Prevalence and Correction of Near Vision Impairment at Seven Sites in China, India, Nepal, Niger, South Africa, and the United States

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• PURPOSE: To estimate the prevalence of near vision impairment and use of corrective spectacles among middle-aged and older adults in different settings and ethnic groups.
• DESIGN: Population-based, cross-sectional study.
• METHODS: People aged ≥35 years were randomly selected with cluster sampling in 4 rural settings in Shunyi (China), Kaski (Nepal), Madurai (India), and Dosso (Niger); 1 semi-urban area in Durban (South Africa); and 2 urban settings in Guangzhou (China) and Los Angeles (USA). Near visual acuity (VA), with and without presenting near correction, was measured at 40 cm using a logMAR near vision tumbling E chart. Subjects with uncorrected binocular near VA ≤20/40 were tested with plus spheres to obtain the best-corrected binocular VA.
• RESULTS: A total of 17 734 persons aged ≥35 years were enumerated and 14 805 (83.5%) were examined. The age- and sex-standardized prevalence of uncorrected near vision impairment (VA ≤20/40) ranged from 49% in Dosso to 60% in Shunyi and Guangzhou, 65% in Kaski and Los Angeles, and 83% in Madurai and Durban. The prevalence of near vision impairment based on best-corrected visual acuity was less than 10% in Guangzhou, Kaski, Durban, and Los Angeles, but as high as 23% in Madurai. In multiple logistic regression models, uncorrected near vision impairment was associated with older age (odds ratio [OR] = 1.14, $P < .001$) and female sex (OR = 1.12, $P = .027$), but not with educational level (OR = 1.01, $P = .812$). Over 90% of people in need of near refractive correction in rural settings did not have the necessary spectacles. These rates were 40% in urban settings.
• CONCLUSIONS: By 50 years of age, the majority of people suffer from near vision impairment, most of which can be corrected optically. Over 90% of those in need of near refractive correction in rural settings do not have the necessary spectacles. (Am J Ophthalmol 2012;154: 107–116. © 2012 by Elsevier Inc. All rights reserved.)

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Uncorrected refractive error is increasingly recognized as an important cause of avoidable visual disability worldwide, and has been included as one of the priority conditions in Vision 2020.[1,2] The World Health Organization (WHO) has also acknowledged that near vision impairment is an important ocular condition affecting quality of life, but it has yet to be included in WHO estimates of diseases burden, in part because of an almost complete lack of scientifically valid, population-based data.[2]

A major cause of loss of near vision in older people is the development of presbyopia, the progressive loss of accommodative amplitude. It has been stated that in human subjects, two-thirds of the accommodation amplitude is lost by the age of 35, and it reaches almost complete loss of accommodation by the age of 50 to 55.[3] This loss of accommodative amplitude with age leads to optically correctable near vision impairment, independent of effects on distance vision, but the impact of loss of accommodation has different effects depending on refractive status. Hyperopic individuals tend to lose near visual acuity earlier, while those with myopia can be protected from near vision impairment. Our interest is in the overall prevalence of near vision impairment, irrespective of whether it is caused by presbyopic changes or has other causes.

The prevalence of near vision impairment, sometimes labeled as presbyopia, has been reported in Tanzania,[4] China,[5] India,[6] and Timor-Leste.[7] Widely varying prevalence rates and spectacle coverage among persons with near vision impairment have been reported, partly attributable to differences in definitions, protocols, measurement conditions, and age groups between studies.[8] These problems hinder a valid comparison of data between areas.

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The purpose of the current study was to evaluate the prevalence of near vision impairment (from all causes) among people aged ≥35 years in different settings and ethnic groups using a standardized protocol. Surveys were conducted in China, Nepal, India, South Africa, Niger, and the United States. By enrolling subjects from the age of 35 years, during the early stages of loss of accommodation,[3] the study results will reflect the age-related rise in the prevalence of near vision impairment caused by presbyopia, along with other changes.

METHODS

• **STUDY SITES AND SAMPLING:** The 2 study sites selected in China were representative of very different levels of socioeconomic development in the east coast region. Shunyi district, in the northeast near Beijing, is representative of a rural/semi-rural area with increasing accessibility and affordability of eye care services. Shunyi district had a population of nearly 732 000 in 2009, covering 1019 square kilometers. The sample was drawn from the rural parts of the district. The Yuexiu District of Guangzhou in the south covers an upper-middle-income population within a large urban area, with a population of 416 407 living in 9.16 square kilometers.

