Prevalence of Refractive Error among Preschool Children in an Urban Population: The Baltimore Pediatric Eye Disease Study

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Purpose: To determine the age-specific prevalence of refractive errors in white and African-American preschool children.

Design: The Baltimore Pediatric Eye Disease Study is a population-based evaluation of the prevalence of ocular disorders in children aged 6 to 71 months in Baltimore, Maryland.

Participants: Among 4132 children identified, 3990 eligible children (97%) were enrolled and 2546 children (62%) were examined.

Methods: Cycloplegic autorefraction was attempted in all children with the use of a Nikon Retinomax K-Plus 2 (Nikon Corporation, Tokyo, Japan). If a reliable autorefraction could not be obtained after 3 attempts, cycloplegic streak retinoscopy was performed.

Main Outcome Measures: Mean spherical equivalent (SE) refractive error, astigmatism, and prevalence of higher refractive errors among African-American and white children.

Results: The mean SE of right eyes was +1.49 diopters (D) (standard deviation [SD] = 1.23) in white children and +0.71 D (SD = 1.35) in African-American children (mean difference of 0.78 D; 95% confidence interval [CI], 0.67–0.89). Mean SE refractive error did not decline with age in either group. The prevalence of myopia of 1.00 D or more in the eye with the lesser refractive error was 0.7% in white children and 5.5% in African-American children (relative risk [RR], 8.01; 95% CI, 3.70–17.35). The prevalence of hyperopia of +3 D or more in the eye with the lesser refractive error was 8.9% in white children and 4.4% in African-American children (RR, 0.49; 95% CI, 0.35–0.68). The prevalence of emmetropia (<−1.00 D to <+1.00 D) was 35.6% in white children and 58.0% in African-American children (RR, 1.64; 95% CI, 1.49–1.80). On the basis of published prescribing guidelines, 5.1% of the children would have benefited from spectacle correction. However, only 1.3% had been prescribed correction.

Conclusions: Significant refractive errors are uncommon in this population of urban preschool children. There was no evidence for a myopic shift over this age range in this cross-sectional study. A small proportion of preschool children would likely benefit from refractive correction, but few have had this prescribed.

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Although many studies have assessed the refractive status of school-aged children,[1–7] few population-based studies have been conducted looking at the refractive status among preschool children,[8] and none have been conducted in the United States. Significant refractive errors left uncorrected in younger children places them at risk for amblyopia[9] and strabismus.[10]

We conducted a population-based study of the visual system of urban African-American and white children aged 6 to 71 months. In this report we provide the distribution of refractive errors. These data will aid in the estimation of the need for spectacles and provide preliminary information on how much of that need is currently being met.

Materials and Methods

The Baltimore Pediatric Eye Disease Study (BPEDS) is a population-based study of African-American and non-Hispanic white children designed to estimate the prevalence and risk factors for pediatric ocular disease.[11] The study included children aged 6 to 71 months who resided in contiguous portions of northeastern and eastern Baltimore City and eastern Baltimore County. All study procedures were approved by the institutional review boards of the Johns Hopkins Bloomberg School of Public Health, the Maryland Department of Health and Mental Hygiene, and the Battelle Memorial Institute.

The details of the methodology of BPEDS are reported elsewhere.[11] In brief, all children aged 6 to 71 months who resided in selected contiguous census tracts of Baltimore City and County

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Table 1. Demographic Characteristics of Participants

Age	White (n = 1030)	African-American (n = 1268)	Total (n = 2298)
	n (%)	n (%)	n (%)
6–11 mos	84 (8.2%)	83 (6.6%)	167 (7.3%)
12–23 mos	175 (17.0%)	191 (15.1%)	366 (15.9%)
24–35 mos	189 (18.4%)	248 (19.6%)	437 (19.0%)
36–47 mos	210 (20.4%)	240 (18.9%)	450 (19.6%)
48–59 mos	201 (19.5%)	261 (20.6%)	462 (20.1%)
60–72 mos	171 (16.6%)	245 (19.3%)	416 (18.1%)
Gender			
Male	467 (45.3%)	627 (49.4%)	1094 (47.6%)
Female	563 (54.7%)	641 (50.6%)	1204 (52.4%)

were eligible to participate. The BPEDS eye examination included assessments of ocular adnexae, anterior and posterior segments, ocular alignment, extraocular muscle motility, stereoacuity, visual acuity, ocular biometry, and refractive error under cycloplegia.

Examinations were conducted from December 2003 to March 2007 in a centrally located, freestanding clinic set up specifically for this study in the community. Children who failed to present to the clinic were offered an in-home examination. Cycloplegia and refraction were conducted in the home exactly as they were in the clinic setting.

Determination of Refractive Error

Refractive error was measured after cycloplegia using a single drop of proparacaine 0.5% followed by 2 drops of cyclopentolate. The cyclopentolate concentration was determined by age: 1% for children aged 1 year or more and 0.5% for children aged 6 to 11 months. Five minutes elapsed between instillation of each cyclopentolate drop. Streak retinoscopy was performed a minimum of 30 minutes after instillation of the second drop of cyclopentolate. If fluctuation of the retinoscopic reflex was observed, an additional drop of cyclopentolate was administered and the refraction was performed 30 minutes later.

Cycloplegic autorefraction was attempted in all children with the use of a handheld Nikon Retinomax K-Plus 2 (Nikon Corporation, Tokyo, Japan). Calibration of the autorefractor was performed daily using a model eye. An instrument-generated confidence level of 8 or greater was required for the measurement to be considered reliable. A maximum of 3 autorefraction attempts were performed. In the event that a reliable autorefraction measure could not be obtained, a study-certified optometrist or ophthalmologist performed cycloplegic streak retinoscopy in a dimly illuminated room using a Welch Allyn retinoscope (Welch Allyn Medical Products, Skaneateles Falls, NY) with the child fixating at distance. For children with strabismus, the fellow eye was occluded while performing retinoscopy to prevent off-axis measurements. Children whose parent(s)/guardian(s) refused cycloplegia were not included in the refractive error analyses.

Guidelines based on clinical consensus for the prescription of spectacles for infants to age 3 years have been published in a Preferred Practice Pattern by the American Academy of Ophthalmology.[12] We extended those prescribing guidelines for the treatment of myopia, hyperopia, and astigmatism to 47 months of age. We also included children aged 48 to 71 months by adding isoametropic myopia and hypermetropia thresholds for prescribing spectacles to −1.50 diopters (D) and +3.50 D, respectively. We then applied the guidelines to our cohort to determine how many children should have had correction prescribed. In addition, we evaluated the effect of decreasing the threshold for astigmatism correction to >+1.50 D from +2.00 D.

During our intake interview, we determined which patients had been prescribed glasses. We evaluated the refractive error findings of these children against the prescribing guidelines to determine what proportion should have received glasses. For this analysis we stipulated that a patient with esotropia or a history of esotropia, even if not meeting the refractive error thresholds, would be considered appropriately treated with correction.

Statistical Analysis and Data Management

Confidence intervals (CIs) for prevalence estimates were calculated using the normal approximation or Poisson distribution where appropriate. Emmetropia was defined as a spherical equivalent (SE) refractive error of >−1.00 D and <+1.00 D. Myopia was defined as an SE refractive error ≤−1.00 D, and hyperopia was defined as an SE refractive error ≥+1.00 D. Astigmatism was defined as a cylinder power of ≥1.5 D, and anisometropia was defined as an interocular difference of ≥1.0 D in SE. A multiple linear regression model was used to assess the association of age, gender, and ethnicity with refractive errors, and a comparable model with normal distribution, identity link, and exchangeable correlation was fit using generalized estimating equations when both right and left eyes were included. SAS version 9.1.3 (SAS Inc., Cary, NC) was used for data analyses.

