1040-5488/15/9201-0006/0 VOL. 92, NO. 1, PP. 6–16
OPTOMETRY AND VISION SCIENCE

ORIGINAL ARTICLE

OPEN

Vision Screening for Children 36 to <72 Months: Recommended Practices

Susan A. Cotter*, Lynn A. Cyert†, Joseph M. Miller‡, and Graham E. Quinn§;
for the National Expert Panel to the National Center for Children's Vision and Eye Health[a]

ABSTRACT

Purpose. This article provides recommendations for screening children aged 36 to younger than 72 months for eye and visual system disorders. The recommendations were developed by the National Expert Panel to the National Center for Children's Vision and Eye Health, sponsored by Prevent Blindness, and funded by the Maternal and Child Health Bureau of the Health Resources and Services Administration, United States Department of Health and Human Services. The recommendations describe both best and acceptable practice standards. Targeted vision disorders for screening are primarily amblyopia, strabismus, significant refractive error, and associated risk factors. The recommended screening tests are intended for use by lay screeners, nurses, and other personnel who screen children in educational, community, public health, or primary health care settings. Characteristics of children who should be examined by an optometrist or ophthalmologist rather than undergo vision screening are also described.

Results. There are two current best practice vision screening methods for children aged 36 to younger than 72 months: (1) monocular visual acuity testing using single HOTV letters or LEA Symbols surrounded by crowding bars at a 5-ft (1.5 m) test distance, with the child responding by either matching or naming, or (2) instrument-based testing using the Retinomax autorefractor or the SureSight Vision Screener with the Vision in Preschoolers Study data software installed (version 2.24 or 2.25 set to minus cylinder form). Using the Plusoptix Photoscreener is acceptable practice, as is adding stereoacuity testing using the PASS (Preschool Assessment of Stereopsis with a Smile) stereotest as a supplemental procedure to visual acuity testing or autorefraction.

Conclusions. The National Expert Panel recommends that children aged 36 to younger than 72 months be screened annually (best practice) or at least once (accepted minimum standard) using one of the best practice approaches. Technological updates will be maintained at http://nationalcenter.preventblindness.org.
(Optom Vis Sci 2015;92:6–16)

Key Words: children's vision, preschool, vision screening, amblyopia, strabismus, refractive error, preschool, visual acuity, risk factor, autorefractor, autorefraction, hyperopia, stereopsis, photoscreener, photoscreening

The purpose of this article is to provide recommendations for screening children aged 36 to younger than 72 months for disorders of the eyes and visual system, primarily amblyopia, strabismus, significant refractive error, and risk factors associated with these disorders. The screening may be performed in educational-, community-, or public health–based settings or in the medical home using recommended methods that are appropriate for the screening venue. The tests recommended herein are intended for vision screenings conducted by lay screeners, school nurses, and other screening personnel in public health settings, primary health care practices, or the child's medical home to identify children in need of further evaluation by an eye care professional.

This article describes best practices supported by available research evidence, as well as acceptable standards for the conduct of

*OD, MS, FAAO
†PhD, OD, FAAO
‡MD, MPH
§MD, MSCE
Southern California College of Optometry at Marshall B. Ketchum University, Fullerton, California (SAC); Northeastern State University Oklahoma College of Optometry, Tahlequah, Oklahoma (LAC); University of Arizona College of Medicine, Tucson, Arizona (JMM); and Department of Ophthalmology, The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania (GEQ).
[a]A full list of the members is provided in the Acknowledgments.
Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.optvissci.com).

vision screening in children aged 36 to younger than 72 months. Using best practice standards should be the goal for all vision screening programs.

RATIONALE FOR VISION SCREENING

Amblyopia and its primary risk factors, strabismus and significant refractive error,[1,2] are the most common visual disorders in preschool children.[3] The prevalence of amblyopia among children aged 36 to younger than 72 months in the United States is about 2%.[4–6] Strabismus, a contributor to amblyopia and a disorder with significant psychosocial consequences,[7,8] has an estimated prevalence of 2.1 to 3.6% in preschool children.[4–6] The prevalence of significant refractive error, a condition more widespread than amblyopia and strabismus combined, is dependent on race/ethnicity, age, and the type of refractive error and criterion used to define the magnitude considered significant.[9–13] For example, recent population-based estimates in a multiethnic cohort of children aged 6 to younger than 72 months found the prevalence of hyperopia greater than or equal to 2.00 diopters (D) and astigmatism greater than or equal to 1.50 D in Hispanic children to be 26.9 and 16.8%, respectively, whereas the prevalence in African American children was 20.8% for hyperopia and 12.7% for astigmatism.[9,11,12] Not all of these children, however, have amblyogenic refractive error or refractive error significant enough to warrant an optical correction. The US Preventive Services Task Force (USPSTF) recommends that children between the ages of 3 and 5 years be screened at least once to detect the presence of amblyopia and amblyogenic risk factors such as strabismus and significant refractive error.[3]

Whereas vision screening is typically easier in school-aged children 6 years and older, evidence suggests that the success of amblyopia treatment is influenced by a child's age, with children younger than 7 years old being more responsive to amblyopia treatment.[14] The recent USPSTF report concluded that there is adequate evidence that early treatment of amblyopia results in improved visual outcomes.[3] In addition, optical correction of significant refractive error may be related to child development[15] and may improve school readiness.[16,17] The USPSTF recommends that children undergo vision screening at least once between the ages of 36 and 72 months instead of waiting until children are school-aged. Ongoing and periodic vision screening during the school years, however, is also important for school-aged children not receiving comprehensive eye examinations because refractive errors and other visual disorders may develop during this time.

Recommendation Development

In 2009, the Maternal and Child Health Bureau, recognizing the importance of early vision and eye health, funded the establishment of the National Center for Children's Vision and Eye Health at Prevent Blindness. A National Expert Panel (NEP) composed of leading professionals in ophthalmology, optometry, pediatrics, public health, and related fields was formed to advise the Center on how best to improve the public health infrastructure supporting the early detection of children's vision problems. The NEP specifically addressed vision screening methodology and the system of care needed to ensure appropriate, subsequent referral for professional eye evaluation and management. The NEP undertook a literature review (through February 2014) of the evidence base underlying vision screening of children aged 36 to younger than 72 months, supplementing their evaluation of the literature with the group's clinical experience where necessary. The rationale and process used to develop the recommendations are fully described in the Appendix, available at http://links.lww.com/OPX/A187. Screening methods designated herein as "best practice" are considered to have a sufficient evidence base from well-designed and well-conducted vision screening studies of children aged 36 to younger than 72 months to support their use in the educational, community, public health, or primary health care environments. Methods considered to be "acceptable practice" have some peer-reviewed published literature, but an insufficient level of evidence for the best practice categorization, generally because of small sample size, flaws in study design, or limited generalizability to the targeted age group or mass vision screening environment.

