Refractive Error in Nigerian Adults: Prevalence, Type, and Spectacle Coverage

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Purpose. To provide data on prevalence and types of refractive error and the spectacle-wearing rate among adults in Nigeria and the degree to which the need for distance correction could be met by off-the-shelf spectacles.

Methods. Multistage, stratified, cluster random sampling with probability proportional to size was used to identify a nationally representative sample of 15,027 persons aged ≥40 years. Distance vision was measured using a reduced logMAR tumbling-E chart. All participants underwent autorefraction, and those with presenting acuity of <6/12 in one or both eyes had their corrected acuity measured and underwent detailed clinical examination to determine the cause.

Results. Included in the survey were 13,599 (89.9%) of the 15,122 persons aged ≥40 years who were enumerated. Uncorrected refractive error was responsible for 77.9% of mild visual impairment (<6/12–6/18), 57.1% of moderate visual impairment (<6/18–6/60), 11.3% of severe visual impairment (<6/60–3/60), and 1.4% of blindness (<3/60). The crude prevalence of myopia (≤0.5 D) and high myopia (≤5.0 D) were 16.2% and 2.1%, respectively. Spectacles could improve the vision of 1279 (9.4%) and 882 (6.5%) participants at the 6/12 and 6/18 level, respectively, but only 3.4% and 4.4% of these individuals wore spectacles to the examination site. Approximately 2,140,000 adults in Nigeria would benefit from spectacles that improved their vision from <6/12 to ≥6/12. More than a third of the need could be met by low-cost, off-the-shelf spectacles.

Conclusions. Uncorrected refractive errors are an important cause of visual impairment in Nigeria, and services must be dramatically improved to meet the need. (*Invest Ophthalmol Vis Sci.* 2011;52:5449–5456) DOI:10.1167/iovs.10-6770

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Refractive error (RE) is a priority for the global VISION2020: The Right to Sight initiative.[1] Worldwide, uncorrected RE is the main cause of moderate and severe visual impairment (VI) and the second leading cause of blindness, accounting for an estimated 153 million and 8 million affected persons, respectively, despite the fact that correction of RE with appropriate spectacles is one of the most cost-effective interventions in eye health.[2]

RE is a significant cause of low vision in African countries, but available data are limited.[3] Nigeria is the most populous country in Africa.[4] Small, population-based studies in Nigeria have shown uncorrected RE, along with cataract and glaucoma, to be among the leading causes of blindness,[5–7] VI, and low vision.[8–12] Hospital- or industry-based Nigerian studies have shown RE to be the commonest ocular condition,[13–15] a leading cause of VI,[16–20] and associated with increased absenteeism and reduced productivity.[14] However, these studies were not nationally representative and cannot be extrapolated to the entire country due to their limited geographic scope, small sample sizes, and lack of validated methodology.

RE is a complex and multifactorial condition that varies in prevalence across populations with different genetics, demographics, ocular, and extrinsic factors, such as education.[21] The Nigerian National Blindness and VI Survey[22–24] indicated that uncorrected RE accounts for 57.1% of moderate VI (visual acuity [VA], >6/18–6/60). Economic consequences are likely to be considerable, as uncorrected RE affects people in the working-age group. To our knowledge, no national survey of RE has been undertaken in Africa, whereas some have been undertaken in Asia.[25–27] This article reports data on the prevalence and types of RE among adults aged 40 or more years in Nigeria.

Methods

The Nigeria survey was conducted over 30 months from 2005 to 2007. The methods have been described in detail elsewhere,[24] and therefore we include only the pertinent elements here.

Definitions

Refractive Error. The WHO categories of VI were used. Blindness was defined as a presenting VA of <3/60 (<20/400, logMAR >1.30) in the better eye, severe visual impairment (SVI) as VA <6/60 to 3/60, and moderate visual impairment (MVI) as <6/18 to 6/60. We also used the term "near normal" to describe VA of <6/12 (<20/40, logMAR >0.3), but ≥6/18 in the better eye. Spherical equivalent (SE) was calculated as half the cylinder plus the spherical component. Low myopia was defined as SE worse than −0.5 D (i.e., < −0.5 D), but better than or equal to −5 D (i.e.,≥ −5 D), and high myopia as SE worse than −5 D (i.e., < −5 D). Low hypermetropia was defined as SE worse than +0.5 D (i.e., ≥ +0.5 D), but better than or equal to +5 D (i.e., ≤ +5 D), and high hypermetropia as worse than +5 D (i.e., >5

D). Astigmatism (minus cylinder format) was defined as a cylindrical error worse than 0.75 D (Table 1).