Table 2. Mean Refractive Error

	Sphere (D), (SD)				Cylinder (D), (SD)			
	Right Eye		*Left Eye*		*Right Eye*		*Left Eye*	
Age (mos), n = (AA, White)	AA	W	AA	W	AA	W	AA	W
6–11 (83, 84)	0.45 (1.65)	1.46 (1.44)	0.53 (1.55)	1.43 (1.40)	0.61 (0.62)	0.82 (0.83)	0.62 (0.59)	0.75 (0.74)
12–23 (191, 175)	0.52 (1.44)	1.27 (1.25)	0.52 (1.43)	1.27 (1.21)	0.54 (0.54)	0.49 (0.52)	0.53 (0.50)	0.50 (0.53)
24–35 (248, 189)	0.32 (1.45)	1.21 (1.26)	0.30 (1.40)	1.30 (1.36)	0.56 (0.61)	0.54 (0.57)	0.58 (0.59)	0.50 (0.54)
36–47 (240, 210)	0.38 (1.27)	1.03 (1.15)	0.40 (1.24)	1.01 (1.09)	0.57 (0.59)	0.49 (0.54)	0.57 (0.55)	0.49 (0.60)
48–59 (261, 201)	0.44 (1.40)	1.30 (1.14)	0.49 (1.43)	1.29 (1.19)	0.57 (0.72)	0.43 (0.47)	0.59 (0.68)	0.43 (0.53)
60–72 (245, 171)	0.46 (1.47)	1.28 (1.27)	0.46 (1.44)	1.33 (1.30)	0.63 (0.74)	0.51 (0.58)	0.59 (0.74)	0.42 (0.60)
Total (1268, 1030)*	0.42 (1.42)	1.23 (1.23)	0.44 (1.40)	1.25 (1.25)	0.58 (0.65)	0.52 (0.57)	0.58 (0.62)	0.49 (0.58)

AA = African-American; D = diopters; SD = standard deviation; W = white.
*Five African-Americans are missing sphere and cylinder measures in both eyes (2 in age group 12–23 mos, 1 in age group 36–47 mos, 1 in age group eye (1 in age group 6–11 mos missing left eye only, 2 in age group 12–23 mos, 4 in age group 24–35 mos, 1 in age group 36–47 mos, and 1 in age group

Results

BPEDS enrolled 4132 children either through door-to-door contact or by phone, and 2546 children (62%) were examined. Of these children, 248 were excluded from these analyses because they were not categorized as African-American or white. Thus, 1268 African-American and 1030 white children (Table 1) are the subjects of this report. The groups of children examined and not examined were similar, except that children examined were more likely to have a caregiver not working outside of the home and a caregiver more likely to have 16 or more years of education.[11] Of the 2298 children who were examined, the parents of 107 refused cycloplegia and their refractive errors were based on the non-cycloplegic evaluation. Thirteen children (0.5%) were unable to be refracted (and were excluded from the analysis), of whom 3 had refused drops and the cycloplegia status of the other 10 was not determined.

Spherical Equivalent Refractive Error

Refractive error was determined by cycloplegic autorefraction in 1805 subjects in both eyes (70.9%), whereas cycloplegic streak retinoscopy was required in either eye of 480 subjects (18.9%). The mean SE refractive error for African-American children was +0.71 D (standard deviation [SD] 1.35) and +0.73 D (SD 1.34) in the right and left eyes, respectively (Table 2). The mean SE error for white children was +1.49 D for right (SD 1.23) and left (SD 1.28) eyes. The range for SE was −5.00 to +9.75 for whites and −8.50 to +6.50 for African-Americans. The difference between white and African-American children was 0.78 D (95% CI, 0.67–0.89) in the right eye and 0.77 D (95% CI, 0.66–0.88) in the left eye. The SE refractive error in both African-Americans and whites did not change significantly between 6 and 71 months ($P = 0.99$ and $P = 0.15$, respectively) (Fig 1). By using both eyes in a multivariate regression model, the difference in refractive error between white and African-American children was 0.77 D (95% CI, 0.66–0.88), adjusted for age and sex. The sex difference in this model was 0.13 D (95% CI, 0.02–0.24), and there was a nonsignificant decline in refractive error by 0.0011 D (95% CI, −0.0041 to 0.0018) for each increasing month of age.

On assessment of the eye with the greater SE refractive error, African-Americans had a higher prevalence of emmetropia than whites (47.0% vs. 25.1%, relative prevalence = 1.87; 95% CI, 1.60–2.11; Table 3). Conversely, whites had a higher prevalence of hypermetropia (relative prevalence = 1.62; 95% CI, 1.51–1.74). Similar results were found when assessing the eye with the lesser SE refractive error (Table 1, Table 4 [available at http://aaojournal.org]).

Large SE refractive errors were uncommon. In the eye with the greater SE refractive error, 78 children (3.4%) had hyperopia of +4 D or more and 13 children (0.6%) had myopia of −3 D or more. SE refractive error analyses did not differ by gender. The SE findings by race for the eye with the greatest refractive error, the least refractive error, and the left and the right eyes are presented in Appendix 1 (available at http://aaojournal.org).

Astigmatic Refractive Error

Mean astigmatism for African-American children was +0.58 D (SD 0.65) for right eyes and +0.58 D (SD 0.62) for left eyes (Table 2). Mean astigmatism for white children was +0.52 D (SD 0.57) for right eyes and +0.49 D (SD 0.58) for left eyes. The mean astigmatic error remained stable in African-American children across the age range studied from 6 to 71 months ($P = 0.26$), whereas for whites there was a statistically significant, although small, decrease of astigmatism of 0.04 D (95% CI, 0.02–0.06, $P = 0.0005$) per year of age. The decline was most evident among white children aged less than 24 months.

There was a low prevalence of astigmatism of ≥3.00 D (Table 5), with-the-rule (WTR) in 1.2%, oblique in 0.5%, and against-the-rule (ATR) in no subjects. There were no significant ethnic differences in the prevalence or direction of astigmatism.

Anisometropia

Clinically important anisometropia was uncommon. The prevalence of anisometropia of ≥2.00 D was 1.0% among African-American and 1.5% among white children (Table 6). Anisometropia of ≥3.00 D was present in 0.2% of African-Americans and 0.7% of whites (relative risk, 0.35; 95% CI, 0.09–1.34).

Spectacle Use and Need

On the basis of consensus guidelines for spectacle correction modified to include the age range of BPEDS, 116 of 2298 (5.05%; 95% CI, 4.14–5.96) participants would benefit from spectacle correction for ametropia (Table 7). If we applied a criterion of astigmatism of >1.50 D, the overall proportion increased to 7.0%.

Only 29 participants (1.26%) were wearing glasses at the time of their study evaluation. Twelve participants (41%) had esotropia or a history of esotropia. Of these 12 participants, 6 (21%) had no need for correction based on refractive error but may have been

by Age and Race

Spherical Equivalent (D), (SD)			
Right Eye		*Left Eye*	
AA	W	AA	W
0.75 (1.56)	1.88 (1.37)	0.84 (1.47)	1.79 (1.36)
0.80 (1.40)	1.52 (1.25)	0.78 (1.39)	1.52 (1.24)
0.60 (1.37)	1.48 (1.28)	0.59 (1.32)	1.55 (1.45)
0.67 (1.25)	1.28 (1.11)	0.68 (1.23)	1.25 (1.09)
0.73 (1.31)	1.51 (1.16)	0.79 (1.39)	1.50 (1.22)
0.78 (1.37)	1.53 (1.28)	0.76 (1.35)	1.54 (1.37)
0.71 (1.35)	1.49 (1.23)	0.73 (1.34)	1.49 (1.28)

48–59 mos, and 1 in age group 60–71 mos). Eight whites are missing sphere and cylinder measures in the right eye and 9 are missing these in the left 48–59 mos missing both eyes).