The NEP has written three reports targeting children aged 36 to younger than 72 months with recommendations for (1) conducting quantitative vision screening, (2) building an integrated data system to track vision screening and subsequent eye care,[18] and (3) specifying recommendations for developing state-level performance measures to track progress toward the goal of providing high-quality vision screening and follow-up to all preschool-aged children.[19]

This document is the first of the three reports and provides vision screening recommendations for children aged 36 to younger than 72 months that incorporate best practices based on currently available evidence. These practices should be reviewed periodically, at least every 5 years, with revised information available on the Web site for the National Center for Children's Vision and Eye Health (http://nationalcenter.preventblindness.org).

Children Requiring Automatic Referral for Examination

Children at high risk for vision disorders and those with readily recognized eye abnormalities such as strabismus or ptosis should be referred directly, and in a timely manner, to an appropriate eye care professional. Because children with known neurodevelopmental disorders (e.g., hearing impairment, motor abnormalities such as cerebral palsy, Down syndrome, cognitive impairment, autism spectrum disorders, or speech delay) have a higher rate of vision problems than those without neurodevelopmental abnormalities,[20–24] they should be referred directly to an optometrist or ophthalmologist for a comprehensive eye examination. Children with systemic diseases or using medications known to cause eye disorders, those with a family history of a first-degree relative with strabismus or amblyopia, and children born prematurely at less than 32 completed weeks of gestation also should receive a comprehensive eye examination rather than be screened.[2,25–27] Additionally, when a parent or guardian believes his or her child may have a vision-related problem, an eye care professional should examine that child. Because the purpose of vision screening is to identify children in need of further care, those who have received a comprehensive eye examination from an eye doctor within the

TABLE 1.

Best practices for vision screening children aged 36 to younger than 72 months

	Recognition visual acuity	Autorefraction
Total testing time[28]	4 min	2 min
Test distance	Best practice: 5 ft (1.5 m) Acceptable practice: 10 ft (3 m)	Varies by instrument Ranges from a few inches to 1 m
Occlusion	Monocular occlusion required	Not required
Testing environment	Illumination of ≥80 cd/m^2 No glare	May require a dim environment; may be affected negatively by direct illumination
Tester	For 5 ft (1.5 m)—1 screener For 10 ft (3 m)—possibly 2 screeners	1 screener required
Cost	Relatively inexpensive for printed test materials Increased cost if computer-based system	Major capital expenditure

m, meters; cd, candelas.

previous 12 months do not need to be screened but should be referred back to their eye doctor for follow-up.

VISION SCREENING PROCESS

In general, there are two vision screening approaches (Table 1) for children aged 36 to younger than 72 months, each with advantages and disadvantages. The first method is a monocular measure of recognition visual acuity using an age-appropriate technique. The alternative approach is to use instrument-based screening methods (autorefraction or photoscreening) to identify amblyogenic risk factors, particularly significant refractive error.[29] All screening personnel should undergo a comprehensive training program, preferably with standardized training and certification in the screening methods to be used, with subsequent continuing education and formal recertification every 3 to 5 years. Tests such as red reflex testing for media opacity detection or cover testing for eye misalignment should only be used as part of the vision screening process if administered by health care personnel professionally trained to perform and interpret the tests. When performed alone, neither test provides sufficient information for a full vision screening,[30,31] although detection of an abnormality should trigger referral for a comprehensive eye examination.

Selecting the vision screening method to be used depends on the screening venue, availability of screening personnel, time allotted for the screening, and funding resources. Ideally, a vision screening program should consist of a single cost-effective test that can be quickly and easily administered by nonmedical personnel to the target population in any environment. Significant training should not be required; the child's cooperation should not be essential; missed referrals and unnecessary referrals should be nonexistent; and the screening results should automatically be integrated into an electronic health record. Any real-world screening method represents a trade-off among all of these factors. Screening programs can be designed to use a single screening test or a combination of more than one test. However, combining two screening tests does not necessarily result in the highest sensitivity and specificity from each component test.[32] The strengths and weaknesses of currently available vision screening methods are described below.

Recognition Visual Acuity Screening

Visual acuity is the quantifiable measure of the ability to identify black symbols on a white background at a standardized test distance. The most commonly measured type, recognition visual acuity, is defined as the ability to discern certain optotypes (letters, numbers, or figures) at a specified distance. Ideally, tests of visual acuity should have the same number of optotypes for each acuity level and the same proportional decrease in size from one acuity level to the next smaller level in logMAR (logarithm of the minimum angle of resolution) progression.[33]

Visual acuity methods for vision screening are widely used for adults and school-aged children. To be performed reliably in children aged 36 to younger than 72 months, however, a number of testing modifications are required (Table 2).[34,35] These include using age-appropriate and adequately illuminated test symbols that can be presented in random order and using a lap card (i.e., card with the test optotypes that the child places on his or her lap) for matching, administering a pretraining or demonstration session before the start of testing to confirm that the child understands and can perform the test, and using a closer test distance. Ideally, the test environment should be quiet and free of distraction, the wait time short, and the child approached in a manner that maximizes his or her cooperation (such as presenting the screening task as a game rather than as a test). The parents and/or teachers of the child to be screened should be fully informed about the importance of vision screening and ideally be provided with practice cards to be used before screening.

Testing Symbols

The HOTV[36,37] and LEA Symbols,[38] two tests that were developed for use in preschool children,[35,39,40] are presently considered *best* practice for visual acuity testing of children aged 36 to younger than 72 months. The letters H, O, T, and V have vertical symmetry, and the LEA Symbols consist of four picture optotypes (house, heart/apple, circle, and square) that blur equally.[38] Although 3-year-old Head Start children have been reported to achieve better visual acuity scores with the LEA Symbols, no statistically significant differences in sensitivity between the tests were found for 3-, 4-, or 5-year-old children.[41] While HOTV optotypes are used

TABLE 2.
Distance visual acuity testing for vision screening of children aged 36 to younger than 72 months

	Best practice	Acceptable practice	Unacceptable
Optotype	Single surrounded HOTV letters or LEA Symbols	Rectangular crowding bar surrounding a single line* of HOTV letters or LEA Symbols	Snellen, Allen figures, Tumbling E, Landolt C, Lighthouse, Kindergarten Eye Chart
Test distance	5 ft (1.5 m)	10 ft (3 m)	20 ft (6 m) Near card Any distance <5 ft (1.5 m)
Monocular* visual acuity	Name or match correctly 3 or 4 out of 4: 20/50 for 3-y-olds 20/40 for 4- and 5-y-olds		Binocular testing
Illumination	≥80 cd/m^2 luminance		Glare on test cards or computer screen
Occlusion	Adhesive patch or opaque paper tape	Specialized occluder glasses	Hand, tissue, paper cup, cover paddle
Examples of currently available commercial products	VIP Screener, single surrounded optotypes (Good-Lite)	MassVAT single surrounded lines (Precision Vision)*	Tests with optotypes listed above Near vision machines like those used at motor vehicle testing facilities

The current list is maintained at http://nationalcenter.preventblindness.org.
*When lines are used, different lines of letters should be used for each eye.

more commonly in preschool-aged epidemiological studies[4,42–44] and randomized clinical trials for amblyopia,[45–47] most children 3 years and older can successfully complete visual acuity testing using either set of optotypes.[48]

Snellen optotypes are not recommended for the measurement of visual acuity in preschool-aged children. Children this age do not know their letters sufficiently well and the letters are not equally detectable. Because Landolt C and Tumbling E tests require discrimination of left-right directionality (rightward vs. leftward pointing), a skill that is not sufficiently developed in preschool children,[49] these tests should also not be used. Picture charts, such as the Allen Preschool Vision Test and the Kindergarten Eye Chart, are also problematic because they are not standardized. Both have variable interline gap widths and shape cues resulting in some of the pictures being more readily identified than others.[35] When pictures are too easily recognized, visual acuity is overestimated in children with amblyopia.[34,50,51] Furthermore, some of the pictures have a cultural bias and others are outdated, making the pictures not readily recognizable by all children.

