A Systematic Review of Vision Screening Tests for the Detection of Amblyopia

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Abstract. ***Objective.*** **To review the test characteristics and the quality of evidence regarding available screening tests for the detection of amblyopia in preschool-aged children to help primary care practitioners select a screening strategy.**

Design. **Systematic review of published studies.**

Data Sources. **The MEDLINE database was searched from 1966 through January 1999 using a broad and inclusive strategy. A total of 9551 citations were identified.**

Study Selection. **All studies that compared the results of commercially available screening tests in preschool-aged children to ophthalmologic examination.**

Data Extraction. **The setting of the study, the age of the population, the type of screening test, criteria for a positive screen, criteria for the ophthalmologic examination, test characteristics, and measures of reliability were abstracted by 2 reviewers for each selected study.**

Data Synthesis. **Four eligible articles were identified that studied the test characteristics of 3 screening tests. None of these studies were performed in a primary care setting. Each study used different criteria for failure of the ophthalmologic examination. None of the studies measured observer or test reliability.**

Conclusions. **Few high-quality data exist regarding the performance of preschool vision screening. Important future work should include the development of a consensus gold standard ophthalmologic examination and evaluation of screening tests in the primary care setting.** ***Pediatrics*** **1999;104:1220–1222;** ***vision screening tests, amblyopia, preschool-aged children.***

Amblyopia is the leading cause of monocular vision loss in adults between 20 and 70 years old.[1] Both the US Preventive Services Task Force[2] and the American Academy of Pediatrics[3] recommend screening all children between 3 and 4 years of age for amblyopia and strabismus. Unfortunately, although the prevalence of amblyopia is between 2% and 5%,[2] many children do not receive vision screening.[4]

Two approaches are available to primary care providers to screen for amblyopia: traditional vision screening and photorefractive screening (photoscreening). Traditional vision screening tests are based on the identification of symbols. Despite the availability of many different traditional vision screening tests, no consensus exists regarding which test performs best in the primary care setting. Photoscreening is based on the interpretation of photographic images of the eyes for defects that could potentially lead to amblyopia. Although these findings may be associated with amblyopia, photoscreening does not detect amblyopia directly. The objective of this study was to review the performance of these screening tests. Unlike previous studies,[1,5] this article systematically reviews the evidence regarding tests available to the primary care practitioner.

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METHODS

The MEDLINE database was searched from 1966 through January 1999 using several exploded subject headings (vision tests, amblyopia, strabismus, refractive errors, visual acuity, or cataract), limited to the English language, human studies, and to age ≤12 years. All studies potentially concerned with preschool vision screening were retrieved. We reviewed the bibliographies of these references for other studies of preschool vision screening that the initial MEDLINE search did not identify. Studies were included if they evaluated vision screening tests available to the practicing physician and did not require procedures uncommon in the primary care setting, such as pharmacologic dilation. Because current guidelines[2,3] call for formal screening during the preschool years, we included only studies in which the population had an average age between 2 and 5 years, studies in which a subpopulation within this age range could be separately evaluated, or studies that did not report an average age but evaluated an age range within the preschool years.

Only high-quality studies that met the following criteria were included: all or a random sample of those who passed and all those who failed the screening test must have received a formal "gold standard" ophthalmologic examination; the person performing the ophthalmologic examination must be masked as to the outcome of the screening; the person performing the screening must be masked to the ocular status of the study subject; and, the criteria used for an abnormal ophthalmologic examination must be defined within the article.[6] To ensure accuracy, 2 readers abstracted each study. Differences were resolved by consensus.

RESULTS

The search identified 9551 citations. Thirty-three articles providing information on preschool vision screening that potentially met the criteria for inclusion were identified and retrieved. Review of bibliographies in these articles did not identify other studies for inclusion. Four articles met all inclusion criteria. The other 29 articles were excluded for the following reasons: they evaluated a screening test that is not commercially available ($n = 6$); had study populations too old ($n = 9$), too young ($n = 2$), or without specified age ($n = 1$); did not

fully describe the ophthalmologic examination ($n = 6$), or did not apply the examination in an equal fashion to all subjects ($n = 1$); or lacking masking ($n = 4$). Of the 4 included studies, 1 addressed traditional vision screening[7] and 3 addressed photoscreening.[8–10] Table 1 summarizes the test characteristics. Because both the gold standard ophthalmologic examination and the research setting varied across all studies, the criteria for abnormal ophthalmologic examination and the prevalence of children with abnormal examinations are also noted in Table 1.

The 1 study of traditional vision screening that met all inclusion criteria[7] also evaluated a photoscreener that is not commercially available. The traditional vision screening component of the study screened 1245 kindergarten children for both visual and stereo acuity. Visual acuity was assessed with the Snellen E chart or with Stycar graded balls if a child could not perform the Snellen E. Stereoacuity was assessed with the Titmus stereotest. Screening failure was visual acuity less than 20/40 in either eye or stereoacuity <80 seconds of arc. All failures and a 20% random sample of those who passed the screening test received formal ophthalmologic evaluation, which included visual acuity assessment, again with the Snellen E or Stycar tests, and refraction without cycloplegia. Overall, 99% of children were successfully screened. Those who could not be screened had unspecified "handicaps." The article provides no information regarding the reasons that children failed screening, such as the percentage who failed only visual acuity testing, those who failed stereo acuity testing, or those who failed both.