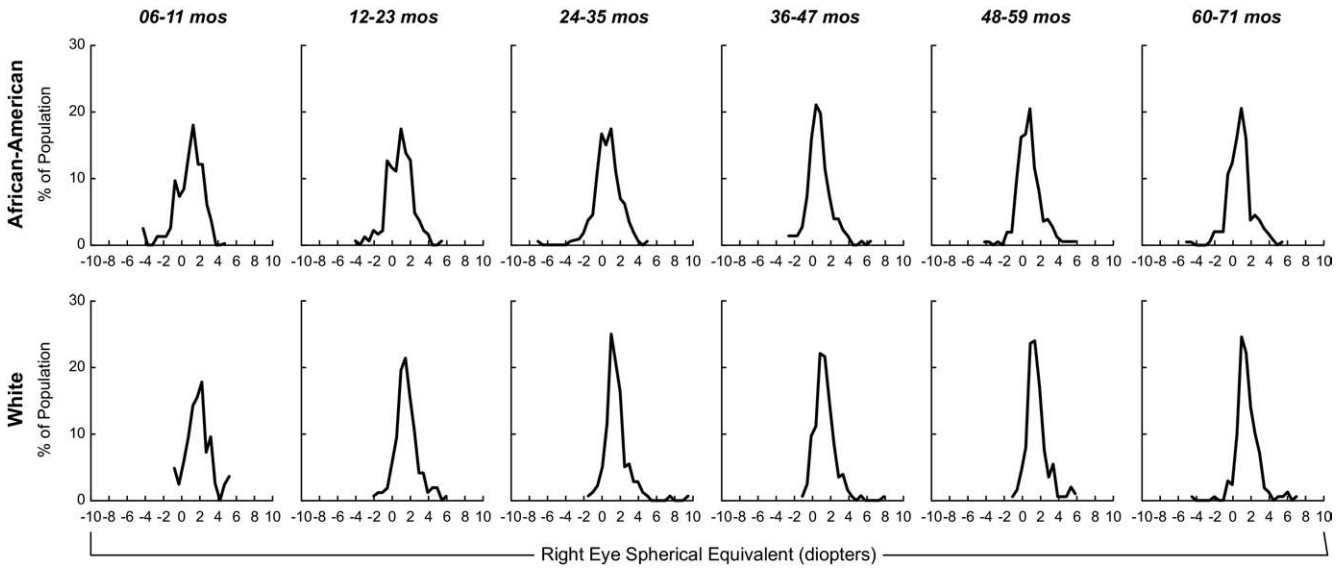

Figure 1. Distribution of SE refractive error in the right eye by age and ethnicity.

prescribed spectacles for management of the strabismus or other unknown reasons. Of the 17 nonstrabismic children, 3 had astigmatism, 1 had anisometropia, 2 had hypermetropia, and 1 had myopia meeting prescribing guidelines (Table 7).[12] Ten children (35%) did not meet refractive error correction guidelines or have a strabismus.

Discussion

We have conducted a population-based cross-sectional prevalence study of ocular disease among children aged 6 to 71 months living in Baltimore City and the adjacent areas of Baltimore County. Significant refractive errors were uncommon. Hyperopia was the most common refractive error among both African-American and white children, but African-Americans were on average approximately +0.75 D less hyperopic than whites. The difference in refractive errors was consistent across the age range of the study population. In addition, although others have reported that refractive error is hypermetropic in infants and shifts toward emmetropia during the first few years of life,[13–17] we did not find this trend toward emmetropia in our study for either racial group when analyzing the entire age range. We did find a small decline in hypermetropia among white children from age 6 to 11 months and age 12 to 23 months.

One study of the refractive error of 298 infants residing in Contra Costa, California[17] (ethnicity was not mentioned), between 3 and 36 months of age, found the mean SE to decrease significantly between 3 and 9 months of age. However, they found no significant change after 9 months of age, similar to our observation. Another study using cycloplegic retinoscopy of 113 infants in the United Kingdom reported a 0.76 D myopic shift during the first year of life.[15] In a study of 254 predominately white children, also from the United Kingdom, subjects were examined at age 9 and 20 months.[16] A significant decrease in mean SE occurred between these 2 refractions. Possible explanations for the difference between these previously published re-

Table 3. Prevalence of Spherical Equivalent Refractive Error in the Eye with

	Myopic SE, n (%)								Emmetropic SE, n (%)	
	≤−4 D		≤−3 D		≤−2 D		≤−1 D		>−1 D to <+1 D	
Age (mos), n = (AA,W)	AA	W	AA	W	AA	W	AA	W	AA	W
6–11 (83, 84)	2 (2.4)	0 (0.0)	3 (3.6)	0 (0.0)	5 (6.0)	0 (0.0)	8 (9.6)	0 (0.0)	29 (34.9)	16 (19.1)
12–23 (181, 175)	1 (0.5)	0 (0.0)	1 (0.5)	0 (0.0)	4 (2.1)	1 (0.6)	14 (7.5)	4 (2.3)	75 (39.7)	35 (20.2)
24–35 (248, 189)	1 (0.4)	0 (0.0)	2 (0.8)	0 (0.0)	8 (3.2)	0 (0.0)	26 (10.5)	2 (1.1)	111 (44.8)	47 (25.4)
36–47 (240, 210)	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)	6 (2.5)	0 (0.0)	14 (5.9)	0 (0.0)	133 (55.7)	73 (34.9)
48–59 (261, 201)	1 (0.4)	0 (0.0)	3 (1.2)	0 (0.0)	5 (1.9)	0 (0.0)	16 (6.2)	3 (1.5)	129 (49.6)	50 (25.0)
60–72 (245, 171)	2 (0.8)	1 (0.6)	2 (0.8)	1 (0.6)	4 (1.6)	1 (0.6)	16 (6.6)	2 (1.2)	117 (48.0)	36 (31.1)
Total (1268, 1030)*	7 (0.6)	1 (0.1)	12 (1.0)	1 (0.1)	32 (2.5)	2 (0.2)	94 (7.4)	11 (1.1)	594 (47.0)	257 (25.1)

AA = African-American; D = diopters; SE = spherical equivalent; W = white.
*Five African-Americans are missing sphere and cylinder measures in both eyes (2 in age group 12–23 mos, 1 in age group 36–47 mos, 1 in age group eye (1 in age group 6–11 mos missing left eye only, 2 in age group 12–23 mos, 4 in age group 24–35 mos, 1 in age group 36–47 mos, and 1 in age group emmetropic range.