Symbol Presentation and Crowding Bars

When a small number of optotypes such as the HOTV or LEA Symbols are used in testing, the possible responses are limited. On any presentation of four letters, the probability of guessing three of four optotypes correctly is about 5%.[45] Thus, any given visual acuity level is considered to be passed if three of three or three of four optotypes are correctly identified at that particular level. Although the presentation of single optotypes generally improves testability, the use of single isolated optotypes substantially reduces the sensitivity for the detection of amblyopia.[52] Surrounding single optotypes with four flanking bars that create a "crowding effect" improves amblyopia detection.[53,54] Isolated HOTV or LEA optotypes with crowding bars presented in printed format or by computer have been used successfully in large-scale studies of preschool children[5,28,44–46] and are considered *best* practice for measuring visual acuity in children aged 36 to younger than 72 months. A single line of optotypes with crowding bars on all four sides extended to form a crowding rectangle surrounding the line of optotypes[48] is also preferable to isolated optotypes without crowding bars; this type of presentation is considered *acceptable* practice.

Occlusion for Visual Acuity Testing

Visual acuity testing should be conducted separately for each eye because unilateral amblyopia is masked by the better-seeing eye when amblyopic children are tested binocularly. Screening personnel need to monitor occlusion carefully because children with reduced vision in one eye often attempt to use their better eye by peeking. Preferred methods of occlusion are to use adhesive eye patches or 2-in wide hypoallergenic surgical tape (e.g., Micropore or Blenderm). An acceptable method is the use of specially constructed occluder glasses (e.g., Good-Lite opaque occluder glasses). Holding a tissue, hand, paper cup, or an occluder paddle over a child's eye is not acceptable because children can easily circumvent these types of occlusion.

Testing Distance

The optimum test distance for measuring visual acuity in children aged 36 to younger than 72 months is shorter than that used for adults and school-aged children. The advantages of a shortened test distance include improved ability to maintain the child's attention and the ability to test the child in a smaller space, thereby avoiding the distractions of a crowded hallway or large testing room. The *best* practice for children this age is to use single surrounded optotypes at a 5-ft (1.5-m) test distance.[28] Significantly increased sensitivity for a given level of specificity, equal to that obtained by eye doctors, has been found when lay screeners use single surrounded LEA Symbols at the 5-ft (1.5-m) test distance[28] compared with when lay screeners use the linear LEA test at 10 ft (3 m). Using a test calibrated for a 10-ft (3-m) test distance is considered *acceptable* practice[34,35]; testing distances closer than 5 ft (1.5 m) should not be used because myopia may be missed. For example, at a test distance of 14 in (33 cm), 3 D of myopia may go undetected. Although 0.50 to 0.75 D of myopia may be masked at the 5-ft (1.5-m) test distance, this small magnitude does not meet the typical referral guideline for preschool myopic refractive error. Thus, test distances greater than 10 ft (3 m), the use of near cards, or vision testing devices that optically simulate distance vision (such as those used at many motor vehicle testing facilities) do not meet the recommended minimum standards for measuring visual acuity in children aged 36 to younger than 72 months. Screening programs that are still using cards calibrated for 10 ft (3 m) should begin moving toward the best practice of testing visual acuity at 5 ft (1.5 m), which will require replacement of equipment.

Illumination of Test Materials

Visual acuity testing is best performed with good illumination and maximum contrast (at least 85%) between the black symbol and the white background.[55] Best practices for illumination are using a lightbox with a translucent visual acuity chart, a lighted stand designed to hold and evenly illuminate the acuity test, or a computer screen display. Insufficient illumination of the test material (<80 cd/m^2)[55] and competing light sources that create glare or uneven illumination (e.g., testing performed beside a window) should be avoided because they can negatively affect visual acuity measurements.

Pass/Fail Criteria for Visual Acuity Testing

The passing criterion for HOTV or LEA Symbols is age specific and must be met by both the right and left eyes separately. Children aged 36 through 47 months must identify correctly three of three or three of four of the 20/50 (5/12.5) optotypes to pass; children aged 48 to younger than 72 months must correctly identify the same number of optotypes at the 20/40 (5/10) level.[4,5,30] Children who do not meet these age-specific criteria for each eye should be referred for a comprehensive eye examination.

Instrument-Based Vision Screening

Instrument-based screening refers to vision screening using automated technology. Generally, instrument-based screening is quick to administer and requires minimal cooperation from the child, thereby making it especially useful for shy, noncommunicative, or preverbal children. Using an automated instrument also offers the advantage of having the potential for the screening results to be integrated directly into a data management system without requiring manual data entry. A recent policy statement published by the American Academy of Pediatrics noted that an instrument-based approach can be used in the medical home as an alternative to visual acuity screening for children aged 3 through 5 years.[29]

Refractive Instrument-Based Methods of Vision Screening

Instrument-based screening using autorefraction or photorefraction/photoscreening identifies the presence and magnitude of refractive error rather than providing a measurement of visual acuity. Each of these screening devices requires instrument- and age-specific pass/fail refractive error criteria. Abnormal refractive error is a significant risk factor for amblyopia.[2] Hyperopic refractive error greater than or equal to 2.00 D spherical equivalent, in particular, is associated with a significantly higher risk of esotropia,[26] which by itself is an additional risk factor for amblyopia. Because of the association among amblyopia, strabismus, and uncorrected significant refractive error, screening for refractive error alone is often successful in identifying children with constant strabismus and moderate to severe levels of amblyopia.[28,30]

Autorefraction

Autorefractors are computerized instruments that use optically automated skiascopy methods or wave-front technology to provide a numeric estimate of refractive error. When used for vision screening purposes, the operator or the instrument must interpret the refractive error measurement as a pass or fail. Although accurate determination of refractive error (hyperopia in particular) requires the instillation of eye drops to provide cycloplegia, eye drops are not used in the screening environment. Accordingly, vision screening by autorefraction only provides an estimate of refractive error; it is not a substitute for an eye examination and refraction by an ophthalmologist or optometrist.