The Nepal study was conducted in a rural area 200 kilometers west of Kathmandu in the Kaski district. The study area in Kaski district consists of rural valleys, hills, and mountains with altitudes ranging from 1000 to 8000 meters. Subsistence agriculture is the occupation of the population residing in this area, which is also partially supported by tourism in the city and villages along trekking routes. The total population of the district is 380 527, with an average density of 189 per square kilometer.

The India study was conducted in 2 subdivisions, namely Thirumangalam and Alanganallur in Madurai district, Tamil Nadu. The study sites are 20 to 25 kilometers from Madurai, the nearest large city. The 2 blocks, with a total population of nearly 250 000 (2001 census) had a rural population of 73%, with the remainder in small towns classified as urban in the census. The sample clusters were drawn from both rural and urban populations. The population is predominantly agriculture-based (86% report agriculture as the main work). Population density is around 350 per square kilometer.

The South Africa study was conducted in a semi-urban area, situated 20 km northwest of Durban. The area is predominantly residential and comprises an estimated population of 580 000 in an area that covers 70.1 square kilometers. The population is primarily isiZulu speaking and of African ancestry, accounting for 99% of the total population, with 1% of Indian origin (2001 census). Low income, unemployment, and poverty are characteristic of the area.

The Niger study was conducted in semi-urban wards and rural villages/hamlets within the Dosso Commune of the Dosso Sanitary District. Dosso is located 140 km from Niamey City, the capital of Niger. Based on the 2001 census updated in 2008, the total population of the Dosso Commune is 79 657. The depressed economy is agriculture-based, with limited access to healthcare services.

The study in Los Angeles was conducted in the population-based Los Angeles Latino Eye Study (LALES) cohort. The LALES population was primarily Latinos of Mexican descent residing in six low- to moderate-income census tracts in the urban La Puente area of Los Angeles County, California.

The surveys were carried out on a randomly selected sample of individuals within each study site—except for Los Angeles, where the study was conducted in a sample of previously examined LALES participants. Sampling frames were constructed using geographically defined clusters based on census data. Cluster boundaries were defined such that each cluster would have approximately 100 study participants. A sample size on the order of 2000 for each site was based on estimating the prevalence of near vision impairment within age subgroups, with adjustment for nonparticipation and cluster design effects.

In door-to-door household visits, eligible persons were enumerated by name, sex, age, education (highest level completed), and spectacle usage. Those ≥65 years of age were interviewed in all households, those 50 to 64 were interviewed in every other household (half of households), and those 35 to 49 were interviewed in every fourth household (one-quarter of households). The interviews covered questions on visual functioning and work productivity and an assessment of the burden of their visual disability. The age-based sampling for interviews was used to ensure a reasonably balanced distribution of study subjects across the 3 age categories.

Examinations took place in local clinics and other community facilities, according to prescheduled dates established at the time of enumeration. Those who did not appear at the examination site were revisited by a member of the enumeration team to encourage participation. Written informed consent was obtained at the time of the examination, if not already obtained during the enumeration visit.

• **EXAMINATION:** Binocular near visual acuity (VA), both with and without correction for those presenting with bifocals or near vision spectacles, was measured at 40 cm using a logMAR near vision tumbling E chart (Precision Vision, La Salle, Illinois, USA) under ambient lighting. In Dosso, VA was measured outdoors in sunlight, because of unreliable power supply. VA was recorded as the smallest line read with 1 or no errors. Subjects with uncorrected binocular near VA ≤20/40 were progressively tested with increasing plus spheres to obtain best-corrected VA. Those

TABLE 1. Study Population by Sex, Age, and Education in 7 Multi-country Study Sites