Table 5. Prevalence of Astigmatism by Severity and Age in the Eye with Greater Astigmatism among African-Americans and Whites

		Worse Eye, n (%)					
		75–105 degrees (WTR)		*165–195 degrees (ATR)*		*Oblique*	
Age (mos), N = (AA, white)	**Cylinder Power (D)**	AA	*White*	AA	*White*	AA	*White*
6–11 (81, 83)	≥1.5	6 (7.4)	11 (13.3)	3 (3.7)	2 (2.4)	4 (4.9)	8 (9.6)
	≥3.0	0 (0.0)	2 (2.4)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.2)
12–23 (186, 171)	≥1.5	12 (6.5)	9 (5.3)	3 (1.6)	3 (1.8)	5 (2.7)	6 (3.5)
	≥3.0	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.6)
24–35 (246, 183)	≥1.5	18 (7.3)	17 (9.3)	2 (0.8)	1 (0.5)	14 (5.7)	1 (0.5)
	≥3.0	2 (0.8)	2 (1.1)	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)
36–47 (237, 205)	≥1.5	27 (11.4)	13 (6.3)	1 (0.4)	1 (0.5)	5 (2.1)	7 (3.4)
	≥3.0	2 (0.8)	4 (2.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
48–59 (258, 199)	≥1.5	26 (10.1)	16 (8.0)	0 (0.0)	0 (0.0)	5 (1.9)	1 (0.5)
	≥3.0	3 (1.2)	1 (0.5)	0 (0.0)	0 (0.0)	2 (0.8)	0 (0.0)
60–72 (243, 171)	≥1.5	23 (9.5)	18 (10.5)	3 (1.2)	0 (0.0)	6 (2.5)	1 (0.6)
	≥3.0	8 (3.3)	3 (1.8)	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)
Total (1251, 1012)*	≥1.5	112 (9.0)	84 (8.3)	12 (1.0)	7 (0.7)	39 (3.1)	24 (2.4)
	≥3.0	15 (1.2)	12 (1.2)	0 (0.0)	0 (0.0)	4 (0.3)	2 (0.2)

AA = African-American; ATR = against the rule; D = diopters; WTR = with the rule.
Oblique axis astigmatism includes all orientations not WTR or ATR. In children with equal power astigmatism where 1 eye has an oblique axis and the other eye has WTR or ATR astigmatism, the eye with oblique axis is defined as the worse eye. Seven children had equal power astigmatism in each eye, with 1 eye axis WTR and the other ATR, but the cylinder measure was <1.5 D for all of them.
*Five African-Americans are missing sphere and cylinder measures in both eyes (2 in age group 12–23 mos, 1 in age group 36–47 mos, 1 in age group 48–59 mos, and 1 in age group 60–71 mos). An additional 12 African-Americans are missing axis measures in both eyes (2 in age group 6–11 mos, 3 in age group 12–23 mos, 2 in age group 24–35 mos, 2 in age group 36–47 mos, 2 in age group 48–59 mos, and 1 in age group 60–71 mos). Eight whites are missing sphere and cylinder measures in the right eye and 9 are missing these in the left eye (1 in age group 6–11 mos missing left eye only, 2 in age group 12–23 mos, 4 in age group 24–35 mos, 1 in age group 36–47 mos, and 1 in age group 48–59 mos missing both eyes). An additional 10 whites are missing axis measures in both eyes (1 in age group 6–11 mos, 2 in age group 12–23 mos, 2 in age group 24–35 mos, 4 in age group 36–47 mos, and 1 in age group 48–59 mos).

ports and our study may include sampling error in previously published clinic-based reports, real differences in the refractive status of the populations studied, methods of refraction, and use of cycloplegia.

Risk factors for the development of amblyopia in children include anisometropia, high ametropia, and astigmatism. Anisometropia of 2.00 D or more was uncommon in our study population, affecting 1.0% of African-Americans and 1.5% of whites studied. Astigmatism of 3.00 D or more was uncommon in both groups, although approximately 11% had astigmatism of 1.50 D or more. The magnitude of astigmatism did not change with increasing age among African-American children but decreased with increasing age among white children. A decrease in astigmatism has been reported.[17–20] The observed reduction in astigmatism could be a testing artifact because of more accurate visual axis measurement of older and presumably more cooperative children.

Previous reports differ on the most common form of astigmatism among children, with some finding ATR most

Greater Refractive Error among African-Americans and Whites

Hyperopic SE, n (%)									
≥+1 D		*≥+2 D*		*≥+3 D*		*≥+4 D*		*≥+5 D*	
AA	*W*	AA	*W*	AA	*W*	AA	*W*	AA	*W*
46 (55.4)	68 (81.0)	20 (24.1)	43 (51.2)	4 (4.8)	20 (23.8)	1 (1.2)	6 (7.1)	0 (0.0)	3 (3.6)
100 (53.2)	134 (77.5)	40 (21.2)	57 (33.0)	14 (7.4)	21 (12.1)	4 (2.1)	10 (5.8)	1 (0.5)	2 (1.2)
111 (44.8)	136 (73.5)	39 (15.7)	56 (30.3)	13 (6.3)	24 (13.0)	3 (1.2)	10 (5.4)	2 (0.8)	5 (2.7)
92 (38.5)	136 (65.1)	37 (15.5)	54 (25.8)	15 (6.3)	20 (9.6)	3 (1.3)	6 (2.9)	2 (0.8)	3 (1.4)
115 (44.2)	147 (73.5)	42 (16.2)	55 (27.5)	22 (8.5)	28 (14.0)	9 (3.5)	12 (6.0)	4 (1.5)	7 (3.5)
111 (45.5)	133 (77.8)	42 (917.2)	57 (33.3)	19 (7.8)	22 (12.9)	5 (2.1)	9 (5.3)	4 (1.6)	5 (2.9)
575 (45.5)	754 (73.8)	220 (17.4)	322 (31.5)	87 (6.9)	135 (13.2)	25 (2.0)	53 (5.2)	13 (1.0)	25 (2.4)

48–59 mos, and 1 in age group 60–71 mos). Eight whites are missing sphere and cylinder measures in the right eye and 9 are missing these in the left 48–59 mos missing both eyes). Seventeen children (3 white, 14 African-American) have SE of equal but opposite magnitude. All were within the

Table 6. Prevalence and Types of Anisometropia

Age (mos), n = (AA, White)	Difference in Power (D)	Hyperopic SE		Myopic SE		SE Antimetropic (mixed)	
		AA	White	AA	White	AA	White
6–11 (83, 84)	≥1.0	2 (2.4)	5 (6.0)	2 (2.4)	0 (0.0)	2 (2.4)	1 (1.2)
	≥2.0	0 (0.0)	3 (3.6)	1 (1.2)	0 (0.0)	0 (0.0)	0 (0.0)
	≥3.0	0 (0.0)	1 (1.2)	1 (1.2)	0 (0.0)	0 (0.0)	0 (0.0)
12–23 (191, 175)	≥1.0	3 (1.6)	5 (2.9)	0 (0.0)	0 (0.0)	3 (1.6)	2 (1.1)
	≥2.0	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.5)	1 (0.6)
	≥3.0	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
24–35 (248, 189)	≥1.0	5 (2.0)	7 (3.7)	2 (0.8)	0 (0.0)	3 (1.2)	3 (1.6)
	≥2.0	1 (0.4)	2 (1.1)	1 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)
	≥3.0	1 (0.4)	2 (1.1)	1 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)
36–47 (240, 210)	≥1.0	3 (1.3)	6 (2.9)	0 (0.0)	0 (0.0)	4 (1.7)	1 (0.5)
	≥2.0	1 (0.4)	1 (0.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	≥3.0	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
48–59 (261, 201)	≥1.0	10 (3.8)	11 (5.5)	0 (0.0)	0 (0.0)	5 (1.9)	1 (0.5)
	≥2.0	2 (0.8)	2 (1.0)	0 (0.0)	0 (0.0)	1 (0.4)	1 (0.5)
	≥3.0	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
60–72 (245, 171)	≥1.0	8 (3.3)	6 (3.5)	2 (0.8)	0 (0.0)	1 (0.4)	3 (1.8)
	≥2.0	0 (0.6)	1 (0.6)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.6)
	≥3.0	0 (0.6)	1 (0.6)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.6)
Total (1268, 1030)*	≥1.0	31 (2.4)	40 (3.9)	6 (0.5)	0 (0.0)	18 (1.4)	11 (1.1)
	≥2.0	4 (0.3)	9 (0.9)	2 (0.2)	0 (0.0)	2 (0.2)	3 (0.3)
	≥3.0	1 (0.1)	4 (0.4)	2 (0.2)	0 (0.0)	0 (0.00)	1 (0.1)

