of the two, has been the subject of controversy.

In 1997, an independent, federally sponsored expert panel of physicians considered the potential issue of whether wearing eyeglasses placed a vehicle occupant at higher risk for eye injuries. However, the panel recommended that airbags not be disconnected for people wearing eyeglasses, nor that people drive without their eyeglasses to prevent eye injuries from airbag deployment. In fact, preliminary statistics suggested that airbag deployment prevented eye injuries that resulted from contact with rigid steering columns and windshields.[29]

Power Tools

The AOA recommends that people who use power tools and related equipment use protective eyewear. Workers' assistants should also wear protective eyewear to protect themselves from flying debris and particles, as well as caustic chemicals. According to the AOA, hospitals treat more than 25,000 patients with injuries related to power tool use, most often from workshop grinders, drills, and saws. Caustic chemicals used for cleaning, painting, or polishing cause a significant number of eye injuries.[30] Welding equipment is also dangerous and causes many eye injuries.[10]

The AOA offers the following advice to help prevent eye injuries in the home improvement environment:

- Wear wrap-around safety goggles made of polycarbonate.
- Use safety goggles that meet the ANSI Z87.1 standards.
- Do not rely on ordinary prescriptive glasses for eye safety.
- Before welding, put on a face shield made especially for welding.

Athletics and Recreation

More than 42,000 sports- and recreation-related eye injuries were reported in 2000. Seventy-two percent of the injuries occurred in persons younger than 25 years, 43 percent occurred in persons younger than 15, and 8 percent occurred in children under 5.[31] The eye injury risk of a sport is proportional to the chance of the eye being impacted with sufficient energy to cause injury.[31]

More than 100,000 eye injuries each year in the United States are estimated to be sports related.[32] In 2002, more than 35,000 eye injuries due to sports were treated in U.S. hospital emergency rooms.[33]

Eye injuries in sports can occur from direct contact with other competitors and from projectiles such as balls and equipment. Most injuries do not cause long-term disability or vision loss, however, a significant number of preventable injuries can lead to the loss of an eye or severe visual impairment.[32]

In 2003, Baltimore City passed the first legislation in the United States requiring all participants in baseball to wear face guards on batting helmets and to use softer core baseballs. In addition, one-eyed players (20/40 or less) and eyeglass wearers are required to wear sports goggles with polycarbonate lenses.

In a 2004 joint policy statement, the American Academy of Pediatrics and the American Academy of Ophthalmology encouraged all athletes and their parents to become aware of the risks associated with participation in sports, and of the availability of a variety of certified sports eye protectors.[31] The risk categories for sports-related eye injury are shown in table 9-3 on the following page.[31]

Table 9-3: Risk categories for sports-related eye injury for the unprotected player.[31]

Risk Category by Type of Sport
High Risk
Small, fast projectiles
Air rifle/BB gun
Paintball
Hard projectiles, fingers, "sticks," close contact
Basketball
Baseball/softball
Cricket
Lacrosse (men's and women's)
Hockey (field and ice)
Squash
Racquetball
Fencing
Intentional injury
Boxing
Full-contact martial arts
Moderate Risk
Tennis
Badminton
Soccer
Volleyball
Water Polo
Football
Fishing
Golf
Low Risk
Swimming
Diving
Skiing (snow and water)
Noncontact martial arts
Wrestling
Bicycling
Eye Safe
Track and field*
Gymnastics
* Javelin and discus have a small but definite potential for injury. However, good field supervision can reduce the extremely low risk of injury to near-negligible.

Source: American Academy of Pediatrics, Committee on Sports Medicine and Fitness, American Academy of Ophthalmology, Eye Health and Public Information Task Force. Protective Eyewear for young athletes. *Ophthalmology* 2004 Mar;111(3):600-3.

