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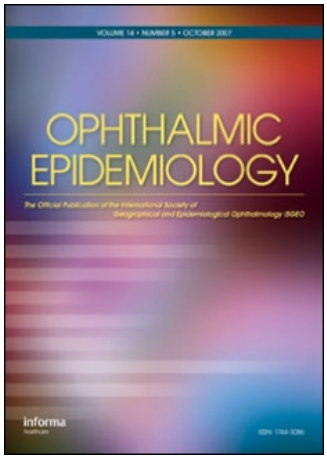

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Refractive Errors in Low-Income Preschoolers

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Refractive Errors in Low-Income Preschoolers

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ABSTRACT

Purpose: **To estimate the overall prevalence of refractive errors in a study population of low-income preschoolers in San Diego County.** ***Methods:*** **The study sample included 507 preschool children selected from a study population of all 3–5 year-old children in Head Start and San Diego Unified School District preschools (74% Latino). The sample was examined by optometrists in the mobile clinic of the University of California, San Diego, Department of Ophthalmology with retinoscopy under cycloplegia to assess the presence of refractive errors defined as myopia $\geq$2D in 3–4 year-olds and $\geq$1D in $>$4 year-olds; hyperopia $\geq$4D in 3–4 year-olds and $\geq$3D in $>$4 year-olds; and astigmatism $\geq$1.75D in 3–4 year-olds and $\geq$1.5D in $>$4 year-olds. Anisometropia was defined as $\geq$1.25D difference between the eyes. Emmetropia was defined as refractive errors below these levels.** ***Results:*** **A total of 16% (n = 81 children) (95% confidence interval: 15.4–16.5) met study definitions of refractive errors in at least one eye. Myopia was found in 3%, (OD Mean Sphere = 2.4D); hyperopia in 7.5% (OD Mean Sphere = 3.8D); astigmatism in 5.5% (OD Mean Cylinder = 2.3D); and 84% were emmetropic (OD Mean Sphere = 1.3D).** ***Conclusions:*** **Hyperopia and astigmatism were the most frequent refractive errors in this sample of low-income preschoolers, most of whom were Latino.**

INTRODUCTION

There have been a few studies examining the prevalence of refractive errors in school age children of various ethnicities.[1–6] The Vision in Preschoolers (VIP) Study has studied a multiethnic group of Head Start children with the goal of determining the most effective methods of vision screening.[7,8] Prevalence data from that study was based on an enriched sample that included all vision screening failures and a random sample of those who passed routine vision screening. Thus, the VIP Study sample by design contained more vision problems than would be expected in the total study population of Head Start children.

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To date there have been no published studies with the objective of determining the prevalence of refractive errors in a multiethnic population of preschoolers.[9] However, this age group may be the most susceptible to developmental consequences of refractive error.[10,11] Timely identification and intervention when certain refractive errors are detected may be important to maintain good vision.

Within the United States, two studies exemplify that minority racial/ethnic groups' visual problems may be under diagnosed. The Medical Expenditure Panel Survey,[12] a study of diagnosed eye and vision conditions in children under 18 years of age, determined that Latino children were less likely to have been diagnosed with a vision or eye condition compared to Caucasian children. Another report[13] found that Latino children were less likely than children of other ethnicities to have had vision screening.

The purpose of the present study was to estimate the overall prevalence of refractive errors in a sample of preschool children 3–5 years of age attending 2 large publicly funded preschool programs in San Diego County, California. The children were enrolled in Head Start (3rd largest Head Start in the nation) or San Diego Unified School District (6th largest school district in the nation) preschools for low-income children. Both organizations have similar income-based eligibility criteria and multiethnic enrollments. The children attending these multiethnic preschools were from low-income families; the majority were Latino.

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MATERIALS AND METHOD

Study design and participants

The protocol for this study was approved by the University of California, San Diego (UCSD) Human Research Protections Program Institutional Review Board and the Human Subjects Research Committees for the Neighborhood House Association Head Start and the San Diego Unified School District.

To estimate prevalence of refractive errors, a study sample of 507 children (enrolled at 19 preschool locations in all 6 regions of San Diego County, in proportion to the low-income child population of the regions) received vision screening plus a full examination, regardless of the screening result. The study sample was representative of the total study population of the screened 16,399 children on the basis of age, ethnicity, race, gender, and organization (Table 1). The sample of 507 included 100% of the children attending the preschools between January and October 2002 (n = 174), and when additional funding was received, between January and June 2004 (n = 333).