AA = African-American; D = diopters; SE = spherical equivalent.
*Five African-Americans are missing SE in both eyes. Nine whites are missing SE in at least 1 eye (8 in both eyes).

prevalent[18,21,22] and others finding WTR most prevalent.[23,24] Cross-sectional studies show an increase in prevalence of WTR and decrease in prevalence of ATR with increasing age.[25,26] Similarly, the axis of astigmatism in our study population was nearly always WTR, with little change by age and no differences by race.

Requirement of Refractive Correction

The need to correct ametropia in preschool children is a recognized public health intervention to prevent the development of amblyopia and strabismus. Debate exists regarding the type and magnitude of refractive errors that warrant correction and at what age.[12,27–30] The 2007 Preferred Practice Pattern from the American Academy of Ophthalmology includes prescribing guidelines for refractive error for children from infancy to 3 years of age.[12] Extending these guidelines to age 71 months (with modification for myopia and hypermetropia in 4- to 5-year-old children; see "Materials and Methods") yields a need for prescribed refractive correction of 5.1% of our urban population (Table 7). If we were to apply a more inclusive criterion of astigmatism of >1.50 D, as suggested by

Table 7. Spectacle Need Based on Prescribing Guidelines*†

Type of Ametropia	Age (n)			
	6–11 mos (167)	12–23 mos (366)	24–47 mos (887)μ	48–71 mos (878)‡
	n (%) [recommendation]	n (%) [recommendation]	n (%) [recommendation]	n (%) [recommendation]
Isoametropia				
Myopia	1 (0.60) [≥−4 D]	0 (0.00) [≥−4 D]	2 (0.23) [≥−3 D]	16 (1.82) [≥−1.5 D]
Hyperopia no esotropia	1 (0.60) [≥+6 D]	3 (0.82) [≥+5 D]	7 (0.79) [≥+4.50 D]	26 (2.96) [≥+3.5 D]
Hyperopia with esotropia	1 (0.60) [>+2 D]	1 (0.27) [>+2 D]	4 (0.45) [>+1.50]	3 (0.34) [>+1.50]
Astigmatism	2 (1.20) [≥3 D]	0 (0.00) [≥2.50 D]	11 (1.24) [>2 D]	20§ (2.28) [>2 D]
Anisometropia				
Myopia	1 (0.60) [≥−2.50 D]	0 (0.00) [≥−2.50 D]	1 (0.11) [≥−2 D]	1 (0.11) [≥−2 D]
Hyperopia	0 (0.00) [≥+2.50 D]	0 (0.00) [≥+2 D]	9 (1.01) [≥+1.50 D]	12 (1.37) [≥+1.50 D]
Astigmatism	0 (0.00) [≥2.50 D]	0 (0.00) [≥2 D]	4 (0.45) [≥ 2 D]	4 (0.46) [≥2 D]

D = diopters.
*Guidelines from American Academy Ophthalmology Preferred Practice Patterns 2007.
†Guidelines extended from 36 to 47 mos.
‡Not part of American Academy Ophthalmology Preferred Practice Patterns.
§If astigmatism in those aged 48 to 72 mos is changed to >1.5 D, then 67 require glasses because of this criterion and 160 require glasses; of these, 16 presented with glasses.

in African-Americans and Whites

Astigmatic		Total SE Anisometropia		Total Anisometropia	
AA	White	AA	White	AA	White
4 (4.8)	5 (6.0)	6 (7.2)	6 (7.1)	10 (12.0)	11 (13.1)
0 (0.0)	0 (0.0)	1 (1.2)	3 (3.6)	1 (1.2)	3 (3.6)
0 (0.0)	0 (0.0)	1 (1.2)	1 (1.2)	1 (1.2)	1 (1.2)
6 (3.1)	6 (3.4)	6 (3.1)	7 (4.0)	12 (6.3)	13 (7.4)
0 (0.0)	0 (0.0)	1 (0.5)	1 (0.6)	1 (0.5)	1 (0.6)
0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
13 (5.2)	9 (4.8)	10 (4.0)	10 (5.3)	23 (9.3)	19 (10.1)
1 (0.4)	1 (0.5)	2 (0.8)	2 (1.1)	3 (1.2)	3 (1.6)
0 (0.0)	0 (0.0)	2 (0.8)	2 (1.1)	2 (0.8)	2 (1.1)
12 (5.0)	11 (5.2)	7 (2.9)	7 (3.3)	19 (7.9)	18 (8.6)
0 (0.5)	2 (1.0)	1 (0.4)	1 (0.5)	1 (0.4)	3 (1.4)
0 (0.5)	2 (1.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.0)
14 (5.4)	5 (2.5)	15 (5.7)	12 (6.0)	29 (11.1)	17 (8.5)
2 (0.8)	0 (0.0)	3 (1.1)	3 (1.5)	5 (1.9)	3 (1.5)
0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
15 (6.1)	8 (4.7)	11 (4.5)	9 (5.3)	26 (10.6)	17 (9.9)
2 (0.8)	0 (0.0)	0 (0.0)	2 (1.2)	2 (0.8)	2 (1.2)
0 (0.0)	0 (0.0)	0 (0.0)	2 (1.2)	0 (0.0)	2 (1.2)
64 (5.0)	44 (4.3)	55 (4.3)	51 (5.0)	119 (9.4)	95 (9.2)
5 (0.4)	3 (0.3)	8 (0.6)	12 (1.2)	13 (1.0)	15 (1.5)
0 (0.0)	2 (0.2)	3 (0.2)	5 (0.5)	3 (0.2)	7 (0.7)

Donahue[28] for children aged 4 to 5 years, the overall proportion increases to 7.0%. Of the 29 children who had been prescribed correction before their BPEDS examination, no indication for use could be found for 10 (34%). These observations of an unmet need in our study population for refractive correction plus the prescription of unnecessary glasses for some children suggest the need to improve the quality of eye care being provided to children in this urban area.

Study Strengths and Limitations

There are a number of strengths in our study. The subjects participated in a population-based study with prospectively developed procedures, including an objective measure of refractive error with complete cycloplegia. The large number of children studied allows for fairly precise estimates of the prevalence of refractive errors for each of the age ranges.

There are limitations to the findings. First, participation in the study was incomplete and there may have been sampling bias if more or less children with refractive errors or visual symptoms attended the clinic than were present in the larger population. If there was a bias associated with caregiver characteristics, we are uncertain in which direction it would have driven our findings. Second, children who had health problems at birth were more likely to be examined, which may have increased the estimated prevalence of refractive error. However, no differences in guardian-reported history of ocular disease or visual symptoms existed between those who were and were not examined. Last, African-American subjects were more myopic than whites. In designing the study we were concerned that African-American children were more likely to have inadequate cycloplegia, thus biasing the African-American patients to less measured hypermetropia. To limit this problem, the protocol required that the study refractionists perform dynamic retinoscopy to determine whether complete cycloplegia had been achieved after 30 minutes and administer an additional dose of cyclopentolate if residual accommodation was observed. However, it is still possible that the disparity in mean SE refractive error was due in part to systematic inadequate cycloplegia among African-Americans.