	Sex		Age (y)			Education						
	Male	Female	35–49	50–64	≥65	None	<Primary	Primary	Secondary	≥ High School	No Info.	All
Shunyi												
Enumerated, n (%)	1865 (46.9)	2112 (53.1)	1402 (35.3)	1651 (41.5)	924 (23.2)	619 (15.6)	263 (6.6)	679 (17.1)	1928 (48.5)	377 (9.5)	111 (2.8)	3977 (100.0)
Examined, n (%)	1613 (45.4)	1941 (54.6)	1200 (33.8)	1543 (43.4)	811 (22.8)	551 (15.5)	246 (6.9)	619 (17.4)	1791 (50.4)	345 (9.7)	2 (0.06)	3554 (100.0)
% Examined	86.5	91.9	85.6	93.5	87.8	89.0	93.5	91.2	92.9	91.5	1.8	89.4
Guangzhou												
Enumerated, n (%)	1110 (48.6)	1174 (51.4)	1095 (47.9)	747 (32.7)	442 (19.4)	33 (1.4)	77 (3.4)	155 (6.8)	426 (18.7)	1434 (62.8)	159 (7.0)	2284 (100.0)
Examined, n (%)	836 (46.0)	981 (54.0)	803 (44.2)	645 (35.5)	369 (20.3)	30 (1.7)	64 (3.5)	134 (7.4)	388 (21.4)	1113 (61.3)	88 (4.8)	1817 (100.0)
% Examined	75.3	83.6	73.3	86.4	83.5	90.9	83.1	86.5	91.1	77.6	55.4	79.6
Kaski												
Enumerated, n (%)	897 (38.0)	1463 (62.0)	973 (41.2)	825 (35.0)	562 (23.8)	1524 (64.6)	203 (8.6)	290 (12.3)	85 (3.6)	232 (9.8)	26 (1.1)	2360 (100.0)
Examined, n (%)	814 (37.8)	1342 (62.2)	861 (39.9)	764 (35.4)	531 (24.6)	1395 (64.7)	179 (8.3)	262 (12.2)	79 (3.7)	217 (10.1)	24 (1.1)	2156 (100.0)
% Examined	90.8	91.7	88.5	92.6	94.5	91.5	88.2	90.3	92.9	93.5	92.3	91.4
Madurai												
Enumerated, n (%)	1246 (42.6)	1676 (57.4)	1469 (50.3)	920 (31.5)	533 (18.2)	1399 (47.9)	521 (17.8)	522 (17.9)	310 (10.6)	168 (5.8)	2 (0.07)	2922 (100.0)
Examined, n (%)	1068 (40.6)	1563 (59.4)	1330 (50.6)	812 (30.9)	489 (18.6)	1263 (48.0)	478 (18.2)	467 (17.8)	278 (10.6)	143 (5.4)	2 (0.08)	2631 (100.0)
% Examined	85.7	93.3	90.5	88.3	91.7	90.3	91.8	89.5	89.7	85.1	100.0	90.0
Durban												
Enumerated, n (%)	784 (28.4)	1980 (71.6)	1380 (49.9)	985 (35.6)	399 (14.4)	151 (5.5)	872 (31.6)	750 (27.1)	389 (14.1)	251 (9.1)	351 (12.7)	2764 (100.0)
Examined, n (%)	482 (24.9)	1457 (75.1)	839 (43.3)	779 (40.2)	321 (16.6)	111 (5.7)	645 (33.3)	513 (26.5)	251 (12.9)	144 (7.4)	275 (14.2)	1939 (100.0)
% Examined	61.5	73.6	60.8	79.1	80.5	73.5	74.0	68.4	64.5	57.4	78.4	70.2
Dosso												
Enumerated, n (%)	1166 (42.2)	1598 (57.8)	1524 (55.1)	796 (28.8)	444 (16.1)	1801 (65.2)	337 (12.2)	273 (9.9)	242 (8.8)	104 (3.8)	7 (0.25)	2764 (100.0)
Examined, n (%)	771 (37.7)	1274 (62.3)	1141 (55.8)	596 (29.1)	308 (15.1)	1352 (66.1)	231 (11.3)	210 (10.3)	171 (8.4)	74 (3.6)	7 (0.34)	2045 (100.0)
% Examined	66.1	79.7	74.9	74.9	69.4	75.1	66.6	76.9	70.7	71.2	100.0	74.0
Los Angeles												
Enumerated, n (%)[a]	—	—	—	—	—	—	—	—	—	—	—	
Examined, n (%)	236 (35.6)	427 (64.4)	192 (29.0)	273 (41.2)	198 (29.9)	22 (3.3)	111 (16.7)	152 (22.9)	109 (16.4)	250 (37.7)	19 (2.9)	663 (100.0)
% Examined	—	—	—	—	—	—	—	—	—	—	—	

[a]Participants were obtained from a list of previously examined individuals.