Improvers. Participants whose unaided VA was <6/12 in the better eye but subsequently improved by one or more visual categories, either with their spectacles or with best correction, were labeled "improvers."

Need for Spectacles. The need for spectacles among the improvers could either have been "met" or "unmet." So as to be comparable with other surveys, "met need" describes the number of participants who wore distance spectacles and had VA <6/12 in the better eye without correction, but who achieved 6/12 or better in the better eye with their present distance spectacles. "Unmet need" was defined as the number of participants who did not wear spectacles and who had VA <6/12 in the better eye without correction, but who could achieve ≥6/12 in the better eye with correction. Met need and unmet needs were also calculated with a cutoff of <6/18 in the better eye.

Some participants presented for VA measurement wearing spectacles, but with an incorrect prescription, defined as a presenting VA of <6/12 (or <6/18), which improved by one or more VA categories with best correction. If best correction improved their VA to ≥6/12 (or ≥6/18) they were defined as having unmet need at the relevant cutoff.

Spectacle Coverage. The percentage of spectacle coverage was defined as: met need/total need × 100%, where total need is met need + unmet need.

Sampling Design and Sample Size

The sample size necessary to meet the parameters of the study was calculated as 15,375 persons aged 40 years or above. Multistage, stratified, cluster random sampling, with probability proportional to size was used to identify a nationally representative sample. Stratification was by place of usual residence (urban/rural). A cluster size of 50 eligible adults was used in randomly selecting a total of 310 clusters across the country, of which 226 (72.9%) were rural and 84 (27.1%) were urban. Five clusters had to be abandoned due to civil unrest or refusal to participate.

Sampling Process, Enumeration, and Registration

Enumerated respondents were invited to attend the "temporary clinical station" set up in each cluster. Eligible respondents were registered with a unique identification number, after verifying their age and residency status, and recording information on sex, ethnic group, occupational status, religion, educational attainment, water supply, and household sanitation.

Visual Acuity Measurement

Visual acuity was measured by an ophthalmic nurse at the central examination site, using a reduced log MAR tumbling-E chart to take three separate measurements. This chart has been validated for use in surveys.[28] First, unaided VA of each eye was measured at 4 m (even if they habitually used distance spectacles), followed by a second assessment of both eyes together (unaided VA). Those who had distance glasses were then reassessed wearing their available glasses (presenting vision). Participants with VA ≤ 6/12 in one or both eyes underwent extensive examination, including dilated funduscopy.

Refractokeratometry

All participants had noncycloplegic refraction by an optometrist using an autorefractokeratometer (ARKM-100; Takagi Seiko, Japan) that was regularly calibrated. If automated readings could not be obtained, refraction was done manually. Participants with VA <6/12 in one or both eyes had their corrected VA measured by subjective refraction based on autorefraction readings. This method was used to estimate the contribution of RE to a participant's VI. VI due to significant RE and uncorrected aphakia was defined as acuity of <6/18 in the better eye before refraction improving to ≥6/18 in one or both eyes after refraction.

TABLE 1. Age- and Sex-Specific Prevalence of Refractive Errors in Nigerian Adults

Age Group	Low Myopia (<−0.5 to ≥−5 D)		High Myopia (<−5 D SE)		Low Hypermetropia (>0.5 to ≥5 D)		Hypermetropia (>2D SE)		High Hypermetropia (>5 D SE)		Emmetropia (−0.5 to +0.5 D)		Astigmatism (<−0.5 DC)	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Women														
40–49	155	5.6	15	0.6	1347	49.0	169	6.2	15	0.6	1218	44.3	1235	44.9
50–59	160	8.7	25	1.4	1268	69.3	278	15.2	10	0.6	368	20.1	1135	62.0
60–69	270	20.7	46	3.5	773	59.2	275	21.1	7	0.5	209	16.0	1055	80.8
70–79	227	35.0	39	6.0	266	41.00	106	16.3	8	1.2	109	16.8	592	91.2
80+	93	44.3	15	7.1	59	28.1	27	12.9	0	0	43	20.5	198	94.3
Total	905	13.4	140	2.1	3713	55.1	855	12.7	40	0.6	1947	28.9	4215	62.5
Men														
40–49	140	6.9	14	0.7	681	33.8	50	2.5	6	0.3	1176	58.3	862	42.7
50–59	145	9.3	13	0.8	903	57.7	114	7.3	9	0.6	496	31.7	992	63.4
60–69	200	17.4	42	3.7	613	53.4	136	11.9	3	0.3	289	25.2	910	79.3
70–79	230	34.8	32	4.9	244	37.0	66	10.0	1	0.2	153	23.2	577	87.4
80+	124	46.4	18	6.7	68	25.5	21	7.9	2	0.8	55	20.6	252	94.4
Total	839	14.8	119	2.1	2509	44.4	387	6.8	21	0.4	2169	38.3	3593	63.5

Data are for right eyes, excluding eyes with cataract surgery.