Inclusion criteria for the study sample were the following:

1) a child enrolled in a preschool of Head Start or San Diego Unified School District;
2) 3 to 5 years of age, inclusive;
3) parental consent; and
4) eye examination under cycloplegia.

Ophthalmic testing

The eye examinations of the 507 children in the study sample were performed in an examination room with lighting maintained at a standard protocol level in the mobile clinic of the UCSD Department of Ophthalmology. Optometrists with extensive experience with preschool children conducted the examinations in accordance with the study protocol.

Table 1. Descriptive characteristics

Demographic variables	Study sample* N = 507	Overall study population** N = 16399
Age at Screening (years)	N %	N %
3	43 (8.5)	2344 (14.3)
4	243 (47.7)	7714 (47)
5	222 (43.8)	6341 (38.7)
Hispanic	374 (73.8)	11039 (67.3)
Caucasian	51 (10.1)	2017 (12.3)
African-American	42 (8.3)	2214 (13.5)
Asian	29 (5.7)	935 (5.7)
Other	11 (2.2)	197 (1.2)
Gender: Female	253 (49.9)	8173 (49.8)
Organization		
Head Start	286 (56.4)	9734 (59.4)
SDCS-Preschool	221 (43.6)	6665 (40.6)

*Received vision screening and eye examination including retinoscopy with cycloplegia.
**Received vision screening.

Distance visual acuity was measured without correction before cycloplegia using the B-VAT PC.[14] A minimum of 30 minutes prior to retinoscopy, one drop of proparacaine was instilled into each eye. A minute later cycloplegia was induced with one drop of a combination of phenylephrine (1.6%), tropicamide (0.167%), and cyclopentolate (1.3%).[15–21]

Retinoscopy was performed with a Welch-Allyn streak retinoscope while the child looked through fogging lenses (+1.50 sphere). The child was asked to fixate on a distant target set at 20/400. The refractive error was assessed by using a Reichert phoroptor to neutralize the two principal meridians of each eye, beginning with the right eye. The working distance power was then subtracted leaving the full cycloplegic retinoscopy. The cycloplegic retinoscopy values were used to determine refractive errors defined below.

Refractive error definitions

The primary definition of refractive error (Figure 1, Definition 1[22–24]) used in the analyses was myopia ≥2D in 3–4 year-olds and ≥1D in >4 year-olds; hyperopia ≥4D in 3–4 year-olds and ≥3D in >4 year-olds; and astigmatism ≥1.75D in 3–4 year-olds and ≥1.50D in >4 year-olds. Anisometropia was defined as ≥1.25D difference between the eyes. Emmetropia was defined as refractive errors below these levels. These definitions correspond with a level equal to or greater than considered clinically useful to detect in the Vision in Preschoolers Study[7] and that may be corrected with glasses in clinical practice.[22–24]

Refractive error	*Definition 1: Clinically useful to detect	**Definition 2: Very important to detect and treat
Myopia		
3-4 year old	≥ 2D	≥ 3D
> 4 years old	≥ 1D	≥ 2D
Hyperopia		
3-4 year old	≥ 4D	≥ 5D
> 4 years old	≥ 3D	≥ 4.5D
Astigmatism		
3-4 year old	≥ 1.75D	≥ 2.5D
> 4 years old	≥ 1.5D	≥ 2D
Anisometropia	≥ 1.25D	≥ 2D

*Corresponds to level equal to or greater than considered clinically useful to detect in the Vision in Preschoolers Study[7]
**Corresponds to level considered to be very important to detect and treat early in the Vision in Preschoolers Study[7]

Figure 1. Refractive error definitions.[22–24]

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In addition, an overall prevalence of refractive error also was estimated at higher levels; i.e., levels considered to be very important to detect and treat early[7] and at which glasses are almost always prescribed.[22–24] This higher level, Definition 2 (Figure 1, Definition 2[22–24]) in the present study, was myopia ≥3D in 3–4 year-olds and ≥2D in >4 year-olds; hyperopia ≥5D in 3–4 year-olds and ≥4.5D in >4 year-olds; and astigmatism ≥2.5D in 3–4 year-olds and ≥2D in >4 year-olds. Anisometropia was defined as ≥2D difference between the eyes.