Unlike tabletop models that are often difficult to use with young children, handheld autorefractors are suitable for vision screening because they are portable and only require a few seconds of a child's attention. At the time of this publication, two handheld autorefractors, the Retinomax (Right Mfg Co Ltd, Tokyo, Japan) and the SureSight Vision Screener (SureSight) (Welch-Allyn, Inc, Skaneateles Falls, NY), have high-quality published performance data in the targeted age range and are commercially available with the appropriate Food and Drug Administration designation; thus, they meet the criteria for *best* practice for preschool vision screening.[28,30] The Vision in Preschoolers (VIP) Study has shown that these two autorefractors meet or exceed the screening performance achieved using recognition visual acuity testing in preschool children.[28,30]

The Retinomax has a high testability rate[28,56,57] and good sensitivity at both 0.90 and 0.94 specificity in children aged 36 to younger than 72 months[28,30]; however, the results are reported in ophthalmic prescription format, which is not readily interpretable by most lay screeners. The SureSight, when used in the "child mode," provides the operator with a pass or fail determination. Although the manufacturer's preprogrammed pass/fail criteria do not perform well in identifying amblyopia and amblyogenic conditions in preschool children,[30] software is available (version 2.24 or 2.25, School Health Corp, Hanover Park, IL) for the SureSight (when used in minus cylinder format) that incorporates the better-performing VIP Study pass/fail criteria for 90% specificity.[30,58] In addition to refractive error data, an asterisk is displayed on the printout when a child fails according to the VIP referral criteria, thus facilitating interpretation of the results for screeners who are not eye professionals. Although there are a number of prior software versions that have been distributed, the NEP recommends that software version 2.24 or 2.25 be used for preschool vision screenings when the SureSight is used.

Photorefraction/Photoscreening

Photorefraction or photoscreening devices use optical images of the eyes' red reflexes to provide a simultaneous, binocular estimate of refractive error. In addition, some instruments have the capability to evaluate ocular alignment and identify media opacities. Depending on the instrument, the output is interpreted by the operator, a central reading center, or a computer. Some instruments allow the implementation of user-defined refractive error criteria to determine the pass/fail cutoffs.

In a large multicenter study that compared various preschool vision screening tests, the three photoscreening instruments evaluated (MTI Photoscreener, Power Refractor II, and iScreen Photoscreener) were found to have unsatisfactory sensitivity in detecting amblyopia, strabismus, and significant refractive error compared with the Retinomax and SureSight autorefractors.[30] Since that time, a number of new or updated photoscreening devices have been introduced to the market, although none has yet undergone the same type of rigorous evaluation.

One of these newer instruments, the Plusoptix Photoscreener (Plusoptix, Nuremberg, Germany), is a binocular device based on the aforementioned Power Refractor II. Considered by some investigators to hold promise for preschool vision screenings,[59] the Plusoptix provides a simultaneous measure of autorefraction and eye alignment and allows the user to specify the desired pass/fail criteria. The device also provides a report containing the child's name, results, and pass/fail status that can be integrated into an electronic medical record.

Comparisons of the Plusoptix and clinical examination results in nonscreening settings have been mixed,[59–63] and there are limited results available that apply to a vision screening environment for children aged 36 to younger than 72 months.[64] Investigators have cautioned that the specificity of the Plusoptix is unacceptably low (37%) for field use when the manufacturer's pass/fail criteria are used,[65] and while modifications of these criteria can result in improved specificity without loss of sensitivity, the ideal refractive error criteria have yet to be determined.[65] Of note, consensus-based refractive error criteria that are thought to place young children at risk for the development of amblyopia and thereby warrant detection by vision screening[66] are based on cycloplegic refractions; these are not intended to be used as cutoff values for vision screening instruments that measure noncycloplegic refractive error.[67] Despite these limitations and lack of robust evidence, the NEP's opinion is that the Plusoptix instrument appears sufficiently promising to be classed as an *acceptable* practice at this time, with the caveat that the optimum refractive error referral criteria have yet to be determined.[65] Thus, when the Plusoptix is used outside of an eye care setting, consultation with a pediatric eye care professional regarding the best cutoffs to use for the particular patient population to be screened is advised until evidence-based refractive error criteria are determined.

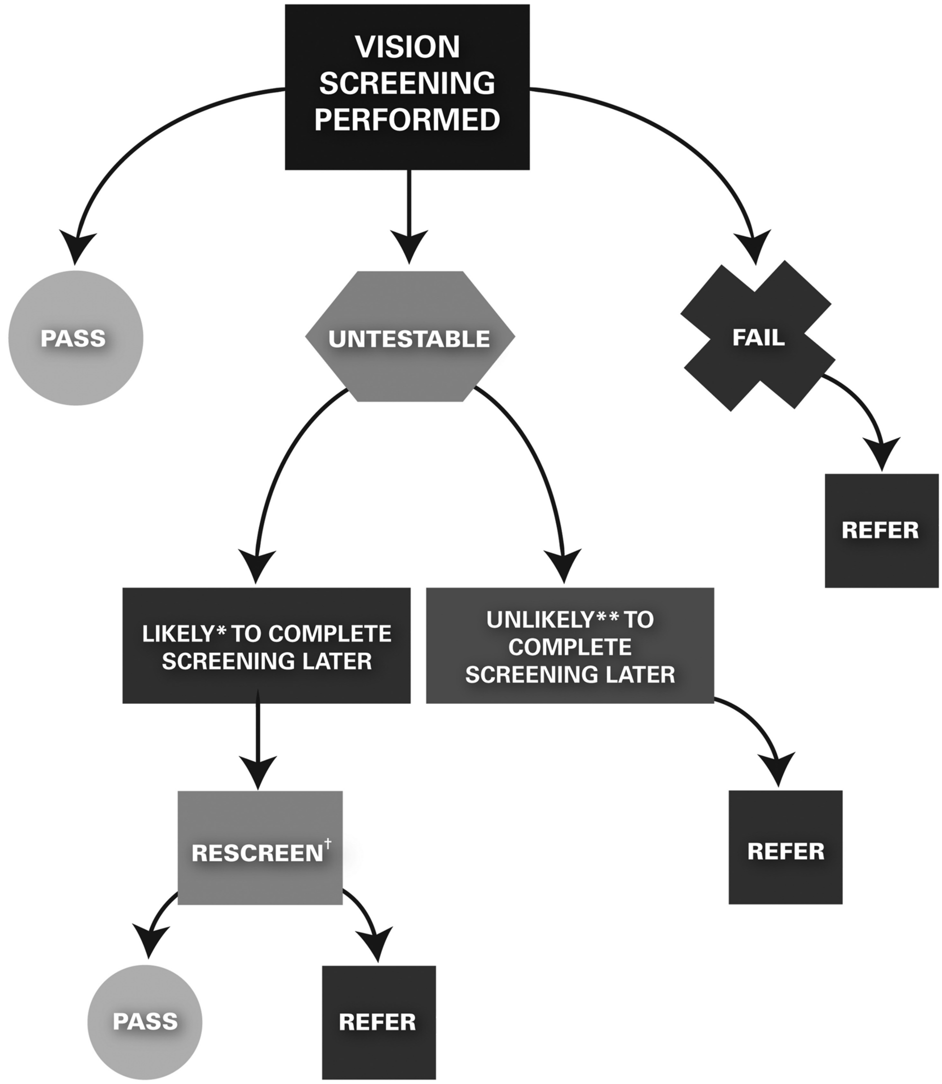
There are a number of other commercially available screening instruments that also lack high-quality published data supporting their use for vision screening children aged 36 to younger than 72 months. The recommendation of best practice for the Plusoptix and other screening devices will require validation studies. An ideal validation study consists of a prospective large-scale vision screening performed by lay screeners in the field, in which all children who pass and fail the screening also receive a comprehensive eye examination (including a cycloplegic refraction) from an optometrist or ophthalmologist masked to the results of the screening. The children screened should be within the targeted age range and also have a wide variety of vision disorders, particularly strabismus, amblyopia, and high refractive error. This type of rigorous assessment is necessary to determine the optimum refractive error referral criteria for a particular instrument.[65] Because autorefractor and photoscreening technologies are evolving rapidly, recommendations for best practice will likely change with the availability of additional quality peer-reviewed data and as the natural history of refractive error and the role of risk factors for the development of amblyopia and strabismus become more clear.[68] Updated information will be found on the Web site for the National Center for Children's Vision and Eye Health (http://nationalcenter.preventblindness.org).