Eye Examination

Participants had an initial anterior segment examination using a torch, including grading lens opacities (LO) against the red reflex, using the Mehra-Minassian (MM) system.[29] Information on the location and type of cataract surgery was elicited, as well as on the use of aphakic correction. Participants proceeded to a more detailed examination by a clinical ophthalmologist if they met certain criteria, including presenting VA <6/12 in one or both eyes. For these participants, the ophthalmologists determined the cause(s) of visual loss by using the principles outlined in the WHO Prevention of Blindness Performa (Version III).[30] All participants with VI were referred to the nearest eye facility.

A detailed examination was performed with a slit lamp microscope (SL 115 Classic Slit Lamp; Carl Zeiss Meditec AG, Jena, Germany), 81-D aspheric condensing lens (Volk Optical, Mentor, OH), Goldmann applanation tonometer, a two-mirror lens (Volk) with no flange for gonioscopy, and a digital camera (Visucam Lite Desktop Fundus Camera; Carl Zeiss Meditec AG).

Approvals

The study adhered to the tenets of the Declaration of Helsinki and was approved by Ethics Committee of London School of Hygiene and Tropical Medicine and Nigeria's Federal Ministry of Health. Informed consent was obtained from the head of the household and all adult respondents.

Statistical Analysis

There was a high correlation between right and left eyes (Pearson's correlation 0.72; $P = 0.001$), and therefore, data are reported only for right eyes. All those with no recorded autorefraction results and those who were pseudo/aphakic in their right eyes were excluded. To ascertain effects of LO on RE, a further analysis excluded participants with significant LO, defined as grade 2B or more (MM grading).[29] The odds ratio (presented with the 95% confidence interval) was used in univariate analysis of spectacle use with key variables, such as sex, literacy, education, occupation, and location of residence.

The following analyses were undertaken to determine proportion of individuals with significant RE who could potentially benefit from off-the-shelf spectacles. Individuals with presenting VA <6/12 in the better eye but improving to 6/12 or better were identified first. Individuals who had undergone procedures for cataract in both eyes (cataract surgery with/or without IOL, or couching) were then excluded. The following criteria were explored for suitability for off-the-shelf spectacles (1) anisometropia of ≤1.0 D SE with ≤1.0 D astigmatism in both eyes; (2) anisometropia of ≤1.5 D SE with ≤1.5 D astigmatism in both eyes; and (3) anisometropia of ≤2.0 D SE with ≤1.25 D astigmatism in both eyes.[26]

Data were analyzed (Stata 11.0; Stata Corp, College Station, TX), and prevalence estimates with 95% confidence intervals and OR from the regression analyses are presented. All analyses took account of additional variation due to stratified cluster sampling design. The design effect due to cluster sampling was taken into account in the calculation of confidence intervals and odd ratios in the regression analysis using the generalized estimating equation (GEE). The Wald *F*-test was used to assess the interaction effect in the multiple regression analyses. Variables with $P < 0.2$ in univariate analyses were included in the multivariate models. $P < 0.05$ was considered to be statistically significant.

Results

Demographics

A total of 15,122 eligible adults aged 40 years and older were enumerated, 13,599 of whom were examined (89.9% response rate, which was similar across all geopolitical zones). The age and sex of those enumerated and those examined were similar, but younger men (40–49 years) were underrepresented (Pearson $R = -3.94$; $P < 0.001$).

Of the 13,599 participants examined, eight had no VA data, and 890 (6.5%) had no information on RE because of ocular factors including corneal opacity, phthisis, and inability to undergo refraction because of blindness. A further 299 (2.2%) participants who had undergone cataract surgery were excluded, leaving 12,402 participants for analysis. Some analyses also excluded 1,715 participants with significant LO, leaving 10,687 participants for analysis.

Distribution and Prevalence of Refractive Error

The distribution of SE refractive error for right eyes was leptokurtotic (Fig. 1). The overall mean and median SE were +0.36 D (95% CI, 0.32–0.41) and +0.63 D (IQR −0.13, 1.25), respectively. After excluding participants with significant LO, these were +0.67 D (0.63, 0.70) and +0.63 D (IQR: 0.13, 1.38), respectively (Fig. 1).