In 1 study of the MTI Photoscreener (Medical Technology and Innovations, Inc, Lancaster, PA),[10] 1003 children (average age of 28.7 months) received screening in either public health clinics or the offices of private pediatricians. The study authors took and interpreted all photographs, according to the manufacturer's directions. All children who had interpretable photographs (97%) received a full ophthalmologic examination.

Two studies addressed photoscreening with the Visiscreen 100 (Vision Research Corporation, Birmingham, AL). The first[9] studied 63 children (3 months to 8 years of age) who were undergoing complete eye examinations. The photographs were taken by technicians and analyzed by the manufacturer. The ophthalmology examination consisted of refraction with cycloplegia. Photographs were analyzable for 90% of the children.

The second Visiscreen 100 study[8] evaluated 127 children (6 months to 6 years of age) recruited through newspaper advertisements. The photographs were taken by technicians and interpreted by the authors. The ophthalmologic examination consisted of visual acuity assessment, when possible, and refraction with cycloplegia. Photographs were analyzable for 89% of the children.

None of the studies addressed observer or test reliability. None of the studies reported the trade-off between sensitivity and specificity with changes in the cutoff for a positive screening.

DISCUSSION

Despite the great number of screening tests available, this systematic review found only 1 high-quality study of traditional vision screening and 3 of photoscreening. None of the 4 studies took place in primary care settings using usual screening procedures, and thus generalization of these articles to the primary care setting is difficult. Furthermore, each article used a different ophthalmologic examination standard to evaluate the screening test, making comparisons across studies challenging.

There are several important limitations of this analysis. Articles not indexed by MEDLINE, not referenced in the articles selected for review, or not in English would not be included in this review. This review included only articles meeting stringent criteria for evidence.

This review identified several problems with the current evidence regarding vision screening. Perhaps the most important is the variation in the gold standard ophthalmologic examination. The ophthalmologic examination should reflect the goals of screening. If the goal is primary prevention of amblyopia, an examination for potentially amblyogenic factors might suffice. Unfortunately, the significance and natural course of these factors are not clear.[5] If the goal of screening is secondary prevention of amblyopia, then

TABLE 1. Summary of Test Characteristics, Criteria for an Abnormal Ophthalmologic Examination, and Prevalence

Test	Sensitivity	Specificity	Ophthalmologic Examination	Prevalence	Reference
Titmus Stereotest and either Snellen E or Stycar graded balls	9%–12.5%	99%	A	6%	7
MTI Photoscreener	75.4%	89.8%	B	20%	10
	81.8%	90.6%	C	*	10
Visiscreen 100	85%	94%	D	60%	8
	91%	74%	E	12%	9

Prevalence is the percentage that failed the criteria for the ophthalmologic exam within each particular study.
* Prevalence not reported.
A, Visual acuity <20/30 in either eye; strabismus; corneal, lens, or fundus abnormality; refractive error >3.00 diopters sphere; astigmatism >2.00 diopters; B, Strabismus; corneal, lens, or fundus abnormality; myopia >1.00 diopter; hyperopia >2.75 diopters; astigmatism >1.00 diopter; anisometropia >1.50 diopters; C, Myopia ≥1.00 diopter; hyperopia ≥2.50 diopters; Anisometropia >1.00 diopter; astigmatism >2.00 diopters for children <12 months or >1.50 diopters for those >12 months; D, Myopia ≥1.00 diopter; hyperopia ≥2.50 diopters; astigmatism >2.00 diopters; anisometropia >1.00 diopter; E, Myopia >5.00 diopters; hyperopia >4.00 diopters; astigmatism >2.00 diopters; anisometropia >1.00 diopter.

the opthalmologic examination should include acuity measurement. If the goal of preschool vision screening is not only to prevent amblyopia but also to treat other ocular pathology, such as nonamblyogenic refractive errors, then formal eye examination and measure of acuity should be performed. Only 1 study included in this review,[7] the study of traditional vision screening, included measurement of visual acuity as part of the ophthalmologic examination. The apparent poor performance of traditional vision screening might reflect the fact that the studies of photoscreening did not include measures of visual acuity in the gold standard examination.

Evaluating screening tests in high prevalence populations may overestimate diagnostic accuracy.[11] Furthermore, none of these studies measured reliability. There is evidence of considerable interobserver variability in the interpretation of photoscreening results when used by nonexperts.[12] Poor reliability in the application of a test will decrease diagnostic accuracy.[13,14]

Another important factor that has not been evaluated is the relationship between the threshold for referral and the test characteristics. The American Academy of Pediatrics has specific guidelines for referral of children for ophthalmologic evaluation.[3] However, the referral guidelines do not specify any particular test, and tests may vary on the optimum threshold value that would maximize sensitivity while allowing adequate specificity.

The available data help the primary care provider only minimally. We recommend the evaluation of vision screening tests in primary care settings using a standardized ophthalmologic examination.

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