Different forms of recommended eye protection for sports with a high risk of eye injury are shown in table 9-4.[31]

Table 9-4: Recommended eye protection for sports with high risk of eye injury.[31]

Sport	Minimal Eye Protector	Comment
Baseball/softball (youth batter and base runner)	ASTM F910*	Face guard attached to helmet
Baseball/softball (fielder)	ASTM F803 for baseball*	ASTM specifies age ranges
Basketball	ASTM F803 for basketball*	ASTM specifies age ranges
Bicycling	Helmet plus streetwear/fashion eyewear	
Boxing	None available; not permitted in sport	Contraindicated for functionally one-eyed athletes
Fencing	Protector with neck bib	
Field hockey (men's and women's)	ASTM F803 for women's lacrosse;* goalie, full-face mask	Protectors that pass for women's lacrosse also pass for field hockey
Football	Polycarbonate eye shield attached to helmet-mounted wire face mask	
Full-contact martial arts	None available; not permitted in sport	Contraindicated for functionally one-eyed athletes
Ice hockey	ASTM F513 face mask on helmet;* goaltenders, ASTM F1587*	HECC or CSA certified; full-face shield
Lacrosse (men's)	Face mask attached to lacrosse helmet	
Lacrosse (women's)	ASTM F803 for women's lacrosse	Should have option to wear helmet
Paintball	ASTM F1776 for paintball*	
Racquet sports (badminton, tennis, paddle tennis, handball, squash, and racquetball)	ASTM F803 for selected sport*	
Soccer	ASTM F803 for selected sport*	
Street hockey	ASTM F513 face mask on helmet*	Must be HECC or CSA certified
Track and field	Streetwear with polycarbonate lenses/fashion eyewear**	
Water polo/swimming	Swim goggles with polycarbonate lenses	
Wrestling	No standard available	Custom protective eyewear can be made

ASTM = American Society for Testing and Materials; CSA = Canadian Standards Association; HECC = Hockey Equipment Certification Council.

Annual Book of ASTM Standards: Vol. 15.07. Sports Equipment; Safety and Traction for Footwear; Amusement Rides; Consumer Products. West Conshohocken, PA: ASTM International; 2003.

**Eyewear that passes ASTM F803* is safer than streetwear eyewear for all sports activities with impact potential.

Source: American Academy of Pediatrics, Committee on Sports Medicine and Fitness, American Academy of Ophthalmology, Eye Health and Public Information Task Force. Protective Eyewear for young athletes. *Ophthalmology* 2004 Mar;111(3):600-3.

Conclusions

Eye injury is a leading cause of total visual impairment in one eye, second only to cataract. Strides have been made in preventing eye injuries through mandatory seatbelt laws; firework regulations; parental education and awareness; and athletic and recreational safety equipment, including encouraging the use of the polycarbonate protective lenses.

Eye care professionals can further assist by advising patients of appropriate protective eyewear, and schools can help by promoting the use of protective eyewear in shop classes, chemistry labs, gym and certain sports training, and anywhere there is a threat to eye health. Increasing eye safety awareness among parents and childcare providers is paramount. Many do not realize the amount of injury-prone activities that children engage in. Adult supervision, when children use unfamiliar and mechanized or high-force equipment, is also recommended.

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Chapter 10

Vision Rehabilitation

Objective 28-10

Increase vision rehabilitation.

a. Increase the use of rehabilitation services by persons with visual impairments.

b. Increase the use of visual and adaptive devices by persons with visual impairments.

Overview

The National Eye Institute (NEI) defines low vision as a visual impairment, not corrected by standard eyeglasses, contact lenses, medication, or surgery, that interferes with the ability to perform everyday activities. According to the NEI, more than 2 million, mostly older, Americans have low vision. Vision loss ranks behind only arthritis and heart disease as the reason for impaired daily functioning in people over the age of 70.[1]

Vision rehabilitation services include clinical assessments, training, counseling, and other support services for persons with visual impairments, including those with low vision. These services equip people with the skills and strategies that enable them to maintain an independent lifestyle. While vision rehabilitation cannot restore lost sight, it can maximize any existing sight. Vision rehabilitation helps people cope with their vision loss, travel safely, take care of their home, meet career objectives, and enjoy leisure activities.[2]

Low vision is most commonly described in terms of remaining visual acuity (central vision) and visual field (peripheral or side vision).[3] Central vision loss causes difficulty with detail discrimination, such as reading books and performing detailed work. Peripheral vision loss causes orientation and mobility problems, such as having difficulty seeing curbs or steps and crossing the street. Peripheral vision loss can also cause difficulty with night vision and low light conditions. Measurement of contrast sensitivity is also important.