Myopia. The crude prevalences of myopia (< −0.5 D) and high myopia (< −5.0 D) were 16.2% (n =2003; 95% CI, 15.2–17.1) and 2.1% (n = 259; 95% CI, 1.8–2.4), respectively (Table 1). After excluding participants with significant lens opacities, the crude prevalence of myopia was 9.4% (95% CI, 8.7%–10.2%) and of high myopia 0.7% (95% CI, 0.5–0.9%). The men had a significantly higher prevalence of myopia (16.9% versus 15.5%; OR 1.29, 95% CI, 1.14–1.47). The prevalence of myopia increased steadily with increasing age ($P < 0.001$; Fig. 2).

Hypermetropia. The crude prevalence of hypermetropia (> +0.5 D) was 50.7% (n = 6283; 95% CI, 49.5–51.9), showing an inverse J-shaped distribution with age (Fig. 2). Excluding those with significant LO did not significantly affect prevalence of hypermetropia (52.1%; 95% CI, 50.8–53.3). Prevalence of high hypermetropia was 0.5% (0.4%–0.6%). The women had a significantly higher prevalence of hypermetropia (55.6% versus 44.7%, OR 1.55; 95% CI, 1.43–1.68).

Astigmatism. The crude prevalence of astigmatism was 63.0% (95% CI, 61.8–64.1), which decreased to 58.7% (95% CI, 57.5–59.9) after those with visually disabling lens opacity were excluded. Prevalence increased significantly with age (P = 0.001). After adjusting for age, the prevalence of myopia was 14.1% and of hypermetropia was 51.1%, which changed to 9.7% and 55%, respectively, when LO were excluded (Table 2).

Sex, Literacy, Residence, and Occupation

Univariate analysis showed that the men had a greater risk of myopia (OR 1.29, 95% CI, 1.14–1.47), but a lower risk of hypermetropia (OR 0.61, 95% CI, 0.55–0.66) than did women.

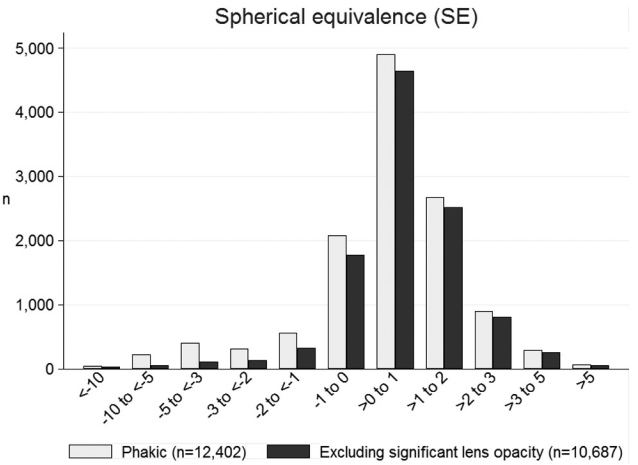

Figure 1. Refractive error in phakic participants, after excluding those with significant lens opacities.