This population-based study of urban African-American and white children aged 6 to 71 months documented low rates of clinically significant SE refractive error, anisometropia, and astigmatism. African-Americans were more myopic and had slightly more astigmatism than whites. Spectacle use was rare in this population, even among those children with clinically important refractive errors.

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Table 4. Prevalence of Spherical Equivalent Refractive Error in the Eye with Lesser

	Myopic SE, n (%)								Emmetropic SE, n (%)	
	≤−4 D		≤−3 D		≤−2 D		≤−1 D		>−1 D to <+1 D	
Age (mos), n = (AA,W)	AA	W	AA	W	AA	W	AA	W	AA	W
6–11 (83, 84)	1 (1.2)	0 (0.0)	1 (1.2)	0 (0.0)	3 (3.6)	0 (0.0)	5 (6.0)	0 (0.0)	35 (42.2)	22 (26.2)
12–23 (191, 175)	0 (0.0)	0 (0.0)	1 (0.5)	0 (0.0)	4 (2.1)	1 (0.6)	12 (6.4)	4 (2.3)	91 (48.2)	56 (32.4)
24–35 (248, 189)	0 (0.0)	0 (0.0)	2 (0.8)	0 (0.0)	5 (2.0)	0 (0.0)	19 (7.7)	0 (0.0)	146 (58.9)	68 (36.8)
36–47 (240, 210)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (1.3)	0 (0.0)	11 (4.6)	0 (0.0)	156 (65.3)	94 (45.0)
48–59 (261, 201)	1 (0.4)	0 (0.0)	2 (0.8)	0 (0.0)	3 (1.2)	0 (0.0)	10 (3.9)	1 (0.5)	165 (63.5)	69 (34.5)
60–72 (245, 171)	2 (0.8)	1 (0.6)	2 (0.8)	1 (0.6)	3 (1.2)	1 (0.6)	12 (4.9)	2 (1.2)	140 (57.4)	55 (32.2)
Total (1268, 1030)*	4 (0.3)	1 (0.1)	8 (0.6)	1 (0.1)	21 (2.3)	2 (0.2)	69 (5.5)	7 (0.7)	733 (58.0)	364 (35.6)

AA = African-American; D = diopters; SE = spherical equivalent; W = white.
*Five African-Americans are missing sphere and cylinder measures in both eyes (2 in age group 12–23 mos, 1 in age group 36–47 mos, 1 in age group eye (1 in age group 6–11 mos missing left eye only, 2 in age group 12–23 mos, 4 in age group 24–35 mos, 1 in age group 36–47 mos, and 1 in age group emmetropic range.

Appendix 1

Tables of Spherical Equivalent Refractive Error for the Eye with Greater Refractive Error, Lesser Refractive Error, and by Race

Table A. Distribution of Spherical Equivalent Refraction in the

	Myopic SE, n (%)										Emmetropic SE, n (%)	
	<=−5D		−4>−5D		−3>−4D		−2>−3D		−1>−2D		>−1<+1D	
Age (mo), n = (AA,W)	AA	W	AA	W	AA	W	AA	W	AA	W	AA	W
6–11 (83, 84)	0 (0.0)	0 (0.0)	2 (2.4)	0 (0.0)	1 (1.2)	0 (0.0)	2 (2.4)	0 (0.0)	6 (7.2)	2 (2.4)	26 (31.3)	14 (16.7)
12–23 (191, 175)	0 (0.0)	0 (0.0)	1 (0.5)	0 (0.0)	1 (0.5)	0 (0.0)	4 (2.1)	2 (1.2)	10 (5.3)	3 (1.7)	73 (38.6)	34 (19.7)
24–35 (248, 189)	1 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)	6 (2.4)	0 (0.0)	22 (8.9)	3 (1.6)	107 (43.2)	46 (24.9)
36–47 (240, 210)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)	5 (2.1)	0 (0.0)	11 (4.6)	1 (0.5)	130 (54.4)	72 (34.5)
48–59 (261, 201)	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)	2 (0.8)	0 (0.0)	2 (0.8)	0 (0.0)	12 (4.6)	3 (1.5)	128 (49.2)	50 (25.0)
60–72 (245, 171)	1 (0.4)	0 (0.0)	1 (0.4)	1 (0.6)	1 (0.4)	0 (0.0)	2 (0.8)	1 (0.6)	14 (5.7)	0 (0.0)	114 (46.7)	36 (21.1)
TOTAL (1268, 1030)*	2 (0.2)	0 (0.0)	5 (0.4)	1 (0.1)	7 (0.6)	0 (0.0)	21 (1.7)	3 (0.3)	75 (5.9)	12 (1.2)	578 (45.8)	252 (24.7)

AA = African American; W = White; SE = spherical equivalent; D = Diopters.
*5 African Americans missing sphere and cylinder measures in both eyes (2 in age group 12–23, 1 in age group 36–47, 1 in age group 48–59 and 1 in left eye only, 2 in age group 12–23, 4 in age group 24–35, 1 in age group 36–47, 1 in age group 48–59 missing both eyes). 17 children (3 White, 14 African

Table B. Distribution of Spherical Equivalent Refraction in the

	Myopic SE, n (%)										Emmetropic SE, n (%)	
	<=−5D		−4>−5D		−3>−4D		−2>−3D		−1>−2D		>−1<+1D	
Age (mo), n = (AA,W)	AA	W	AA	W	AA	W	AA	W	AA	W	AA	W
6–11 (83, 84)	0 (0.0)	0 (0.0)	1 (1.2)	0 (0.0)	0 (0.0)	0 (0.0)	2 (2.4)	0 (0.0)	4 (4.8)	1 (1.2)	33 (39.8)	21 (25.0)
12–23 (191, 175)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.5)	0 (0.0)	3 (1.6)	1 (0.6)	9 (4.8)	3 (1.7)	90 (47.6)	56 (32.4)
24–35 (248,189)	1 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.8)	0 (0.0)	4 (1.6)	0 (0.0)	14 (5.7)	2 (1.1)	145 (58.5)	66 (35.7)
36–47 (240, 210)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (1.3)	0 (0.0)	8 (3.4)	0 (0.0)	156 (65.3)	94 (45.0)
48–59 (261, 201)	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)	1 (0.4)	0 (0.0)	1 (0.4)	0 (0.0)	9 (3.5)	1 (0.5)	163 (62.7)	69 (34.5)
60–72 (245, 171)	1 (0.4)	0 (0.0)	1 (0.4)	1 (0.6)	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)	10 (4.1)	1 (0.6)	139 (57.0)	55 (32.2)
TOTAL (1268, 1030)*	1 (0.1)	0 (0.0)	3 (0.2)	1 (0.1)	4 (0.3)	0 (0.0)	14 (1.1)	1 (0.1)	54 (4.3)	8 (0.8)	726 (57.5)	361 (35.3)

AA = African American; W = White; SE = spherical equivalent; D = Diopters.
5 AA missing sphere and cylinder measures in both eyes (2 in age group 12–23, 1 in group 36–47, 1 in group 48–59 and 1 in group 60–71) 8 W missing group 24–35, 1 in group 36–47, 1 in group 48–59 missing both eyes)* 17 children (3 W, 14 AA) with spherical equivalent of equal but opposite