Children were first evaluated in terms of myopia and hyperopia based on the eye with the largest spherical value. If the child did not meet the criteria for myopia or hyperopia in either eye, then the presence of astigmatism in cylinder diopters was determined. In addition and separately, we examined the refractive error of the children who had been first classified as meeting the criteria for myopia or hyperopia to determine the subset that also met the criteria for astigmatism.

Also, the refractive errors that met Definition 1 were subgrouped by using the optical cross method to describe both principal meridians. Thus, these refractive errors were further categorized[1] as:

1) simple myopia (i.e., myopia without astigmatism);
2) compound myopic astigmatism (i.e., astigmatism in which the two principal meridians of an eye are both myopic);
3) simple hyperopia (i.e., hyperopia without astigmatism);
4) compound hyperopic astigmatism (i.e., astigmatism in which the two principal meridians of an eye are both hyperopic);
5) simple myopic astigmatism (i.e., astigmatism in which one principal meridian is myopic and the other emmetropic, or in which both principal meridians are myopic);
6) simple hyperopic astigmatism (i.e., astigmatism in which one principal meridian is hyperopic and the other emmetropic, or in which both principal meridians are hyperopic); and
7) mixed astigmatism (i.e., astigmatism in which one principal meridian is hyperopic and the other myopic).

Statistical analysis

Statistical analyses were conducted using Statistica for Windows, version 6.1 (Statsoft, Tulsa, OK). Sample size calculations for this study were based on the protocol by Negrel et al.[3] Hence, an anticipated 22% prevalence rate of refractive error with a 2% error rate resulted in an estimated sample size of 340 subjects (95% CI, 304–386). Therefore, with a sample size of 507 children, we had power to address the overall prevalence as the primary hypothesis. Subgroup differences were examined as exploratory analyses.

Continuous variables were compared between the study sample and overall study population using a two-sample t-test, or a Wilcoxon Rank Sum test whenever the normality assumption did not hold. Discrete variables were compared using Chi Square and Fisher's Exact Test.

The prevalence of each type of refractive error was calculated as a ratio (the number of children with each type of refractive error as a fraction of the whole sample of 507 children) and reported with a 95% confidence interval, assuming a normal distribution. Differences in spherical equivalents and visual acuity, transformed into LogMAR, were examined using t-test or one-way ANOVA when assumptions of normality and homogeneity of variances were met. Otherwise, Mann-Whitney Rank Sum or Kruskal-Wallis ANOVA was used. Multiple comparisons were not made. Probabilities of 0.05 were considered to be statistically significant.

Correlations between amount of refractive errors expressed in spherical equivalents and visual acuity expressed in LogMAR were examined using Pearson's *r* or Spearman's *rho* if assumption of normality was not satisfied.

RESULTS

Demographic characteristics of the study sample compared to the overall study population

There were no differences in demographic characteristics between the study sample of 507 children and the overall study population of 16,399 children in age, ethnicity, gender, and preschool organization (Table 1). All comparisons of demographic characteristics yielded p-values of 0.18 or larger.

Primary analysis

Using Definition 1 (Figure 1) for the study sample of 507 preschoolers yielded an overall prevalence of refractive error of 16% (n = 81) (95% CI, 15.4–16.5). Most children were found to be emmetropic, 84% (n = 426), i.e., no myopia, hyperopia, or astigmatism.

The prevalence of refractive errors in at least one eye by Definition 1 was as follows:

a) myopia, 3% (n = 15) (95% CI, 2.7–3.2). Most of these children (n = 11) had a combination of myopia and astigmatism, (i.e., mixed astigmatism or compound myopic astigmatism),
b) hyperopia, 7.5% (n = 38) (95% CI, 7.1–7.9). Of these children (n = 6) had a combination of hyperopia and astigmatism (i.e., mixed astigmatism or compound hyperopic astigmatism); and
c) astigmatism alone, 5.5% (n = 28) (95% CI, 4.7–6.3) (Table 2).

In this study sample, 8.9% (n = 45) (95% CI, 8.4–9.3) had astigmatism alone or with myopia or hyperopia (Table 3). Anisometropia was found in 7.3% of the sample (n = 37) (95% CI, 6.9–7.6) (Table 3).