TABLE 2. Prevalence of Uncorrected and Best-Corrected Near Visual Acuity >20/40, 20/40 to 20/63, and <20/63 in 7 Multi-country Study Sites

	Sex[a]		Age (y)[a]					
	Male	Female	35–39	40–49	50–59	60–69	70+	All[b]
Shunyi								
>20/40	33.0; 82.8	30.2; 78.0	97.4; 98.3	71.6; 97.8	14.1; 91.6	4.7; 67.2	1.1; 31.0	39.8 (38.5,41.0); 81.7 (80.4, 82.9)
20/40-20/63	39.1; 13.3	38.9; 15.9	1.7; 0.86	24.5; 1.7	57.4; 7.4	46.2; 26.6	32.3; 46.2	34.2 (32.6,35.8); 13.3 (12.1, 14.5)
<20/63	28.0; 3.9	30.9; 6.1	0.86; 0.86	3.9; 0.52	28.5; 0.96	49.0; 6.2	66.6; 22.9	25.8 (24.7,27.0); 4.5 (3.8, 5.1)
Guangzhou								
>20/40	38.5; 94.0	40.2; 89.5	84.7; 100.	58.4; 99.8	23.3; 98.5	16.1; 89.6	6.4; 54.7	38.8 (36.9, 40.7); 92.1 (91.0, 93.3)
20/40-20/63	45.1; 5.3	41.1; 9.0	5.5; 0.0	35.0; 0.19	59.2; 1.4	55.2; 9.1	55.1; 38.9	43.3 (41.2, 45.7); 6.6 (5.5, 7.7)
<20/63	16.4; 0.72	18.8; 1.5	9.9; 0.0	6.6; 0.0	17.5; 0.19	28.7; 1.3	38.5; 6.4	17.4 (15.6, 19.2); 0.9 (0.4, 1.5)
Kaski								
>20/40	25.1; 90.3	37.6; 93.1	94.4; 100.	50.2; 98.6	11.4; 98.2	8.2; 91.7	13.1; 68.0	33.9 (32.3, 35.4); 93.6 (92.7, 94.4)
20/40-20/63	42.4; 6.9	36.9; 3.7	5.3; 0.0	35.3; 0.54	49.7; 0.99	50.1; 5.6	45.1; 19.7	39.1 (37.1, 41.1); 3.7 (3.0, 4.3)
<20/63	32.6; 2.8	25.6; 3.2	0.33; 0.0	14.6; 0.90	38.9; 0.79	41.7; 2.7	41.9; 12.3	26.8 (25.1, 28.6); 2.5 (1.9, 3.1)
Madurai								
>20/40	16.2; 79.6	18.5; 76.2	49.0; 95.7	11.6; 89.8	10.4; 73.5	8.9; 54.9	5.1; 53.3	14.6 (13.3, 15.9); 74.9 (73.1, 76.6)
20/40-20/63	67.3; 15.4	63.5; 19.3	46.1; 3.1	78.3; 8.6	69.1; 21.7	63.2; 35.6	54.9; 34.5	66.3 (64.5, 68.1); 18.1 (16.5, 19.6)
<20/63	16.5; 5.0	18.0; 4.4	4.9; 1.2	10.1; 1.6	20.5; 4.9	28.0; 9.5	40.1; 12.2	17.4 (15.9, 18.9); 4.8 (3.8, 5.7)
Durban								
>20/40	15.2; 92.7	12.3; 91.4	46.7; 93.3	16.4; 96.5	5.2; 96.0	1.5; 87.7	3.7; 68.6	15.4 (13.7, 17.0); 90.1 (89.0, 91.3)
20/40-20/63	55.0; 4.2	46.5; 5.7	39.6; 4.2	52.1; 2.7	52.3; 2.8	48.1; 8.1	39.2; 17.6	47.8 (45.4, 50.1); 4.9 (4.0, 5.8)
<20/63	29.9; 3.1	41.2; 3.0	13.8; 2.5	31.6; 0.84	42.5; 1.2	50.5; 4.2	57.1; 13.8	35.4 (33.3, 37.4); 3.1 (2.4, 3.8)
Dosso								
>20/40	54.5; 90.9	59.3; 90.1	91.7; 98.8	57.5; 97.4	46.9; 94.2	41.0; 82.0	19.3; 51.7	49.6 (47.4, 51.8); 87.1 (85.6, 88.5)
20/40-20/63	38.3; 5.5	34.1; 6.1	7.7; 1.2	39.6; 2.0	48.0; 4.2	47.0; 12.0	50.2; 24.6	41.1 (38.9, 43.3); 7.4 (6.1, 8.7)
<20/63	7.3; 3.6	6.5; 3.8	0.61; 0.0	2.9; 0.62	5.1; 1.6	12.0; 6.0	30.4; 23.7	7.6 (6.3, 8.9); 4.0 (3.0, 4.9)
Los Angeles								
>20/40	32.2; 95.7	26.0; 95.8	92.9; 98.6	50.8; 99.2	13.3; 98.3	14.1; 98.1	10.5; 85.1	35.3 (32.5, 38.0); 96.4 (95.2, 97.6)
20/40-20/63	39.0; 3.8	34.4; 3.5	2.9; 1.4	37.7; 0.82	44.8; 1.7	37.8; 1.3	38.1; 12.7	35.2 (31.9, 38.6); 2.4 (1.4, 3.4)
<20/63	28.8; 0.43	39.6; 0.70	4.3; 0.0	11.5; 0.0	42.0; 0.0	48.1; 0.64	51.5; 2.2	29.0 (25.9, 32.1); 0.3 (0.0, 0.8)