Refractive Error among African-Americans and Whites

Hyperopic SE, n (%)									
≥+1 D		≥+2 D		≥+3 D		≥+4 D		≥+5 D	
AA	W	AA	W	AA	W	AA	W	AA	W
43 (51.8)	62 (73.8)	18 (21.7)	34 (40.5)	3 (3.6)	16 (19.1)	1 (1.2)	5 (6.0)	0 (0.0)	1 (1.2)
86 (45.5)	113 (65.3)	32 (16.9)	49 (28.3)	10 (5.3)	19 (11.0)	4 (2.1)	8 (4.6)	1 (0.5)	2 (1.2)
83 (33.5)	117 (63.2)	29 (11.7)	40 (21.6)	8 (3.2)	14 (7.6)	1 (0.4)	8 (4.3)	1 (0.4)	2 (1.1)
72 (30.1)	115 (55.0)	29 (12.1)	35 (16.8)	6 (2.5)	12 (5.7)	3 (1.3)	2 (1.0)	2 (0.8)	1 (0.5)
85 (32.7)	130 (65.0)	29 (11.2)	40 (20.0)	14 (5.4)	17 (8.5)	4 (1.5)	7 (3.5)	2 (0.8)	3 (1.5)
92 (37.7)	114 (66.7)	30 (12.3)	41 (24.4)	14 (5.7)	13 (7.6)	4 (1.6)	6 (3.5)	0 (0.0)	4 (2.3)
461 (36.5)	651 (63.7)	167 (13.2)	239 (23.4)	55 (4.4)	91 (8.9)	17 (1.3)	36 (3.5)	6 (0.5)	13 (1.3)

48–59 mos, and 1 in age group 60–71 mos). Eight whites are missing sphere and cylinder measures in the right eye and 9 are missing these in the left 48–59 mos missing both eyes). Seventeen children (3 white, 14 African-American) have SE of equal but opposite magnitude. All were within the

Eye with the Greater Refractive Error by Race

Hyperopic SE, n (%)											
+1<+2D		+2<+3D		+3<+4D		+4<+5D		+5<+6D		>=+6D	
AA	W	AA	W	AA	W	AA	W	AA	W	AA	W
26 (31.3)	25 (29.8)	16 (19.3)	23 (27.4)	3 (3.6)	14 (16.7)	1 (1.2)	3 (3.6)	0 (0.0)	3 (3.6)	0 (0.0)	0 (0.0)
60 (31.8)	77 (44.5)	26 (13.8)	36 (20.8)	10 (5.3)	11 (6.4)	3 (1.6)	8 (4.6)	1 (0.5)	1 (0.6)	0 (0.0)	1 (0.6)
72 (29.0)	80 (43.2)	26 (10.5)	32 (17.3)	10 (4.0)	14 (7.6)	1 (0.4)	5 (2.7)	2 (0.8)	3 (1.6)	0 (0.0)	2 (1.1)
55 (23.0)	82 (39.2)	22 (9.2)	34 (16.3)	12 (5.0)	14 (6.7)	1 (0.4)	3 (1.4)	1 (04.)	2 (1.0)	1 (0.4)	1 (0.5)
73 (28.1)	92 (46.0)	20 (7.7)	27 (13.5)	13 (5.0)	16 (8.0)	5 (1.9)	5 (2.5)	3 (1.2)	4 (2.0)	1 (0.4)	3 (1.5)
69 (28.3)	76 (44.4)	23 (9.4)	35 (20.5)	14 (5.7)	13 (7.6)	1 (0.4)	4 (2.3)	4 (1.6)	2 (1.2)	0 (0.0)	3 (1.8)
355 (28.1)	432 (42.3)	133 (10.5)	187 (18.3)	62 (4.9)	82 (8.0)	12 (1.0)	28 (2.7)	11 (0.9)	15 (1.5)	2 (0.2)	10 (1.0)

age group 60–71)* 8 Whites missing sphere and cylinder measures in the right eye and 9 are missing these in the left eye (1 in age group 6–11 missing American) with spherical equivalent of equal but opposite magnitude. All were within the emmetropic range.

Eye with the Lesser Refractive Error by Race

Hyperopic SE, n (%)											
+1<+2D		+2<+3D		+3 <+4D		+4<+5D		+5<+6D		>=+6D	
AA	W	AA	W	AA	W	AA	W	AA	W	AA	W
25 (30.1)	28 (33.3)	15 (18.1)	18 (21.4)	2 (2.4)	11 (13.1)	1 (1.2)	4 (4.8)	0 (0.0)	1 (1.2)	0 (0.0)	0 (0.0)
54 (28.6)	64 (37.0)	22 (11.6)	30 (17.3)	6 (3.2)	11 (6.4)	3 (1.6)	6 (3.5)	1 (0.5)	1 (0.6)	0 (0.0)	1 (0.6)
54 (21.8)	77 (41.6)	21 (8.5)	26 (14.1)	7 (2.8)	6 (3.2)	0 (0.0)	6 (3.2)	1 (0.4)	0 (0.0)	0 (0.0)	2 (1.1)
43 (18.0)	80 (38.8)	23 (9.6)	23 (11.0)	3 (1.3)	10 (4.8)	1 (0.4)	1 (0.5)	2 (0.8)	0 (0.0)	0 (0.0)	1 (0.5)
56 (21.5)	90 (45.0)	15 (5.8)	23 (11.5)	10 (3.9)	10 (5.0)	2 (0.8)	4 (2.0)	2 (0.8)	3 (1.5)	0 (0.0)	0 (0.0)
62 (25.4)	73 (42.7)	16 (6.6)	28 (16.4)	10 (4.1)	7 (4.1)	4 (1.6)	2 (1.2)	0 (0.0)	1 (0.6)	0 (0.0)	3 (1.8)
294 (23.3)	412 (40.3)	112 (8.9)	148 (14.5)	38 (3.0)	55 (5.4)	11 (0.9)	23 (2.3)	6 (0.5)	6 (0.6)	0 (0.0)	7 (0.7)

sphere and cylinder measures in the right eye and 9 are missing these in the left eye (1 in age group 6–11 missing left eye only, 2 in group 12–23, 4 inmagnitude. All were within the emmetropic range.

Table C. Distribution of Spherical Equivalent

	Myopic SE, n (%)										Emmetropic SE, n (%)	
	<=−5D		−4>−5D		−3>−4D		−2>−3D		−1>−2D		>−1<+1D	
Age (mo), n = (AA,W)	AA	W	AA	W	AA	W	AA	W	AA	W	AA	W
6–11 (83, 84)	0 (0.0)	0 (0.0)	2 (2.4)	0 (0.0)	0 (0.0)	0 (0.0)	2 (2.4)	0 (0.0)	5 (6.0)	1 (1.2)	30 (36.1)	18 (21.4)
12–23 (191, 175)	0 (0.0)	0 (0.0)	1 (0.5)	0 (0.0)	1 (0.5)	0 (0.0)	4 (2.1)	1 (0.6)	8 (4.2)	4 (2.3)	80 (42.3)	44 (25.4)
24–35 (248, 189)	1 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)	6 (2.4)	0 (0.0)	17 (6.9)	2 (1.1)	122 (49.2)	59 (31.9)
36–47 (240, 210)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	6 (2.5)	0 (0.0)	9 (3.8)	1 (0.5)	143 (59.8)	80 (38.3)
48–59 (261, 201)	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)	1 (0.4)	0 (0.0)	1 (0.4)	0 (0.0)	10 (3.9)	1 (0.5)	150 (57.7)	58 (29.0)
60–72 (245, 171)	1 (0.4)	0 (0.0)	1 (0.4)	1 (0.6)	0 (0.0)	0 (0.0)	2 (0.8)	1 (0.6)	13 (5.3)	0 (0.0)	124 (50.8)	44 (25.7)
TOTAL (1268, 1030)*	2 (0.2)	0 (0.0)	5 (0.4)	1 (0.1)	3 (0.2)	0 (0.0)	21 (1.7)	2 (0.2)	62 (4.9)	9 (0.9)	649 (51.4)	303 (29.7)