Most of the 81 children with refractive error were affected with simple hyperopia and compound hyperopic astigmatism (52%), followed by mixed astigmatism (37%) (Figure 2). Figure 3 shows the distribution of refractive errors in spherical equivalent (SE) refraction. Significantly more children were hyperopic than myopic, ($p < .001$). Using Definition 2, (Figure 1)

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Table 2. Clinical characteristics of children with refractive errors (Definition 1*) by type N = 507

	Myopia (n = 15)	Hyperopia (n = 38)	Astigmatism (n = 28)	Emmetropia (n = 426)
Mean OD Sphere				
Mean ± (SD)	−2.40 (1.78)	3.8 ± (1.2)	0.8 ± (1.2)	1.3 ± (0.75)
Median (Range)	−2.25 (−6.75, 0.5)	3.7 (2.6.75)	0.9 (−1, 3.25)	1.25 (−1.25, 3.5)
Mean OD Cylinder				
Mean ± (SD)	2.13 (1.21)	0.55 ± (0.85)	2.15 ± (1)	0.24 ± (0.3)
Median (Range)	2.25 (0, 4)	0.5 (0, 4)	1.9 (0.5, 4.5)	0 (0, 1.5)
OD Spherical Equivalents				
Mean ± (SD)	−1.3 ± (1.75)	4.12 ± (1.3)	1.9 ± (1.1)	1. 4 ± (0.7)
Median (Range)	−0.625 (−6, .875)	3.9 (2, 7)	1.8 (−0.25, 4)	1.5 (−1.1, 3.5)
OD LogMAR Visual Acuity				
Mean ± (SD)	0.60 ± (0.29)	0.36 ± (0.30)	0.5 ± (0.25)	0.22 ± (0.18)
Median (Range)	0.48 (0.3, 1.3)	0.30 (0, 1.3)	0.48 (0, 1)	0.18 (0, 0.7)
Mean OS Sphere				
Mean ± (SD)	−2.5 ± (1.7)	3.9 ± (1.2)	0.8 ± (1.3)	1.3 ± (0.8)
Median (Range)	−2.25 (−5.25, −0.25)	3.5 (2.25, 8)	0.9 (−1.5, 3.75)	1.25 (−1.25, 3.5)
Mean OS Cylinder				
Mean ± (SD)	2.15 ± (1.2)	0.65 ± (0.9)	2.5 ± (1.2)	0.3 ± (0.35)
Median (Range)	2.5 (0.25, 4.25)	0.5 (0, 4)	2.1 (0.5, 5.25)	0.25 (0, 1.5)
OS Spherical Equivalents				
Mean ± (SD)	−1.4 ± (1.6)	4.3 ± (1.3)	2 ± (1.16)	1.5 ± (0.75)
Median (Range)	−1 (−4.4, 0.5)	4 (2.25, 8.1)	1.9 (0, 4.9)	1.5 (−1.25, 4)
OS LogMAR Visual Acuity				
Mean ± (SD)	0.72 ± (0.32)	0.37 ± (0.27)	0.55 ± (0.2)	0.22 ± (0.13)
Median (Range)	0.54 (0.48, 1.3)	0.30 (0, 1.3)	0.54 (0.1, 1)	0.18 (0,1)

*See Figure 1.
Note: Children were first evaluated in terms of myopia and hyperopia based on the eye with the largest spherical value. If the child did not meet the criteria for myopia or hyperopia in either eye, then the presence of astigmatism in cylinder diopters was determined. In addition and separately, we examined the children who had been first classified on the basis of meeting the criteria for myopia or hyperopia to determine the subset that also met the criteria for astigmatism. See Table 3.

the prevalence of refractive errors was 5.5% (n = 28) (95% CI, 4.7–6.3).

Correlations between visual acuity and type of refractive error

Correlations between visual acuity expressed in LogMAR and amount of refractive error expressed in spherical equivalents for the sample (N = 507) and for the subsample of children with refractive errors (n = 81) were statistically significant but weak ($rs \leq .25, .30$, respectively) (Table 4). Correlations by type of refractive error were consistently high for myopia, $rho(15) \leq -.55$, and hyperopia, $rho(38) \geq .61$, compared to emmetropia, $rho(426) \geq .06$.

Exploratory secondary analyses

Rate of refractive error for Latinos vs. non-Latinos

There was no difference in overall prevalence of refractive errors between the Latino and non-Latino preschool children, 59/374 (15.8%) vs. 22/133 (16.5%), $p = .94$. Proportionally more non-Latino children (15/133 = 12%) were hyperopic compared to Latino children (23/374 = 6.1%), $p = .025$.