[a]Data given as % uncorrected visual acuity; best-corrected visual acuity. Best-corrected visual acuity was not available for 16 participants in Shunyi, 15 in Madurai, 8 in Durban, and 1 in Los Angeles.

[b]Standardized age- and sex-adjusted prevalence (95% confidence interval): uncorrected visual acuity; best-corrected visual acuity.

TABLE 3. Multiple Logistic Regression Odds Ratios for Uncorrected Visual Acuity ≤20/40 in 7 Multi-country Study Sites[a]

	Uncorrected Visual Acuity ≤20/40		
Study Site	Older Age	Female Sex	Lower Education Level
Shunyi	1.30 (1.22–1.39)	1.26 (0.97–1.63)	1.08 (0.95–1.23)
	$P < .001$	$P = .078$	$P = .225$
Guangzhou	1.13 (1.10–1.16)	0.93 (0.78–1.10)	1.09 (0.92–1.30)
	$P < .001$	$P = .341$	$P = .288$
Kaski	1.13 (1.10–1.16)	0.72 (0.53–0.98)	1.11 (1.05–1.18)
	$P < .001$	$P = .038$	$P = .001$
Madurai	1.09 (1.07–1.11)	1.11 (0.88–1.39)	0.96 (0.87–1.07)
	$P < .001$	$P = .375$	$P = .451$
Durban	1.16 (1.12–1.20)	1.52 (0.92–2.51)	1.16 (1.01–1.33)
	$P < .001$	$P = .096$	$P = .039$
Dosso	1.09 (1.08–1.10)	1.24 (0.98–1.57)	0.72 (0.64–0.81)
	$P < .001$	$P = .069$	$P < .001$
Los Angeles	1.12 (1.06–1.19)	2.07 (1.19–3.61)	1.20 (1.04–1.38)
	$P = .004$	$P = .022$	$P = .023$
All sites	1.14 (1.13–1.15)	1.12 (1.01–1.23)	1.01 (0.96–1.06)
	$P < .001$	$P = .027$	$P = .812$

[a]Data are given as odds ratios (95% confidence interval) in a multiple logistic regression model for each site with age, sex, and education level as covariables. Age and the 5 levels of education were modeled as continuous variables.