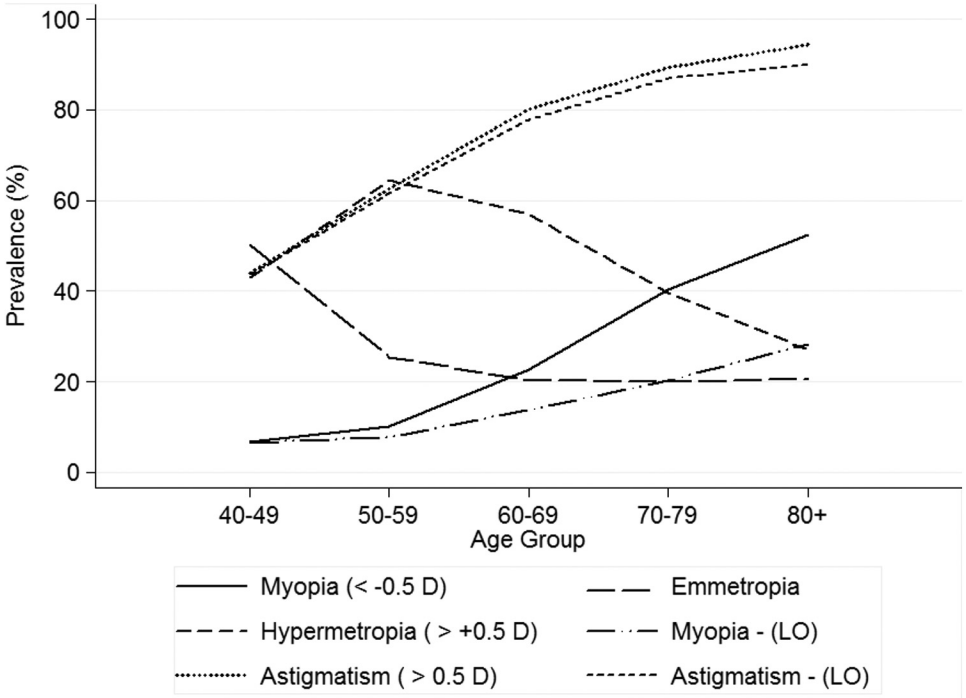

FIGURE 2. Crude prevalence of refractive errors and in a subgroup of participants without significant lens opacities. (−)LO, lens opacities (cataract) excluded.

Illiteracy was associated with myopia (OR 1.37, 95% CI, 1.19–1.58), hypermetropia (OR 1.35, 95% CI, 1.23–1.48), and astigmatism (OR 1.57, 95% CI, 1.44–1.72). Residence in a rural area was associated with an increased risk of myopia (OR 1.35, 95% CI, 1.11–1.63) and astigmatism (OR 1.21, 95% CI, 1.08–1.35). Manual occupation was also associated with myopia (OR 1.57, 95% CI, 1.35–1.84) and astigmatism (OR 1.50, 95% CI, 1.38–1.63; Table 3; Fig. 3).

Spectacle Wear

Only 1.2% (169) of phakic participants (1.2%) wore distance spectacles to the examination site. Another 38 claimed to own distance spectacles, but did not habitually wear them and were classified as nonwearers. Of the 2003 adults identified as having myopia, only 28 (1.4%) were wearing spectacles, and none of those had high myopia (n = 258). Of the 6823 participants identified with hypermetropia, 79 (1.3%) were wearing spectacles. The prevalence of spectacle wear increased with age (0.69% in 40–49-year-olds, 0.97% in 50–59-year-olds, 1.22% in 60–69-year-olds, and 70–79-year-olds, and 1.47% in >80-year-olds). The 299 participants who had undergone cataract surgery were also more likely to be wearing spectacles (14.4% versus 0.9% in phakic participants).

TABLE 2. Age-Adjusted Prevalence of Different Refractive Errors among Nigerian Adults

Refractive Error	*N*	Prevalence (%)	
		Crude	Adjusted
Myopia	12,402	16.2	14.1
Emmetropia	12,402	33.2	34.8
Hypermetropia	12,402	50.7	51.1
Myopia LO	10,687	9.4	9.7
Emmetropia LO	10,687	35.5	35.3
Hypermetropia LO	10,687	55.1	55.0
Astigmatism	12,402	63.0	60.3
Astigmatism LO	10,687	58.7	59.2

(−)LO, excluding lens opacities (cataract).

Improvers and Incorrect Prescriptions

A total of 2248 (16.5%; 95% CI, 15.7–17.4) participants were improvers. We estimate that 3,890,000 (95% CI, 3,700,000–4,100,000) adults over 40 years of age would require optical correction to improve VA status by at least one vision category. Just over half (n = 80, 51.0%) of the spectacle wearers had an incorrect prescription at the 6/12 cutoff; this number was lower at the 6/18 cutoff (n = 65, 41.4%).

Spectacle Coverage

A need for spectacles was identified in 1279 (9.4%) and 882 (6.5%) individuals at the 6/12 and 6/18 cutoffs, respectively, only 43 and 39 of whom were wearing appropriate spectacles. The overall spectacle coverage was 3.4% (95% CI, 2.3–4.4) and 4.4% (95% CI, 2.9–5.9) at the 6/12 and 6/18 cutoffs, respectively.

There were 1190 individuals with significant RE at the 6/12 level who were phakic in one or both eyes (Table 4). The proportion of the need that could be met by off-the-shelf spectacles, using different criteria for anisometropia and astigmatism, ranged from 33.9% to 44.4% (Table 4).

Unmet Need

Over 90% (OR 96.6%, 95% CI, 95.5–97.7) of participants who needed spectacles did not own them, owned a pair but did not use them routinely, or used an incorrect prescription. Our results show that 9.1% (95% CI: 8.5–9.6) of all Nigerian adults over 40 years (2,140,000 individuals), have an unmet need for spectacles, which would improve their distance vision from <6/12 to ≥6/12.