Nonrefractive Instrument-Based Methods of Vision Screening

Analogous to auditory evoked brain response methods of newborn hearing screening, there are computerized systems that assess the integrity and maturation of the visual system through measurement of the electroencephalographic visual evoked response,[69] thereby providing information regarding the functional integrity of the visual system. Another approach for vision screening that is currently under investigation is retinal birefringence scanning,[70,71] which simultaneously detects both the child's ability to accurately align the fovea of each eye to a common point in space and focus each fovea on that point. At present, there is insufficient evidence to recommend either of these methods for screening children aged 36 to younger than 72 months over either visual acuity testing or acceptable instrument-based methods of vision screening.

Stereoacuity Testing for Vision Screening

Stereoacuity (depth perception) testing performed in isolation has not been a fruitful preschool vision screening method.[30] However, when combined with the SureSight Vision Screener, the Stereo Smile II test has been shown to increase the detection rate of strabismus (an amblyogenic condition).[72] Because two screening tests do not necessarily result in a higher detection rate as compared with each test alone,[32] whether to add stereoacuity testing is dependent on the goals of the screening program and resources available. In instances when stereoacuity testing is required or desired for screening preschool children, the Stereo Smile II test, which is commercially available as the PASS (Preschool Assessment of Stereopsis with a Smile) test (Vision Assessment Corporation, Elk Grove Village, IL), should be used because it performs better than the Random Dot E test of stereoacuity.[30] As new research emerges, the role of stereoacuity testing in combination with other vision screening tests will be reviewed.



* "Likely" includes children who are inattentive, uncooperative, will not allow occlusion, or do not understand the task.
** "Unlikely" includes children with cognitive, physical or behavioral issues that preclude successful testing.
† Rescreen as soon as possible, at least within 6 months. If the rescreen is not possible, then refer.

FIGURE 1.
Flowchart for children who receive a vision screening.

Untestable Children and Rescreening Guidelines

Children who are inattentive, are uncooperative, will not allow one eye to be covered for monocular visual acuity testing, or do not appear to understand the screening task are not considered to have failed, but instead are deemed "untestable" (Fig. 1). Untestable preschool children are about twice as likely to have a vision problem than those who successfully pass a screening.[73] If practical, untestable children should be rescreened the same day. When a same-day rescreening is not feasible, rescreening should be scheduled as soon as possible, but in no case later than 6 months. Because children unable to be screened with visual acuity testing can often complete autorefraction testing and vice versa,[73] one should consider using the alternate method for rescreening if both are available. Untestable children with cognitive, physical, or behavioral issues that are likely to preclude successful rescreening, children who are unable to be rescreened within 6 months, and those who fail rescreening should be referred directly for a comprehensive eye examination by an optometrist or ophthalmologist (Fig. 1).

COMPONENTS OF A COMPREHENSIVE VISION SCREENING PROGRAM

Vision screening of children aged 36 to younger than 72 months, which is recommended by the USPSTF,[3] can be performed either by measuring recognition visual acuity directly or by using instrument-based methods of autorefraction or photoscreening to identify amblyogenic refractive error. Sufficient evidence showing that either method is effective when the aforementioned best practice testing methods are used has accumulated.[28,30] The number of children to be screened, time allotted for screening, available budget for implementing the screening program, and reporting requirements will be factors in determining whether a recognition visual acuity–based screening program, an instrument-based program, or a hybrid of the two is used.

Regardless of the screening method(s) selected and whether the child passes or fails the vision screening, the screening system is only successful when the results are used in a meaningful way. Screening results must be recorded and communicated to the child's parents, and as appropriate to the medical home/primary care provider, the school, and necessary state agency, with subsequent referral to an ophthalmologist or optometrist for examination and care when indicated. Specific data systems must be established to facilitate this process[18] and programs should monitor overall system performance at the population level to ensure that screening goals are being met.[19]

SUMMARY OF RECOMMENDATIONS

1. All children aged 36 to younger than 72 months should be screened annually (best practice) or at least once (acceptable minimum standard) during the interval between their third and sixth birthdays. Exceptions to this include children with the following: readily observable ocular abnormalities, neurodevelopmental disorders, systemic conditions that have associated ocular abnormalities, first-degree relatives with strabismus or amblyopia, a history of prematurity (<32 completed weeks), and parents who believe their child has a vision problem. These children should be referred directly to an ophthalmologist or optometrist for a comprehensive eye examination. Children who have received an eye examination from an eye care professional within the prior 12 months do not need to be screened. A vision screening program based on best practice standards should be the goal.
2. Children who are unable or refuse to complete testing are considered untestable. These children are more likely to have vision problems than testable children,[73] and thus should be rescreened either the same day or soon afterward, but in no case later than 6 months. Children with cognitive, physical, or behavioral issues likely to preclude rescreening and those unable to be rescreened in a timely manner because of administrative or other issues should be referred directly for a comprehensive eye examination.
3. Currently, there are two best practice vision screening methods for children aged 36 to younger than 72 months: (1) monocular vision acuity testing and (2) instrument-based testing using autorefraction. For visual acuity testing, appropriately scaled (logMAR) single crowded HOTV letters or LEA Symbols surrounded by crowding bars at a 5-ft (1.5-m) test distance with the child matching or reading the optotypes aloud should be used. A passing score is the correct identification of three of three or three of four optotypes with each eye at the 20/50 level for children aged 36 through 47 months and at the 20/40 level for children aged 48 to younger than 72 months. Acceptable practices are to use the HOTV or LEA Symbols calibrated for a 10-ft (3-m) test distance or to use a single line of these optotypes surrounded by a rectangular crowding bar on all four sides. Other optotypes like Allen pictures and the Tumbling E should not be used.

   The other best practice vision screening method is instrument-based screening using either the Retinomax autorefractor or the SureSight Vision Screener set in child mode and programmed with the VIP Study pass/fail criteria software for 90% specificity (version 2.24 or 2.25) in minus cylinder form. Using the Plusoptix photoscreener is considered acceptable practice, as is adding the PASS stereoacuity test as a supplement to one of the best practice screening methods.
4. Vision screening requires training and certification of screening personnel, acquiring sufficient and appropriate space, obtaining and maintaining equipment and supplies, as well as recording and reporting the screening results to the family, primary care provider/medical home, and when indicated the school or appropriate state agency.
5. A best practice for children who fail vision screening includes documentation of the referral to and subsequent comprehensive eye examination by an optometrist or ophthalmologist.
6. A range of resources to support implementation of these recommendations, including demonstrations of the vision screening process, can be found at http://nationalcenter.preventblindness.org.