AA = African American; W = White; SE = spherical equivalent; D = Diopters.
5 African Americans missing sphere and cylinder measures in both eyes (2 in age group 12–23, 1 in age group 36–47, 1 in age group 48–59 and 1 in left eye only, 2 in age group 12–23, 4 in age group 24–35, 1 in age group 36–47, 1 in age group 48–59 missing both eyes) 17 children (3 White, 14

Table D. Distribution of Spherical Equivalent

	Myopic SE, n (%)										Emmetropic SE, n (%)	
	<=−5D		−4>−5D		−3>−4D		−2>−3D		−1>−2D		>−1<+1D	
Age (mo), n = (AA,W)	AA	W	AA	W	AA	W	AA	W	AA	W	AA	W
6–11 (83, 84)	0 (0.0)	0 (0.0)	1 (1.2)	0 (0.0)	1 (1.2)	0 (0.0)	2 (2.4)	0 (0.0)	5 (6.0)	2 (2.4)	29 (34.9)	17 (20.5)
12–23 (191, 175)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.5)	0 (0.0)	3 (1.6)	2 (1.2)	11 (5.8)	2 (1.2)	83 (43.9)	46 (26.6)
24–35 (248, 189)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.8)	0 (0.0)	4 (1.6)	0 (0.0)	19 (7.7)	3 (1.6)	130 (52.4)	53 (28.7)
36–47 (240, 210)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)	2 (0.8)	0 (0.0)	10 (4.2)	0 (0.0)	143 (59.8)	86 (41.2)
48–59 (261, 201)	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)	2 (0.8)	0 (0.0)	2 (0.8)	0 (0.0)	11 (4.2)	3 (1.5)	141 (54.2)	60 (30.5)
60–72 (245, 171)	1 (0.4)	1 (0.0)	1 (0.4)	1 (0.6)	1 (0.4)	0 (0.0)	1 (0.4)	0 (0.0)	11 (4.5)	1 (0.6)	129 (52.9)	47 (27.5)
TOTAL (1268, 1030)*	1 (0.1)	0 (0.6)	3 (0.2)	1 (0.1)	8 (0.6)	0 (0.0)	8 (0.6)	2 (0.2)	67 (5.3)	11 (1.1)	655 (51.9)	310 (30.4)

AA = African American; W = White; SE = spherical equivalent; D = Diopters.
5 AA missing sphere and cylinder measures in both eyes (2 in age group 12–23, 1 in group 36–47, 1 in group 48–59 and 1 in group 60–71) 8 W missing group 24–35, 1 in group 36–47, 1 in group 48–59 missing both eyes)* 17 children (3 W, 14 AA) with SE of equal but opposite magnitude. All were within

Refraction in the Right Eye by Race

Hyperopic SE, n (%)											
+1<+2D		*+2<+3D*		*+3 <+4D*		*+4<+5D*		*+5<+6D*		*>=+6D*	
AA	*W*	AA	*W*	AA	*W*	AA	*W*	AA	*W*	AA	*W*
25 (30.1)	25 (29.8)	15 (18.1)	21 (25.0)	3 (3.6)	14 (16.7)	1 (1.2)	2 (2.4)	0 (0.0)	3 (3.6)	0 (0.0)	0 (0.0)
59 (31.2)	69 (39.9)	23 (12.2)	34 (19.7)	9 (4.8)	12 (6.9)	3 (1.6)	7 (4.1)	1 (0.5)	1 (0.6)	0 (0.0)	1 (0.6)
67 (27.0)	80 (43.2)	23 (9.3)	27 (14.6)	10 (4.0)	9 (4.9)	0 (0.0)	6 (3.2)	1 (0.4)	0 (0.0)	0 (0.0)	2 (1.1)
47 (19.7)	81 (38.8)	23 (9.6)	31 (14.8)	8 (3.4)	13 (6.2)	1 (0.4)	1 (0.5)	1 (0.4)	1 (0.5)	1 (0.4)	1 (0.5)
60 (23.1)	94 (47.0)	19 (7.3)	26 (13.0)	13 (5.0)	12 (6.0)	2 (0.8)	3 (1.5)	3 (1.2)	5 (2.5)	0 (0.0)	1 (0.5)
63 (25.8)	76 (44.4)	22 (9.0)	33 (19.3)	14 (5.7)	10 (5.9)	3 (1.2)	2 (1.2)	1 (0.4)	1 (0.6)	0 (0.0)	3 (1.8)
321 (25.4)	425 (41.6)	125 (9.9)	172 (16.8)	57 (4.5)	70 (6.9)	10 (0.8)	21 (2.1)	7 (0.6)	11 (1.1)	1 (0.1)	8 (0.8)

age group 60–71)* 8 Whites missing sphere and cylinder measures in the right eye and 9 are missing these in the left eye (1 in age group 6–11 missing African American) with spherical equivalent of equal but opposite magnitude. All were within the emmetropic range.

Refraction in the Left Eye by Race

Hyperopic SE, n (%)											
+1<+2D		*+2<+3D*		*+3 <+4D*		*+4<+5D*		*+5<+6D*		*>=+6D*	
AA	*W*	AA	*W*	AA	*W*	AA	*W*	AA	*W*	AA	*W*
26 (31.3)	28 (33.7)	16 (19.3)	19 (22.9)	2 (2.4)	11 (13.3)	1 (1.2)	5 (6.0)	0 (0.0)	1 (1.2)	0 (0.0)	0 (0.0)
55 (29.1)	72 (41.6)	25 (13.2)	32 (18.5)	7 (3.7)	10 (5.8)	3 (1.6)	7 (4.1)	1 (0.5)	1 (0.6)	0 (0.0)	1 (0.6)
59 (23.8)	77 (41.6)	24 (9.7)	31 (16.8)	7 (2.8)	11 (6.0)	1 (0.4)	5 (2.7)	2 (0.8)	3 (1.6)	0 (0.0)	2 (1.1)
51 (21.3)	81 (38.8)	22 (9.2)	26 (12.4)	7 (2.9)	11 (5.3)	1 (0.4)	3 (1.4)	2 (0.8)	1 (0.5)	0 (0.0)	1 (0.5)
69 (26.5)	88 (44.0)	16 (6.2)	24 (12.0)	10 (3.9)	14 (7.0)	5 (1.9)	6 (3.0)	2 (0.8)	2 (1.0)	1 (0.4)	2 (1.0)
68 (27.9)	73 (42.7)	17 (7.0)	30 (17.5)	10 (4.1)	10 (5.9)	2 (0.8)	4 (2.3)	3 (1.2)	2 (1.2)	0 (0.0)	3 (1.8)
328 (26.0)	419 (41.0)	120 (9.5)	162 (15.9)	43 (3.4)	67 (6.6)	13 (1.0)	30 (2.9)	10 (0.8)	10 (1.0)	1 (0.1)	9 (0.9)

sphere and cylinder measures in the right eye and 9 are missing these in the left eye (1 in age group 6–11 missing left eye only, 2 in group 12–23, 4 in the emmetropic range.