DISCUSSION

This survey provides the first population-based data on the magnitude of RE in Nigeria. The two main findings are the

TABLE 3. Association of Different REs with Sociodemographic Factors, Excluding Lens Opacities

		Myopia			Hyperopia			Astigmatism		
Variables	***N***	***n***	**Univariate Analysis OR (95% CI)**	**Multivariate Analysis OR (95% CI)**	***n***	**Univariate Analysis OR (95% CI)**	**Multivariate Analysis OR (95% CI)**	***n***	**Univariate Analysis OR (95% CI)**	**Multivariate Analysis OR (95% CI)**
Age group										
40–49	4717	310	1.0	1.0	2030	1.0	1.0	2060	1.0	1.0
50–59	3192	248	1.2 (1.0–1.4)	1.1 (1.0–1.4)	2126	2.6 (2.4–2.9)	2.8 (2.5–3.0)	1966	2.1 (1.9–2.3)	2.0 (1.8–2.2)
60–69	1907	262	2.3 (1.9–2.7)	2.1 (1.7–2.5)	1246	2.5 (2.2–2.8)	2.6 (2.4–3.0)	1485	4.5 (4.0–5.2)	4.2 (3.7–4.9)
70–79	712	144	3.6 (2.9–4.5)	3.1 (2.5–3.9)	403	1.7 (1.5–2.0)	1.9 (1.6–2.2)	619	8.6 (6.8–10.8)	7.7 (6.1–9.7)
80+	159	45	5.6 (3.8–8.3)	4.6 (3.1–6.8)	78	1.3 (0.9–1.8)	1.5 (1.1–2.1)	143	11.5 (6.9–20.2)	10.0 (6.0–16.6)
Sex										
Female	5728	482	1.0	1.0	3479	1.0	1.0	3316	1.0	
Male	4959	527	1.3 (1.1–1.5)	1.2 (1.1–1.5)	2404	0.6 (0.6–0.7)	0.6 (0.5–0.6)	2957	1.1 (1.0–1.2)	
Literacy										
Literate	5150	415	1.0	1.0	2636	1.0		2731	1.0	1.0
Illiterate	5537	594	1.4 (1.2–1.6)	1.2 (1.0–1.4)	3247	1.3 (1.2–1.5)		3542	1.6 (1.4–1.7)	1.2 (1.1–1.3)
Residence										
Urban	2407	183	1.0		1363	1.0		1327	1.0	
Rural	8280	826	1.3 (1.1–1.6)		4520	0.9 (0.8–1.0)		4946	1.2 (1.1–1.3)	
Occupation										
Nonmanual	4645	339	1.0	1.0	2555	1.0		2463	1.0	1.0
Manual	5884	649	1.6 (1.3–1.8)	1.2 (1.1–1.5)	3234	1.0 (0.9–1.1)		3699	1.5 (1.4–1.6)	1.2 (1.1–1.3)
Other	157	21	2.0 (1.2–3.2)	1.2 (0.7–2.1)	93	1.2 (0.7–2.1)		110	2.1 (1.4–3.0)	1.1 (0.8–1.7)

relatively low prevalence of myopia and the extremely low spectacle coverage. Data from studies undertaken in Asia, Europe, the Americas, and Australia are shown in Table 5 for comparison. The table contains only studies of adults conducted since 1985 that measured RE with reproducible methods.

Using autorefraction results and a VA cutoff of <6/12, we estimate that there are 15,765,000 (95% CI, 15,530,000–16,001,000) adults with RE in Nigeria. Optical correction can potentially improve the vision of 4 million adults by one or more VA categories, and more than 2 million to normal levels of vision. Many of the remaining 2 million may require other interventions (i.e., cataract surgery).

The crude prevalence of myopia in Nigeria (16.2%) was lower than that in Asia (Pakistan, Bangladesh, India, Singapore, and Myanmar),[25,26,31–33] but comparable to Western populations (Netherlands, United States, and Australia)[34,35,37] and similar to the adult black population in Barbados (21.9%) (Table 5).[39] The prevalence of high myopia (2.1%) was similar to the rate in white Australians aged 40 years and older,[37] higher than findings in the Baltimore Eye Study (1.4% overall)[35] and in a study in Bangladesh (1.8%).[26] It is likely that these population differences are partly accounted for by a genetic mechanism for myopia, as demonstrated in multiple familial, familial aggregation, and twin studies that suggest the involvement of multiple genes rather than a single major gene effect.[40] More data on the genetic basis of RE are needed from African populations.