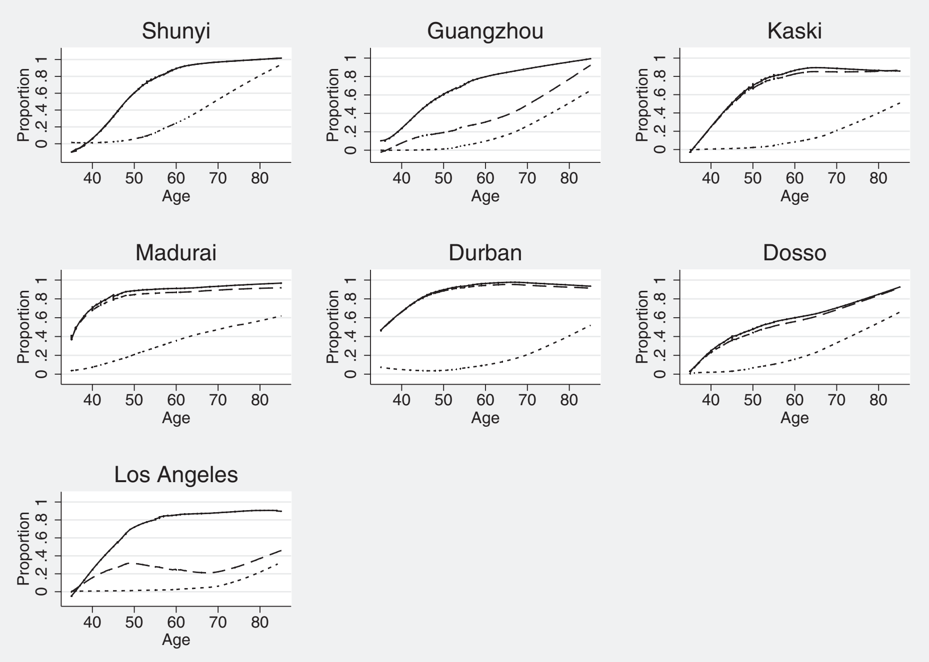

FIGURE. LOWESS smoothed age-specific distributions of near visual acuity ≤20/40 in 7 multi-country study sites: uncorrected (top curve), presenting (middle curve), and best corrected VA (bottom curve).

presenting with binocular near VA ≤20/63 that could be improved by 2 or more lines were provided with near vision glasses free of charge.

• **DATA MANAGEMENT AND ANALYSIS:** Computerized data entry was carried out at each study site using standardized programs. Measurement data ranges, frequency

TABLE 4. Spectacle Wearing in Participants With Uncorrected Near Visual Acuity 20/40 to 20/63 and <20/63 in 7 Multi-country Study Sites[a]

Study Site	Refractive Correction				Total
	None	Distance Only	Distance & Near	Near Only	
Shunyi	1366 (98.7)	14 (1.01)	3 (0.22)	1 (0.07)	1384 (100.0)
	1034 (98.4)	9 (0.86)	7 (0.67)	1 (0.10)	1051 (100.0)
Guangzhou	212 (27.2)	38 (4.87)	36 (4.62)	494 (63.3)	780 (100.0)
	54 (16.8)	15 (4.67)	89 (27.7)	163 (50.8)	321 (100.0)
Kaski	780 (92.3)	20 (2.38)	20 (2.38)	20 (2.38)	840 (100.0)
	542 (89.1)	28 (4.61)	24 (3.95)	14 (2.30)	608 (100.0)
Madurai	1601 (93.6)	23 (1.34)	58 (3.39)	29 (1.69)	1711 (100.0)
	398 (86.9)	28 (6.11)	30 (6.55)	2 (0.44)	458 (100.0)
Durban	900 (95.4)	3 (0.32)	36 (3.82)	4 (0.42)	943 (100.0)
	698 (93.8)	5 (0.67)	30 (4.03)	11 (1.48)	744 (100.0)
Dosso	640 (87.7)	8 (1.10)	11 (1.51)	71 (9.73)	730 (100.0)
	127 (91.4)	3 (2.16)	1 (0.72)	8 (5.76)	139 (100.0)
Los Angeles	64 (26.8)	2 (0.84)	79 (33.1)	94 (39.3)	239 (100.0)
	18 (7.59)	2 (0.84)	164 (69.2)	53 (22.4)	237 (100.0)

[a]Data are presented as number (percentage) of participants. The top entry pertains to uncorrected near visual acuity 20/40 to 20/63 and the bottom entry to visual acuity <20/63.

distributions, and consistency among related measurements were checked with data-cleaning programs.

Crude and standardized prevalence rates of near visual acuity 20/40 to 20/63 and <20/63 were calculated using uncorrected and best-corrected binocular VA. In adjusting for the age and sex differences across the 7 sites, the standardization procedure calculated the prevalence rates that would result if each site had an age and sex distribution similar to that of the aggregated sample across all 7 sites. The association of age, sex, and educational level with near vision impairment (uncorrected binocular near VA ≤20/40) was investigated with multiple logistic regression.