CONCLUSIONS

It is the NEP's intent that this summary will prove useful for eye care professionals playing a leadership role in ensuring that children aged 36 to younger than 72 months in their communities receive high-quality vision screening and appropriate follow-up.

ACKNOWLEDGMENTS

Members of the NEP to the National Center for Children's Vision and Eye Health

Shirley A. Russ, MD, MPH (Panel Chair), University of California, Los Angeles-Center for Healthier Children, Families and Communities, Los Angeles, CA; Sandra S. Block, OD, MEd, FAAO (Panel Cochair), Illinois College of Optometry, Chicago, IL; Joseph M. Miller, MD, MPH (Panel Cochair), The Clara and Murray Walker Professor and Chair of Ophthalmology and Vision Science, The University of Arizona College of Medicine, Tucson, AZ; Martha Dewey Bergren, DNS, RN, University of Illinois-Chicago, College of Nursing, Chicago, IL; Richard T. Bunner, MA, Ohio Department of Health (Retired), Columbus, OH; Susan A. Cotter, OD, MS, FAAO, Southern California College of Optometry at Marshall B. Ketchum University, Fullerton, CA; Lynn A. Cyert, PhD, OD, FAAO, Northeastern State University, Oklahoma College of Optometry, Tahlequah, OK; Holly A. Grason, MA, Department of Population, Family and Reproductive Health, Johns Hopkins University Bloomberg School of Public Health, Baltimore, MD; E. Eugenie Hartmann, PhD, University of Alabama at Birmingham, School of Optometry, Birmingham, AL; Karen F. Hughes, MPH, Chief, Division of Family and Community Health Services, Ohio Department of Health, Columbus, OH; Amy K. Hutchinson, MD, Department of Ophthalmology, Emory University School of Medicine, Atlanta, GA; Alex R. Kemper, MD, MPH, Department of Pediatrics and Duke Evidence-based Practice Center, Duke Clinical Research Institute, Duke University School of Medicine, Durham, NC; Sandra Leonard, RN, MS, FNP, Division of Adolescent and School Health, Centers for Disease Control and Prevention, Atlanta, GA; Stacy Ayn Lyons, OD, FAAO, Chair, Department of Specialty and Advanced Care, New England College of Optometry, Boston, MA; Wendy L. Marsh-Tootle, OD, MS, FAAO, University of Alabama at Birmingham, School of Optometry, Birmingham, AL; Renee Mika, OD, FAAO, Cherry Street Health Services-Heart of the City Health Center, The Grand Rapids Lion's Club Vision Clinic, Grand Rapids, MI; Bruce D. Moore, OD, FAAO, Marcus Professor of Pediatric Studies, New England College of Optometry, Boston, MA; Nicole Pratt, New Jersey Statewide Parent Advocacy Network, Newark, NJ; Graham E. Quinn, MD, MSCE, Division of Pediatric

Ophthalmology, The Children's Hospital of Philadelphia and Scheie Eye Institute, University of Pennsylvania Health System, Philadelphia, PA; Jean E. Ramsey, MD, MPH, Associate Professor for Ophthalmology and Pediatrics, Boston University School of Medicine, Boston, MA; Michael X. Repka, MD, Zanvyl Krieger Children's Eye Center and Adult Strabismus Service, Wilmer Eye Institute and the Department of Pediatrics, The Johns Hopkins University School of Medicine, Baltimore, MD; David K. Wallace, MD, MPH, Department of Ophthalmology, Duke University Eye Center and Department of Pediatrics, Duke University School of Medicine, Durham, NC.

Development of these recommendations was produced, in part, through a cooperative agreement (H7MMC15141) and grant (H7MMC24738) from the Maternal and Child Health Bureau of the Health Resources and Services Administration, US Department of Health and Human Services. The views expressed in the publication represent the consensus of the NEP to the National Center for Children's Vision and Eye Health and do not necessarily reflect the official policies of the US Department of Health and Human Services or the Health Resources and Services Administration, nor does mention of the department or agency names imply endorsement by the US Government. The recommendations herein do not necessarily reflect the views of any individual member of the panel, the institution where she or he is employed, or any of the professional organizations to which the panel members belong.

The corresponding author has no financial conflict of interest regarding the subject matter in this article.

Received October 31, 2013; accepted June 10, 2014.

APPENDIX

The Appendix, a description of the rationale and process used to develop the recommendations, is available at http://links.lww.com/OPX/A187.