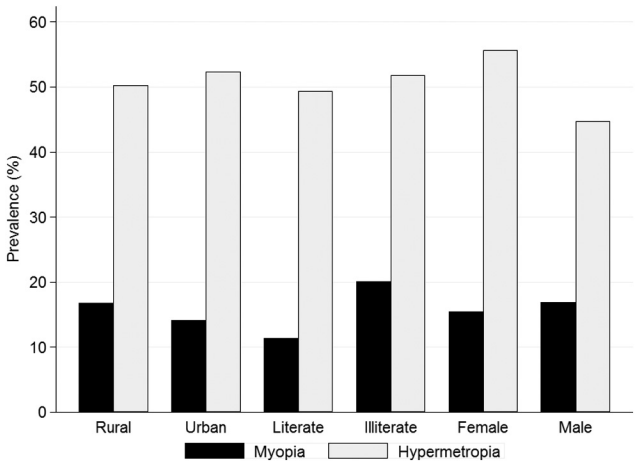

FIGURE 3. Prevalence of refractive error by place of residence, literacy, and sex.

The prevalence of myopia showed a steady increase with age, similar to reports from Pakistan[25] and Bangladesh.[26] Much of the myopia in older age groups was the result of cataract, and participants with significant LO accounted for 41.5% of all myopes. Effect of age on prevalence of myopia has been observed in other studies.[25,26,31–39,41–46] However, this age-related trend was evident, even after participants with visually significant cataract were excluded. In contrast, most studies of Western populations show a decrease in prevalence of myopia with age, followed by an increase at older ages (J-shaped relationship).[39] There may be a U-shaped trend in Nigeria, with the decrease and subsequent increase in prevalence coming at earlier ages than Western populations. It would be instructive for future research in Nigeria to include refractive error in younger age groups as well, to elucidate the longitudinal changes and cohort effects that have been observed in other studies.[42–45] The men in our survey had a slightly higher prevalence of myopia than did the women, as has been reported in other studies.[26,37,47–49]

The prevalence of hypermetropia (50.7%) was considerably higher than that in most Asian studies, being closer to that in populations of predominantly European or African descent. The relationship between hypermetropia and age showed a pattern similar that in to studies from Asia and Barbados,[25–27,31,33,39,49] with a rise to maximum levels in the 50- to 59-year-old group, followed by a decline in later years. Hypermetropia prevalence was significantly higher in women (55.6% versus 44.7%), which has been observed elsewhere.[26,31,37,39,50]

Astigmatism was prevalent in 63.0% (58.7%, after excluding those with visually significant cataract). Many studies of RE have not examined the prevalence of astigmatism. The prevalence in our survey was similar to findings from South India

TABLE 4. Proportion of Need for Spectacle Correction at the 6/12 Level That Could Be Met by Off-the-Shelf Spectacles, Using Different Criteria for Anisometropia and Astigmatism

	≤1D SE and ≤1D cyl			≤1.5DSE and ≤1.5D cyl			≤2D SE and ≤1.25D cyl		
Age Group	***n***	**≤1D**	**%**	***n***	**≤1.5D**	**%**	***n***	**≤2D**	**%**
40–49 years	138	43	31.2	138	31	22.5	138	46	33.3
50–59 years	278	105	37.8	278	88	31.7	278	114	41.0
60–69 years	393	170	43.3	393	139	35.4	393	172	43.8
70–79 years	285	111	39.0	285	100	35.1	285	133	46.7
80 + years	96	37	38.5	96	45	46.9	96	63	65.6
Total	1190	466	39.2	1190	403	33.9	1190	528	44.4

Criteria were anisometropia (SE) and astigmatism in one or both eyes.

(60.4% and 59.1% in rural and urban participants in Tamilnadu, respectively).[49]

Participants who were illiterate were more likely to be myopic or hypermetropic and to have astigmatism. Participants with manual occupations and those living in rural areas were also more likely to be myopic and have astigmatism. Some of these findings contrast with other population-based studies, which have shown associations between myopia, higher education levels, professional occupations and residence in urban areas[25,26,32,33,40,43,46,48,51] (in support of the use–abuse theory of myopia). There are, however, exceptions to these trends: The Baltimore Eye Study showed that the association between years of education and myopia was stronger for white persons than for black persons,[35] the Chennai Study (India) showed a higher prevalence of myopia in participants living in rural areas,[49] and the Bangladesh study showed a significantly lower risk of myopia with literacy, urban living, and nonmanual occupation.[26] This variability in findings suggests that the risk factors for myopia are context specific, and that time spent outdoors may be the more important environmental variable in myopia in some populations.[52]