The proportion of participants with uncorrected, presenting, and best-corrected near VA ≤20/40 was graphed as a function of age for each site using LOWESS smoothing. The LOWESS procedure imputes smoothed values for age-specific rates using a locally weighted regression of the prevalence of visual impairment on age.

Statistical analyses were performed using Stata/SE Statistical Software: Release 9.0 (Stata Corporation, College Station, Texas, USA). Confidence intervals (CI) and *P* values (significant at the $P \leq .05$ level) were calculated with adjustment for clustering effects associated with the sampling design.

RESULTS

A TOTAL OF 17 734 PERSONS AGED >35 YEARS WERE ENUmerated and 14 805 (83.5%) examined, with distributions across age, sex, and education by study site as shown in Table 1. Not included among the examined are 44 enumerated individuals (0.25%) who came to the examination site but were unable to cooperate with visual acuity testing.

In multiple logistic regression modeling for each site, participation in the examination was associated with older age in Kaski and Durban, female sex at all 7 sites, and higher educational level in Shunyi and Kaski.

Across the 7 sites, the examined population was 39.3% male, ranging from 24.9% in Durban to 46.0% in Guangzhou. The mean age was 53.3 ± 12.6 years, ranging from 49.8 years in Dosso to 57.4 years in Los Angeles. Educational background varied considerably between sites. Overall, nearly one-third of those examined were without formal education, but the site prevalence ranged from 66.1% and 64.7% in Dosso and Kaski to 1.7% and 3.4% in Guangzhou and Los Angeles, respectively. Education at the high school level or higher was reported by 15.9% of subjects, ranging from 64.4% and 38.8% in Guangzhou and Los Angeles to 3.63% and 5.44% in Dosso and Madurai, respectively.

Sex- and age-specific prevalence of uncorrected and best-corrected binocular near visual acuity >20/40, 20/40 to 20/63, and <20/63 is shown for each study site in Table 2. Generally, half of the population at each site will experience near vision impairment (VA ≤20/40) by the 40- to 49-year age interval, earlier in Madurai and Durban, and approximately half will have near VA <20/63 by their seventies.

The standardized age- and sex-adjusted prevalence of uncorrected and best-corrected VA is also shown in Table 2.

In multiple logistic regression modeling, uncorrected near VA ≤20/40 was associated with older age in all study sites (Table 3). Female sex was significantly associated

TABLE 5. Correction of Near Vision Impairment in Participants With Uncorrected Near Visual Acuity ≤20/40 in 7 Multi-country Study Sites[a]

Study Site	Need Already Corrected to >20/40	Unmet Need for Refractive Correction – Lines of Improvement Possible With Best Correction: Correctable to >20/40						Not Correctable to >20/40							All
	>20/40	1	2	3	4	≥5	All	0	1	2	3	4	≥5	All	
Shunyi	3 (0.12)	67 (2.77)	315 (13.0)	484 (20.0)	436 (18.0)	413 (17.1)	1715 (70.9)	144 (5.95)	142 (5.87)	146 (6.04)	115 (4.75)	86 (3.56)	68 (2.81)	701 (29.0)	2419 (100.0)
Guangzhou	643 (58.4)	49 (4.45)	65 (5.90)	127 (11.5)	42 (3.81)	22 (2.00)	305 (27.7)	44 (4.00)	49 (4.45)	33 (3.00)	17 (1.54)	4 (0.36)	6 (0.54)	153 (13.9)	1101 (100.0)
Kaski	56 (3.87)	16 (1.10)	80 (5.52)	429 (29.6)	163 (11.3)	533 (36.8)	1221 (84.3)	53 (3.66)	24 (1.66)	25 (1.73)	26 (1.80)	22 (1.52)	21 (1.45)	171 (11.8)	1448 (100.0)
Madurai	92 (4.27)	21 (0.97)	62 (2.88)	376 (17.5)	858 (39.8)	159 (7.38)	1476 (68.5)	443 (20.6)	17 (0.79)	48 (2.23)	39 (1.81)	10 (0.46)	29 (1.35)	586 (27.2)	2154 (100.0)
Durban	27 (1.61)	25 (1.49)	96 (5.72	284 (16.9)	312 (18.6)	777 (46.3)	1494 (89.0)	63 (3.75)	20 (1.19)	15 (0.89)	23 (1.37)	13 (0.77)	24 (1.43)	158 (9.41)	1679 (100.0)
Dosso	60 (6.90)	12 (1.38)	72 (8.29)	324 (37.3)	162 (18.6)	53 (6.10)	613 (70.5)	109 (12.5)	36 (4.14)	18 (2.07)	17 (1.96)	11 (1.27)	5 (0.58)	196 (22.6)	869 (100.0)
Los Angeles	315 (66.3)	6 (1.26)	18 (3.79)	38 (8.00)	37 (7.79)	36 (7.58)	135 (28.4)	13 (2.74)	7 (1.47)	2 (0.42)	2 (0.42)	1 (0.21)	0 (0.00)	25 (5.26)	475 (100.0)