Causes of Visual Impairment

Age-related eye diseases and conditions (age-related macular degeneration, diabetic retinopathy, glaucoma, and cataract) are the leading causes of visual impairments in people over the age of 65.[1,3,4,5,6,7] These causes are described below.

- **Age-related macular degeneration (AMD):** An eye disease associated with aging that gradually destroys sharp, central vision. Central vision is needed for seeing objects clearly and for common daily tasks such as reading and driving. Symptoms include blurred vision, straight lines that may appear crooked, and a blind spot.
- **Diabetic retinopathy:** An eye disease that is a complication of diabetes and a leading cause of blindness. The disease occurs when diabetes damages the tiny blood vessels inside the retina, the light-sensitive tissue at the back of the eye. There are no symptoms in the early stages of diabetic retinopathy. Symptoms in more severe cases of diabetic retinopathy include blurred vision and spots "floating" in the person's vision (see chapter 5: Diabetic Retinopathy).
- **Glaucoma:** An eye disease in which the normal fluid pressure inside the eye slowly rises, damaging the optic nerve, leading to vision loss. There are no symptoms in the early stages of glaucoma. As the disease progresses, it causes people to slowly lose their peripheral vision (see chapter 6: Glaucoma).
- **Cataract:** An eye disease in which a clouding of the lens in the eye causes vision loss. Most cataracts are related to aging. Symptoms include blurred vision, glare from the sun or a lamp that may appear too bright, and colors that may not appear as bright as they once did (see chapter 7: Cataract).

Other diseases, stroke, head injury, or tumors may also cause conditions that result in visual impairment.[7]

The Low Vision Exam

A specialist in low vision, either an ophthalmologist or optometrist, performs the low vision exam. This examination forms the basis for the development of a vision rehabilitation plan for people diagnosed with low vision. The eye exam and plan development process identifies limitations in visual acuity, visual field, and contrast sensitivity. More importantly, the process offers people with low vision the support needed by providing prescriptions of visual devices, offering discussions and demonstrations about the use of adaptive technology, and encouraging appropriate training and intervention to regain lost independence and quality of life. The low vision examination and vision rehabilitation process often require multiple visits to appropriate eye care and rehabilitation professionals.

Vision Rehabilitation

Vision rehabilitation involves a continuum of care, beginning with medical and surgical intervention, and proceeding to the prescription of visual devices and vision rehabilitation services. Rehabilitation is a treatment modality and intervention designed to make the most of residual vision, to provide the person with practical adaptation for the normal activities of daily living,[8] and to help ensure their safety and maintain their independence.[3]

Vision rehabilitation can take place in numerous settings, including eye care professionals' offices, rehabilitation centers and hospitals, university-based clinics, schools, state or private agencies, veterans administration programs, charitable agencies, and independent living centers.[9]

Multidisciplinary teams of professionals work together under the supervision of an eye care professional to perform the following:

- Examine people who have visual impairments.
- Prescribe assistive technology and adaptive devices, and train the patient in their use.
- Identify and incorporate new ways of performing tasks and getting around the existing living environment.

The team of professionals may include the following:[8]

- **Specialist in Low Vision:** An ophthalmologist or optometrist who specializes in the evaluation of low vision. This person conducts a diagnostic exam of the patient to confirm medical status, determine the types and levels of visual impairment, and develop goals and objectives with the patient. The specialist can prescribe visual devices and teach people how to use them. A specialist in low vision will supervise the implementation of the patient's individual low vision rehabilitation plan.
- **Occupational therapist:** Licensed professional, under the supervision of an eye care professional, who helps to evaluate the needs of people with low vision, makes appropriate referrals, recommends appropriate adaptive devices, and

instructs the patient in the use of these devices in an effort to ensure that the patient's goals and objectives are achieved.