REFERENCES

1. Tarczy-Hornoch K, Cotter SA, Borchert M, McKean-Cowdin R, Lin J, Wen G, Kim J, Varma R. Prevalence and causes of visual impairment in Asian and non-Hispanic white preschool children: Multi-ethnic Pediatric Eye Disease Study. Ophthalmology 2013; 120:1220–6.
2. Tarczy-Hornoch K, Varma R, Cotter SA, McKean-Cowdin R, Lin JH, Borchert MS, Torres M, Wen G, Azen SP, Tielsch JM, Friedman DS, Repka MX, Katz J, Ibironke J, Giordano L. Risk factors for decreased visual acuity in preschool children: the multi-ethnic pediatric eye disease and Baltimore pediatric eye disease studies. Ophthalmology 2011;118:2262–73.
3. United States Preventive Services Task Force. Vision screening for children 1 to 5 years of age: US Preventive Services Task Force Recommendation statement. Pediatrics 2011;127:340–6.
4. Multi-ethnic Pediatric Eye Disease Study Group. Prevalence of amblyopia and strabismus in African American and Hispanic children ages 6 to 72 months: The Multi-ethnic Pediatric Eye Disease Study. Ophthalmology 2008;115:1229–36.
5. Friedman DS, Repka MX, Katz J, Giordano L, Ibironke J, Hawse P, Tielsch JM. Prevalence of amblyopia and strabismus in white and African American children aged 6 through 71 months: The Baltimore Pediatric Eye Disease Study. Ophthalmology 2009;116:2128–34.
6. McKean-Cowdin R, Cotter SA, Tarczy-Hornoch K, Wen G, Kim J, Borchert M, Varma R. Prevalence of amblyopia or strabismus in Asian and non-Hispanic white preschool children: Multi-ethnic Pediatric Eye Disease Study. Ophthalmology 2013;120:2117–24.
7. Satterfield D, Keltner JL, Morrison TL. Psychosocial aspects of strabismus study. Arch Ophthalmol 1993;111:1100–5.
8. Mojon-Azzi SM, Kunz A, Mojon DS. Strabismus and discrimination in children: are children with strabismus invited to fewer birthday parties? Br J Ophthalmol 2011;95:473–6.
9. Multi-ethnic Pediatric Eye Disease Study Group. Prevalence of myopia and hyperopia in 6- to 72-month-old African American and Hispanic children: The Multi-ethnic Pediatric Eye Disease Study. Ophthalmology 2010;117:140–7.
10. Giordano L, Friedman DS, Repka MX, Katz J, Ibironke J, Hawes P, Tielsch JM. Prevalence of refractive error among preschool children in an urban population: the Baltimore Pediatric Eye Disease Study. Ophthalmology 2009;116:739–46.
11. Wen G, Tarczy-Hornoch K, McKean-Cowdin R, Cotter SA, Borchert M, Lin J, Kim J, Varma R. Prevalence of myopia, hyperopia, and astigmatism in non-Hispanic white and Asian children: The Multi-ethnic Pediatric Eye Disease Study. Ophthalmology 2013;120:2109–16.
12. Fozailoff A, Tarczy-Hornoch K, Cotter S, Wen G, Lin J, Borchert M, Azen S, Varma R. Prevalence of astigmatism in 6- to 72-month-old African American and Hispanic children: The Multi-ethnic Pediatric Eye Disease Study. Ophthalmology 2011;118:284–93.
13. Ying GS, Maguire MG, Cyert LA, Ciner E, Quinn GE, Kulp MT, Orel-Bixler D, Moore B. Prevalence of vision disorders by racial and ethnic group among children participating in Head Start. Ophthalmology 2014;121:630–6.
14. Holmes JM, Lazar EL, Melia BM, Astle WF, Dagi LR, Donahue SP, Frazier MG, Hertle RW, Repka MX, Quinn GE, Weise KK. Effect of age on response to amblyopia treatment in children. Arch Ophthalmol 2011;129:1451–7.
15. Ibironke JO, Friedman DS, Repka MX, Katz J, Giordano L, Hawse P, Tielsch JM. Child development and refractive errors in preschool children. Optom Vis Sci 2011;88:181–7.
16. Roch-Levecq AC, Brody BL, Thomas RG, Brown SI. Ametropia, preschoolers' cognitive abilities, and effects of spectacle correction. Arch Ophthalmol 2008;126:252–8.
17. Atkinson J, Anker S, Nardini M, Braddick O, Hughes C, Rae S, Wattam-Bell J, Atkinson S. Infant vision screening predicts failures on motor and cognitive tests up to school age. Strabismus 2002;10: 187–98.
18. Hartmann EE, Block SS, Wallace DK; for the National Expert Panel to the National Center for Children's Vision and Eye Health. Vision and eye health in children 36 to <72 months: proposed data system. Optom Vis Sci 2014;91:24–30.
19. Marsh-Tootle WL, Russ SA, Repka MX; for the National Expert Panel to the National Center for Children's Vision Eye Health. Vision and eye health in children 36 to <72 months: proposed data definitions. Optom Vis Sci 2014;91:17–23.
20. Nyong'o OL, Del Monte MA. Childhood visual impairment: normal and abnormal visual function in the context of developmental disability. Pediatr Clin North Am 2008;55:1403–15.
21. Menacker SJ. Visual function in children with developmental disabilities. Pediatr Clin North Am 1993;40:659–74.
22. Shevell M, Ashwal S, Donley D, Flint J, Gingold M, Hirtz D, Majnemer A, Noetzel M, Sheth RD. Practice parameter: evaluation of the child with global developmental delay: report of the Quality Standards Subcommittee of the American Academy of Neurology and The Practice Committee of the Child Neurology Society. Neurology 2003;60:367–80.
23. Das M, Spowart K, Crossley S, Dutton GN. Evidence that children with special needs all require visual assessment. Arch Dis Child 2010; 95:888–92.