The leptokurtosis and negative skewness of the distribution of spherical equivalent RE in this population was similar to that in other studies.[25,26,31–33,40,50,53] After participants with significant LO were excluded, the mean spherical equivalent was +0.67 D, the same as Australians aged ≥49 years,[54] but different from adults aged ≥40 years in Bangladesh (−0.19 D),[26] Pakistan (−0.4 D),[25] and Myanmar (−1.3 D).[32]

Spectacle coverage rates were significantly lower than reported among similar age groups in Bangladesh (3.0%),[27] Pakistan (6.2%),[25] and India (17.4%),[31] although it should be appreciated that the definition of "unmet need" for spectacles does not necessarily equate with demand for correction. None of the participants with high myopia were wearing spectacles. Incorrect prescriptions were common among the few wearing spectacles, with just over half improving by ≥1 VA category with best correction. This suggests a need to improve both quality and affordability of optical and refractive services in Nigeria. Over one third of the need for distance correction among individuals who were phakic in one or both eyes could be met by off-the-shelf spectacles.

Limitations of this study include possible overestimation of myopia in younger participants, as autorefraction was not performed after cycloplegia. The analysis used refractive data from the right eye, which is in keeping with several other studies,[26,32,33] but differs from some studies that included the worse eye in their analyses.[25,45,49] Younger males were underrepresented, as they were more likely to be at work at the time of examination, which may have led to a slight overestimation of refractive error. The MM lens-grading system was used to provide some data on lens opacities in all participants, regardless of their visual acuity. Individuals undergoing full ophthalmic examination had their lenses graded using LOCS III.[55,56] finally, presbyopia, and anisometropia were not addressed.

This is the first population-based, national RE survey in Africa, to the authors' knowledge. The distribution of RE in

TABLE 5. Summary of Results from Selected Population-Based Refractive Error Studies

Study	Country	Sample Size	Age Group (y)	Myopia	High Myopia	Hypermetropia	Astigmatism
NBVIS	Pakistan[25]	14,490	≥30	<−0.5G; 36.5	<−5.0D; 4.6	>0.5D; 27.1	>0.75D; 27.1
NBLVS	Bangladesh[26]	11,624	≥30	≤−0.5D; 22.1	≤−5.0D; 1.8	>0.5D; 20.6	>0.5D; 34.6
APEDS	India[31]	10,293	≥40	<−0.5D; 34.6	<−5.0D; 4.5	>0.5D; 18.4	>0.5D; 37.6
MES	Myanmar[32]	1,863	≥40	<−1.0D; 42.7	<−6.0D; 6.5	>1.0D; 15.0	>1.0D; 30.6
SMES	Singapore[33]	2,974	40–80	<−0.5D; 38.7	<−5.0D; 3.9	>0.5D; 27.4	<−0.5D; 33.3
RES	Netherlands[34]	6,543	≥55	≤1.0D; 17.6	≤−5.0D; 4.0	≥3.0D; 17.6	Not studied
BES	United States[35]	5,036	≥40	<−0.5D; 19.4 (B)	<−6.0D; 0.0–1.4 (B)	>0.5D	>0.5D
						41.0 (B)	15.8–38.3 (B)
				28.1 (W)	1.3–2.5 (W)	43.9 (W)	24.4–48.9 (W)
BDES	United States[36]	4,533	43–84	<−0.5D; 26.2	<−5.0D; 3.8	>0.5D; 49	Not studied
MVIP	Australia[37]	4,744	≥40	<−0.5D; 17.0	<−5.0D; 2.1	>0.5D; 37.0	Not studied
BMES	Australia[38]	3,654	49–97	<−0.5D; 15.0	≤−4.0D; 3.0	>0.5D; 57.0	>1.0D; 37.0
BdES	Barbados[39]	4,709	≥40	<−0.5D; 21.9	Not studied	>0.5D; 46.9	Not studied

Data are expressed as the spherical equivalent in diopters and the prevalence (%). NBVIS, National Blindness and Visual Impairment Survey; NBLVS, National Blindness and Low Vision Survey; APEDS, Andhra Pradesh Eye Disease Study; MES, Meiktila Eye Study; SMES, Singapore Malay Eye Survey; RES, Rotterdam Study; BES, Baltimore Eye Study; BDES, Beaver Dam Eye Study; MVIP, Melbourne Visual Impairment Project; BMES, Blue Mountains Eye Study; BdES, Barbados Eye Study; (B), black; (W), white participants.

Nigeria appears closer to that of white and black populations in Europe and America, and differs from Asian populations. Findings indicate a low prevalence of myopia in Nigeria, exceedingly low spectacle coverage, a large unmet need for spectacles, and a need to improve the quality, access and affordability of optical and refractive services—a VISION2020 priority.

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APPENDIX

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