- **Vision Rehabilitation Therapist** (formally known as Rehabilitation teacher)**:** Trained educator who provides assistance in activities of daily living and may instruct the patient in the use of prescribed low vision devices and community resources under the supervision of the specialist in low vision.
- **Orientation and mobility (O&M) professional:** Specialist who trains people with low vision to achieve independent movement within home, school, work, and community settings. The O&M specialist provides instruction in the use of white canes, guide dogs, electronic vision devices, and sighted-guide techniques.
- **Social Worker:** A professional who helps people with visual impairments cope with vision loss, its associated emotional stresses, and the social changes it produces.
- **Rehabilitation counselor:** Trained professional who provides evaluation and assistance in educational and vocational activities.
- **Technology specialist or adaptive technology specialist:** Professional who has expertise in adaptive computer hardware and software and experience in working with people with disabilities related to low vision or visual impairment. This specialist can also help students in a classroom setting or job site setting learn the application of adaptive technology.

Visual and Adaptive Devices

Visual and adaptive devices include both prescribed and nonprescribed devices that help people with low vision enhance their remaining vision. Eye care professionals trained in low vision typically prescribe these devices. The appropriate selection of assistive technology and low vision devices, and training in their application, are crucial for ensuring proper use and is part of the rehabilitation plan.[3,8]

Visual devices include the following:

- Reading glasses with high-powered lenses and microscopic bifocals
- Handheld and/or stand magnifiers (illuminated and non-illuminated)
- Video magnifiers (closed-circuit television)

- Absorptive lenses and filters
- Telescopes and telescopic spectacles
- Computers with large-print and speech-output systems.

Today, computers are more often assisting people with low vision with activities such as reading and writing. Special software programs, such as screen magnifiers, increase text size and offer additional help with seeing. This software allows a person with low vision to operate a computer with a standard screen.

Computerized, synthesized speech is also used. An increasing number of manufacturers make devices that combine video magnification, screen magnification, and scanning with speech synthesis.

Adaptive devices help people with visual impairments perform daily tasks within their living environment. Adaptive devices include the following:

- Lighting: the single most important factor in enhancing visual functioning.
- Glare, contrast, and color modification (e.g., tape in a contrasting color applied to the top edge of each step is useful in preventing falls).
- Large-button telephones.
- Large-print reading material.
- Enlarged checks and writing devices.
- Black felt-tip pens for writing.
- Talking watches, clocks, and calculators.
- Raised-dot or fluorescent markings for stove and oven dials.[8,10]

The effectiveness of these types of devices will likely depend on the person and his or her goals for independence.[10] According to the American Occupational Therapy Association, training in the use of visual devices is needed for optimal effectiveness.[11]

Data

Healthy Vision 2010 Baseline Data. Baseline data from the National Health Interview Survey collected in 2002 indicate 14.1 Americans per 1,000 aged 18 years and older with a visual impairment use vision rehabilitation services (see table 10-1). The Healthy People target for 2010 is to increase the number of people with visual impairments aged 18 years and older who use rehabilitation services by 9.9 percent, to 15.5 per 1,000.

Table 10-1: Number of adults aged 18 years and older with visual impairments per 1,000 reporting using vision rehabilitation services, 2002.

Persons 18 years and older with visual impairments	Use of rehabilitation services Rate per 1,000
Total	14.1
Race and ethnicity	
American Indian or Alaska Native only	DSU
Asian or Pacific Islander only	DNA
Asian only	DSU
Native Hawaiian or Other Pacific Islander only	DSU
Black or African American only	DSU
White only	13.6
2 or more races	DSU
American Indian or Alaska Native; White	DSU
Black or African American; White	DSU
Hispanic or Latino	DSU
Non Hispanic or Latino	12.6
Black or African American only, not Hisp/Latino	DSU
White only, not Hispanic or Latino	12.1
Gender	
Female	14.0
Male	DSU
Education level	
Under 12 years	DSU
12 years	21.8
13 years and over	15.0

DNA: Data have not been analyzed.

DSU: Data do not meet the criteria for statistical reliability, data quality, or confidentiality.