Differences between genders

The overall difference in prevalence of refractive error (male: 20.6%, n = 52 vs. female: 17.7%, n = 45) was not significant, $p = .40$. Proportionally more females were found to have hyperopia (21/253 = 8.3% for females vs. 17/254 = 6.7% for males) while proportionally more males were myopic (10/254 = 3.9% for males vs. 5/253 = 2% for females). The difference was statistically significant only across conditions, (8.3% for females having hyperopia vs. 3.9% for males having myopia, $p = .04$).

DISCUSSION

A study sample of 507 low-income children attending public preschools received eye examinations with retinoscopy under cycloplegia. Sixteen percent of the sample had refractive errors at a level considered to be clinically useful to detect in preschool children in the Vision in Preschoolers Study.[7] A total of 5.5% of the sample had refractive errors at a level considered very important to detect early and treat with glasses.[7] While glasses are not always prescribed at the former level, they are almost always prescribed at the latter level.[24]

The results of this study were limited to a sample of preschool children of a larger study population of low-income preschool

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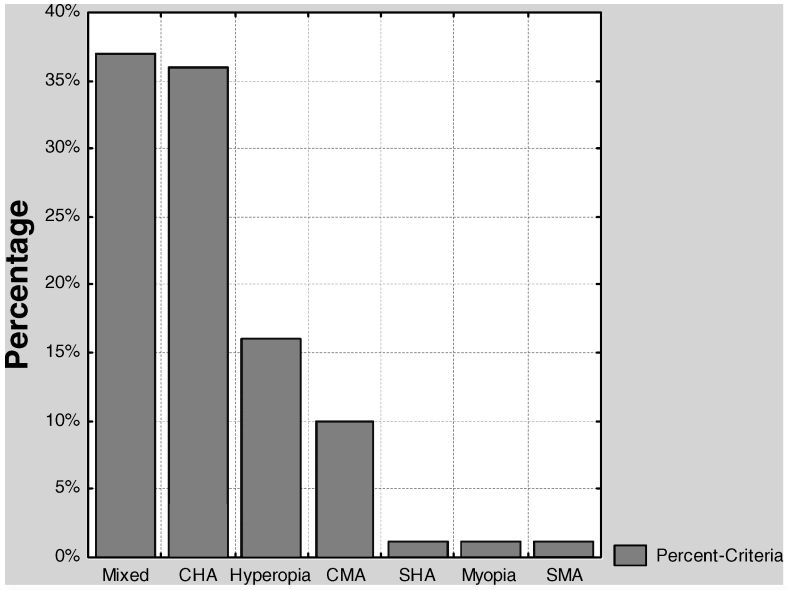

Mixed = Mixed Astigmatism (i.e., astigmatism in which one principal meridian is hyperopic and the other myopic).
CHA= Compound Hyperopic Astigmatism (i.e., astigmatism in which the two principal meridians of an eye are both hyperopic).
Hyperopia = Simple Hyperopia (i.e., hyperopia without astigmatism).
CMA = Compound Myopic Astigmatism (i.e., astigmatism in which the two principal meridians of an eye are both myopic).
SHA = Simple Hyperopic Astigmatism (i.e., astigmatism in which one principal meridian is hyperopia and the other emmetropic, or in which both principal meridians are hyperopic).
Myopia = Simple Myopia (i.e., myopia without astigmatism).
SMA = Simple Myopic Astigmatism (i.e., astigmatism in which one principal meridian is myopic and the other emmetropic, or in which both principal meridians are myopic).

Figure 2. Refractive error categories using Definition 1 and optical cross categorization method (n = 81).