24. Ikeda J, Davitt BV, Ultmann M, Maxim R, Cruz OA. Brief report: incidence of ophthalmologic disorders in children with autism. J Autism Dev Disord 2013;43:1447–51.
25. Amblyopia Preferred Practice Pattern ® Guidelines. San Francisco, CA: American Academy of Ophthalmology; 2012:29. Available at: http://one.aao.org/preferred-practice-pattern/amblyopia-ppp-september-2012. Accessed July 28, 2014.
26. Cotter SA, Varma R, Tarczy-Hornoch K, McKean-Cowdin R, Lin J, Wen G, Wei J, Borchert M, Azen SP, Torres M, Tielsch JM, Friedman DS, Repka MX, Katz J, Ibironke J, Giordano L. Risk factors associated with childhood strabismus: The Multi-ethnic Pediatric Eye Disease and Baltimore Pediatric Eye Disease Studies. Ophthalmology 2011; 118:2251–61.
27. Bonamy AK, Holmstrom G, Stephansson O, Ludvigsson JF, Cnattingius S. Preterm birth and later retinal detachment: a population-based cohort study of more than 3 million children and young adults. Ophthalmology 2013;120:2278–85.
28. Vision in Preschoolers Study Group. Preschool vision screening tests administered by nurse screeners compared with lay screeners in the vision in preschoolers study. Invest Ophthalmol Vis Sci 2005;46: 2639–48.
29. American Academy of Pediatrics, American Academy of Ophthalmology, American Association for Pediatric Ophthalmology and Strabismus, American Association of Certified Orthoptists. Instrument-based pediatric vision screening policy statement. Pediatrics 2012; 130:983–6.
30. Schmidt P, Maguire M, Dobson V, Quinn G, Ciner E, Cyert L, Kulp MT, Moore B, Orel-Bixler D, Redford M, Ying GS. Comparison of preschool vision screening tests as administered by licensed eye care professionals in the Vision In Preschoolers Study. Vision in Preschoolers Study Group. Ophthalmology 2004;111:637–50.
31. Huang K, Tarczy-Hornoch K, Borchert M, Azen S, Cotter S, Wen G, Varma R, MEPEDS Study Group, Mckean-Cowdin R, Torres M. The Brückner test: detection of strabismus & amblyopia in infants & young children. Optom Vis Sci 2012;89:E-abstract 120023.
32. Macaskill P, Walter SD, Irwig L, Franco EL. Assessing the gain in diagnostic performance when combining two diagnostic tests. Stat Med 2002;21:2527–46.
33. Bailey IL, Lovie JE. New design principles for visual acuity letter charts. Am J Optom Physiol Opt 1976;53:740–5.
34. Fern KD, Manny RE. Visual acuity of the preschool child: a review. Am J Optom Physiol Opt 1986;63:319–45.
35. Anstice NS, Thompson B. The measurement of visual acuity in children: an evidence-based update. Clin Exp Optom 2014;97:3–11.
36. Lippmann O. Vision of young children. Arch Ophthalmol 1969;81: 763–75.
37. Friendly D. Preschool visual acuity screening tests. Trans Am Ophthalmol Soc 1978;76:383–480.
38. Hyvärinen L, Näsänen R, Laurinen P. New visual acuity test for preschool children. Acta Ophthalmol (Copenh) 1980;58:507–11.
39. Cyert L, Schmidt P, Maguire M, Moore B, Dobson V, Quinn G. Threshold visual acuity testing of preschool children using the crowded HOTV and Lea symbols acuity tests. J AAPOS 2003;7:396–9.
40. Hered RW, Murphy S, Clancy M. Comparison of the HOTV and Lea Symbols charts for preschool vision screening. J Ophthalmic Nurs Technol 1997;16:68–73.
41. Vision in Preschoolers (VIP) Study Group. Effect of age using Lea symbols or HOTV for preschool vision screening. Optom Vis Sci 2010;87:87–95.
42. Friedman DS, Repka MX, Katz J, Giordano L, Ibironke J, Hawes P, Burkom D, Tielsch JM. Prevalence of decreased visual acuity among preschool-aged children in an American urban population: The Baltimore Pediatric Eye Disease Study, methods, and results. Ophthalmology 2008;115:1786–95.
43. Pai AS, Rose KA, Leone JF, Sharbini S, Burlutsky G, Varma R, Wong TY, Mitchell P. Amblyopia prevalence and risk factors in Australian preschool children. Ophthalmology 2012;119:138–44.
44. Cotter SA, Tarczy-Hornoch K, Wang Y, Azen SP, Dilauro A, Borchert M, Varma R. Visual acuity testability in African-American and Hispanic children: the multi-ethnic pediatric eye disease study. Am J Ophthalmol 2007;144:663–7.
45. Holmes JM, Beck RW, Repka MX, Leske DA, Kraker RT, Blair RC, Moke PS, Birch EE, Saunders RA, Hertle RW, Quinn GE, Simons KA, Miller JM. The amblyopia treatment study visual acuity testing protocol. Arch Ophthalmol 2001;119:1345–53.
46. Moke PS, Turpin AH, Beck RW, Holmes JM, Repka MX, Birch EE, Hertle RW, Kraker RT, Miller JM, Johnson CA. Computerized method of visual acuity testing: adaptation of the amblyopia treatment study visual acuity testing protocol. Am J Ophthalmol 2001; 132:903–9.
47. Pediatric Eye Disease Investigator Group. A randomized trial of atropine vs. patching for treatment of moderate amblyopia in children. Arch Ophthalmol 2002;120:268–78.
48. Vision in Preschoolers Study Group. Preschool visual acuity screening with HOTV and Lea symbols: testability and between-test agreement. Optom Vis Sci 2004;81:678–83.
49. Pick HL, Eleanor J. Gibson: Learning to perceive and perceiving to learn. Dev Psychol 1992;28:787–94.
50. Mocan MC, Najera-Covarrubias M, Wright KW. Comparison of visual acuity levels in pediatric patients with amblyopia using Wright figures, Allen optotypes, and Snellen letters. J AAPOS 2005; 9:48–52.
51. Mayer DL, Gross RD. Modified Allen pictures to assess amblyopia in young children. Ophthalmology 1990;97:827–32.
52. Simons K. Visual acuity norms in young children. Surv Ophthalmol 1983;28:84–92.
53. Flom MC, Weymouth FW, Kahneman D. Visual resolution and contour interaction. J Opt Soc Am 1963;53:1026–32.
54. Flom MC, Heath GG, Takahashi E. Contour interaction and visual resolution: contralateral effects. Science 1963;142:979–80.
55. Committee on Vision. Recommended standard procedures for the clinical measurement and specification of visual acuity. Report of working group 39. Assembly of Behavioral and Social Sciences, National Research Council, National Academy of Sciences, Washington, D.C. Adv Ophthalmol 1980;41:103–48.
56. Borchert M, Wang Y, Tarczy-Hornoch K, Cotter S, Deneen J, Azen S, Varma R. Testability of the Retinomax autorefractor and IOLMaster in preschool children: the Multi-ethnic Pediatric Eye Disease Study. Ophthalmology 2008;115:1422–5.
57. Pai AS, Rose KA, Samarawickrama C, Fotedar R, Burlutsky G, Varma R, Mitchell P. Testability of refraction, stereopsis, and other ocular measures in preschool children: the Sydney Paediatric Eye Disease Study. J AAPOS 2012;16:185–92.
58. Vision in Preschoolers Study Group. Findings from the Vision in Preschoolers (VIP) Study. Optom Vis Sci 2009;86:619–23.
59. Matta NS, Singman EL, Silbert DI. Performance of the plusoptiX S04 photoscreener for the detection of amblyopia risk factors in children aged 3 to 5. J AAPOS 2010;14:147–9.
60. Dahlmann-Noor AH, Vrotsou K, Kostakis V, Brown J, Heath J, Iron A, McGill S, Vivian AJ. Vision screening in children by Plusoptix Vision Screener compared with gold-standard orthoptic assessment. Br J Ophthalmol 2009;93:342–5.

61. Paff T, Oudesluys-Murphy AM, Wolterbeek R, Swart-van den Berg M, de Nie JM, Tijssen E, Schalij-Delfos NE. Screening for refractive errors in children: the plusoptiX S08 and the Retinomax K-plus2 performed by a lay screener compared to cycloplegic retinoscopy. J AAPOS 2010;14:478–83.
62. Mirzajani A, Heirani M, Jafarzadehpur E, Haghani H. A comparison of the Plusoptix S08 photorefractor to retinoscopy and cycloretinoscopy. Clin Exp Optom 2013;96:394–9.
63. Ayse YK, Onder U, Suheyla K. Accuracy of Plusoptix S04 in children and teens. Can J Ophthalmol 2011;46:153–7.
64. Arthur BW, Riyaz R, Rodriguez S, Wong J. Field testing of the plusoptiX S04 photoscreener. J AAPOS 2009;13:51–7.
65. Nathan NR, Donahue SP. Modification of Plusoptix referral criteria to enhance sensitivity and specificity during pediatric vision screening. J AAPOS 2011;15:551–5.
66. Donahue SP, Arnold RW, Ruben JB. Preschool vision screening: what should we be detecting and how should we report it? Uniform guidelines for reporting results of preschool vision screening studies. J AAPOS 2003;7:314–6.
67. Singman E, Matta N, Tian J, Silbert D. A comparison of referral criteria used by the PlusoptiX photoscreener. Strabismus 2013;21: 190–4.
68. Donahue SP, Arthur B, Neely DE, Arnold RW, Silbert D, Ruben JB. Guidelines for automated preschool vision screening: a 10-year, evidence-based update. J AAPOS 2013;17:4–8.
69. Simon JW, Siegfried JB, Mills MD, Calhoun JH, Gurland JE. A new visual evoked potential system for vision screening in infants and young children. J AAPOS 2004;8:549–54.
70. Hunter DG, Nassif DS, Piskun NV, Winsor R, Gramatikov BI, Guyton DL. Pediatric Vision Screener 1: instrument design and operation. J Biomed Opt 2004;9:1363–8.
71. Loudon SE, Rook CA, Nassif DS, Piskun NV, Hunter DG. Rapid, high-accuracy detection of strabismus and amblyopia using the pediatric vision scanner. Invest Ophthalmol Vis Sci 2011;52: 5043–8.
72. Vision in Preschoolers Study Group. Does assessing eye alignment along with refractive error or visual acuity increase sensitivity for detection of strabismus in preschool vision screening? Invest Ophthalmol Vis Sci 2007;48:3115–25.
73. Vision in Preschoolers Study Group. Children unable to perform screening tests in vision in preschoolers study: proportion with ocular conditions and impact on measures of test accuracy. Invest Ophthalmol Vis Sci 2007;48:83–7.

Susan Cotter
Southern California College of Optometry at
Marshall B. Ketchum University
2575 Yorba Linda Blvd
Fullerton, CA 92831
e-mail: scotter@ketchum.edu