Source: 2002 National Health Interview Survey, National Center for Health Statistics, Centers for Disease Control and Prevention.

As shown in table 10-1, persons with visual impairments who had at least some college were less likely to use vision rehabilitation services than persons with less education. Baseline data were also collected about the number of visually impaired adults who use visual and adaptive devices. According to the 2002 National Health Interview Survey, 22 percent of persons with visual impairments aged 18 years and older use visual and adaptive devices (see table 10-2). The Healthy People target for 2010 is to increase to 26 percent the number of persons with visual impairments aged 18 years and older who use visual and adaptive devices such as telescopic or other prescriptive lenses, magnifiers, large-print or talking materials, closed-caption television, white canes, and/or guide dogs.

Table 10-2: Number of adults aged 18 years and older with visual impairments per 1,000 reporting using visual and adaptive devices by race/ethnicity, gender, and education level, 2002.

Persons 18 years and older with visual impairments	Use of visual and adaptive devices Percent
Total	22%
Race and ethnicity	
American Indian or Alaska Native only	DSU
Asian or Pacific Islander only	DSU
Asian only	DSU
Native Hawaiian or Other Pacific Islander only	DSU
Black or African American only	20%
White only	23%
2 or more races	25%
American Indian or Alaska Native; White	DSU
Black or African American; White	DSU
Hispanic or Latino	17%
Non Hispanic or Latino	23%
Black or African American only, not Hisp/Latino	20%
White only, not Hispanic or Latino	24%
Gender	
Female	22%
Male	23%
Education level	
Under 12 years	22%
12 years	23%
13 years and over	23%

DSU: Data do not meet the criteria for statistical reliability, data quality, or confidentiality.

Source: 2002 National Health Interview Survey, National Center for Health Statistics, Centers for Disease Control and Prevention.

Men and women aged 18 years and older with visual impairments were equally likely to use visual and adaptive devices (see table 10-2). Similarly, persons with visual impairments aged 18 years and older and any level of education were equally likely to use visual and adaptive devices. For the available race and ethnicity data, respondents who said they were two or more races with visual impairments were most likely to use visual and adaptive devices, and Hispanics/Latinos with visual impairments were least likely to use them.

Issues

Activities of Daily Living

Visual impairments have been found to be strongly associated with greater difficulty in performing the activities of daily living, leisure pursuits, education, vocation, and social interactions. These daily activities include walking and sleeping.[12]

Daily life becomes complicated when people are unable to perform such functions as reading mail, checking price tags, reading nutritional and preparation information on food packages, driving, sewing, or traveling alone. As a result, many people with low vision become socially isolated because they can no longer enjoy simple social activities. Health is compromised when people cannot recognize medications or read labels, when people with diabetes cannot effectively use blood-glucose monitoring systems,[13] or when they lose interest in cooking because the microwave panel or stove dials are indiscernible.[14]

Employment

Less than 50 percent of people who are blind or visually impaired are successfully employed. A third of the people who have jobs consider themselves underemployed and also have an average monthly pay rate that is 37 percent lower than the pay rate of people who are not disabled. No other social or economic group in this country has a higher unemployment rate than those who are blind or visually impaired. [15]

Getting Around

Visual impairment affects not only the ability to read, but the ability to move safely in different environments. There is strong evidence that among older persons, low vision increases the likelihood of falling.[16]

Because driving is such an important activity, health care providers should talk to their patients with visual impairments about the functional and psychological consequences of losing their driving license.[3] The eye care professional should also advise patients according to the rules of their particular state.