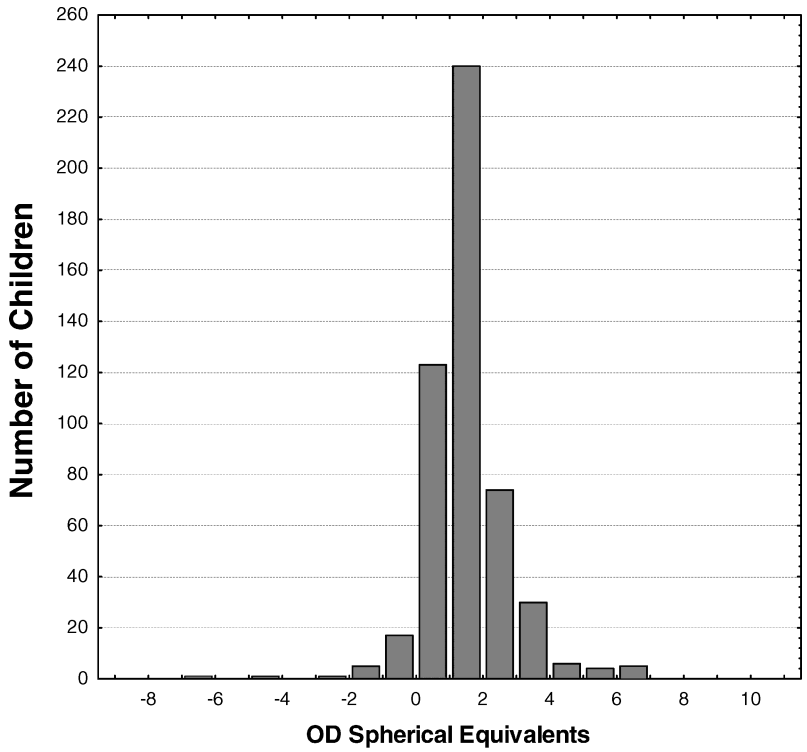

Figure 3. Distribution of spherical equivalents with cycloplegia.

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Table 3. Clinical characteristics of children with astigmatism or anisometropia* and other refractive errors (Definition 1)

	Astigmatism and astigmatism with myopia or hyperopia (n = 45)	Anisometropia and anisometropia with other refractive error (n = 37)
Mean OD Sphere		
Mean ± (SD)	0.3 ± (2.5)	1.3 ± (2.75)
Median (Range)	0.25 (−6.75, 6)	1.5 (−6.75, 6.75)
Mean OD Cylinder		
Mean ± (SD)	2.3 ± (1)	0.8 ± (0.9)
Median (Range)	2 (0.5, 4.5)	0.5 (0, 4)
OD Spherical Equivalents		
Mean ± (SD)	1.5 ± (2.4)	1.7 ± (2.5)
Median (Range)	1.5 (−6.1, 6.4)	2 (−6.1, 7)
OD LogMAR Visual Acuity		
Mean ± (SD)	0.55 ± (0.27)	0.41 ± (0.32)
Median (Range)	0.48 (0, 1.3)	0.30 (0, 1.3)
Mean OS Sphere		
Mean ± (SD)	0.4 ± (2.4)	1.5 ± (3)
Median (Range)	0.5 (−5.25, 5.5)	1.75 (−5.25, 8)
Mean OS Cylinder		
Mean ± (SD)	2.5 ± (1.1)	0.9 ± (0.9)
Median (Range)	2.25 (0.5, 5.25)	0.75 (0, 4.25)
OS Spherical Equivalents		
Mean ± (SD)	1.6 ± (2.2)	2 ± (2.8)
Median (Range)	1.5 (−4.4, 6.4)	2.25 (−4.4, 8.1)
OS LogMAR Visual Acuity		
Mean ± (SD)	0.58 ± (0.23)	0.47 ± (0.38)
Median (Range)	0.54 (0.1, 1.3)	0.3 (0.1, 1.3)

*Mean difference of refractive error between the 2 eyes was 1.56 sphere diopters (SD = 0.5D, range = 1.25−4, n = 35), and 1.38 cylinder diopters (SD = 0.18, range = 1.25–1.50, n = 2).

children. While there were no differences between the sample and the study population with respect to the demographic characteristics assessed, it is not possible to extrapolate these results to all low-income preschool children with similar demographics.

The two large preschool programs vigorously recruited low-income children through multicultural outreach via mailings, churches, parks and shopping centers. The enrolled sample of preschool children has characteristics similar to those of low-income children 3–5 years of age in San Diego County. Further, since all the parents of the participants in this study population met similar income criteria, income level was not likely to confound the results.

The sample size was not large enough to estimate prevalence of types of refractive errors by ethnic or age subgroups. Larger studies are needed to estimate prevalence rates within such subgroups. However, for the present there are no published studies that estimate the prevalence of refractive errors in a population of low-income preschool children, most of whom are Latino. Recent reports[12,13] have indicated possible disparities in vision care, particularly among Latino and low-income children.

Few studies have examined hyperopia and/or astigmatism in relation to cognitive development.[10] We have found that preschoolers with bilateral refractive errors at a level deemed very important to detect and treat had reduced scores on standardized, widely used measures of visual-motor function that are predictive of future academic performance.[11]

In summary, the findings of this study indicate that low-income preschoolers need ocular evaluation for refractive errors and that some may need corrective lenses.

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