Emotional Impact

According to the clinical literature, older adults and persons with visual impairments may experience a range of psychological reactions, including grief, confusion, fear, anxiety, depression, loss of control, loss of self-esteem, diminished social comfort, and social isolation.[16] In many cases, these psychological and emotional reactions will need to be addressed before rehabilitation can begin.[3]

Awareness and Use

A nationwide telephone survey was conducted in 1994 for Lighthouse International. People aged 45 years and older (n=1,217) were asked about their experience, attitudes, and knowledge of visual impairments. The findings revealed that knowledge about the availability of local vision rehabilitation services was seriously lacking, creating a huge gap between the need for services and access to services. They found that more than one-third (35%) of middle-aged and older Americans did not know whether there were local public or private agencies in their community that provided services for people with visual impairments. Another 21 percent reported that there were no services.[17]

Lack of awareness regarding the availability of vision rehabilitation services was more pronounced among those who are thought of as having the greatest need for vision rehabilitation: older Americans (43% of those aged 65–74 years, and 40% of those aged 75 and older); the least educated (40% of those without a high school degree); and those with severe vision impairments (42%). The Lighthouse survey also revealed that many older adults simply accept the diminishment of vision as a natural part of aging and assume that they have no options.[17]

Results of the Lighthouse survey revealed that 30 percent of respondents with impaired vision used visual devices such as magnifiers or telescopes. Of the respondents who used visual devices, two-thirds (67%) believed they were important to their day-to-day activities. Only less than one-quarter (22%) of these respondents stated that the devices were prescribed or recommended by an eye care professional or general physician, and 65 percent reported that they never received any training in their proper use. Other than large-print materials, which were used by 21 percent of people surveyed with impaired vision, other adaptive devices were used only by a small minority.[17]

Effectiveness

In general, research supports the value of low vision examinations, vision rehabilitation, and adaptive devices. Some of the specific results are as follows:

- According to the American Occupational Therapy Association, training in the use of adaptive devices is needed for optimal effectiveness.[11]
- Researchers found that training in the use of magnification was effective in promoting continued use of low vision devices. The authors reported that 85.4 percent of the devices were still being used 12 to 24 months after they were prescribed when patients were appropriately trained.[18]
- Researchers found that people with visual impairments due to advanced age-related macular degeneration could reduce their emotional distress and increase functioning through vision rehabilitation that included training in self-management skills.[19]

Researchers have measured the effectiveness of low vision rehabilitation. One study used the Visual Functioning Questionnaire designed by The National Eye Institute to assess low vision services. In that survey, nearly all people (99%) with low vision who used rehabilitation services reported improvement. More than half (54%) reported low vision services as being "very useful."[20]

Another study looked at people with advanced diabetic retinopathy. It found that after receiving low vision services, the percentage of people able to read newspaper text increased from less than 2 percent to nearly 100 percent. It also found that of those who had stopped working because of their vision loss, nearly three-quarters had returned to work.[21]

For the older population, it is theorized that effective vision rehabilitation could help prevent functional impairments associated with high mortality and acute and chronic morbidity, including falls, hip fractures, and accidents while driving.[22] Activity limitations intensified by vision loss, such as decreased physical activity, may have negative implications for long-term health.[7]

Access to Care

Because low vision is more prevalent among populations at lower socioeconomic levels and among older adults who have fewer financial resources to purchase services and devices, low-income and some older Americans face greater difficulty in obtaining low vision adaptive devices and/or vision rehabilitation services.[11]

Some adults with low vision lack access to services because eye care professionals with expertise in low vision are not available in their communities.[16] While there may be an adequate number of eye care professionals across the country, they may not be evenly distributed geographically.

Conclusions

Age-related diseases and conditions such as macular degeneration, glaucoma, diabetic retinopathy, and cataract are the leading causes of visual impairments in people above age 65. Although there is no cure for these diseases, assistance is available to help those who have experienced vision loss because of them. Vision rehabilitation services include counseling, clinical assessments, teaching, and other support services that help people maintain their independence in daily living. The availability of visual and adaptive devices such as magnifiers, telescopic spectacles, and voice-output computer programs also help to improve the quality of life for persons with visual impairments.

Unfortunately, many consumers are unaware of the available services and devices for those with visual impairments, even though many states sponsor programs that offer vision rehabilitation services to eligible persons. Research in vision rehabilitation has revealed many successes in helping people to improve their independence and quality of life. The current challenge is to increase awareness of the availability and potential benefits of vision rehabilitation and adaptive technologies. Special efforts need to be put in place to communicate such availability to the aging American population, since the incidence of visual impairment increases almost directly with age.

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June 2006