[a]Data expressed as number (percentage) of participants, not including 16 participants in Shunyi, 15 participants in Madurai, 8 participants in Durban, and 1 participant in Los Angeles with missing best-corrected visual acuity.

with near vision impairment in Los Angeles, while in Kaski female subjects had significantly less impairment. Lower educational level was associated with near vision impairment in Kaski, Durban, and Los Angeles; in Dosso, those with less education had less impairment.

LOWESS smoothed curves of uncorrected, presenting, and best-corrected near VA ≤20/40 across the entire age range are shown in the Figure. The area between the uncorrected and best-corrected VA curves represents the magnitude of the need for refractive correction. The area between the uncorrected and presenting VA curves, negligible except for Guangzhou and Los Angeles, represents need for refractive correction that has already been met with spectacles.

When study site was included as a covariate in the multiple logistic regression reported in Table 3, with Shunyi as the regression reference the prevalence of uncorrected near VA ≤20/40 was comparatively higher in Madurai (odds ratio [OR]: 5.05 [4.03–6.34]; $P < .001$) and Durban (OR: 5.79 [4.50–7.44]; $P < .001$]), and comparatively lower in Dosso (OR: 0.49 [0.38–0.65]; $P < .001$).

Table 4 shows the use of vision correction for participants with near VA 20/40 to 20/63 and <20/63. Except for Guangzhou and Los Angeles, the use of spectacles for near vision correction was uncommon.

Table 5 shows the "already met" and "unmet" need for refractive correction among those with uncorrected near VA ≤20/40. Because of the high use of near vision correction in the urban Guangzhou and Los Angeles sites, approximately 60% of those needing refractive correction had already been corrected to VA >20/40 with their presenting spectacles. In the other (rural) sites, generally less than 5% of the need for refractive correction had been met with existing spectacles.

As shown in Table 5, most of the unmet need (those not presenting with VA >20/40) was correctable to VA >20/40 with best correction, generally with an improvement of at least 3 lines of VA. Those not experiencing any improvement with best correction (zero lines) accounted for generally less than 5% of the participants with uncorrected VA ≤20/40, except in Dosso (12.5%) and Madurai (20.6%).

Unmet need correctable by at least 2 lines with best correction ranged from 69.0% in Guangzhou to 93.5% in Durban. Improvement in VA by at least 2 lines was associated with younger age in all sites, ranging from OR: 0.87 (0.82–0.91); $P = .002$ in Los Angeles to OR: 0.96 (0.94–0.99); $P = .004$ in Durban. Improvement of ≥2 lines of VA was also associated with higher educational levels in Madurai (OR: 1.36 [1.21–1.54]; $P < .001$) and Dosso (OR: 1.24 [1.00–1.53]; $P = .050$) and lower educational levels in Los Angeles (OR: 0.69 [0.48–0.98]; $P = .043$). Sex was not statistically significant.

DISCUSSION

THE CURRENT STUDY IS THE FIRST MULTI-SITE STUDY OF near vision impairment among populations with various ethnic backgrounds, using standardized methods for visual acuity measurement.

The study was carried out at 7 sites in 6 countries. Guangzhou and Los Angeles provided samples from urban populations, Durban from a semi-urban population, and the other 4 sites from rural population settings. Demographic characteristics were substantially different between sites: women predominated in Kaski (62.0%), Durban (71.6%), and Los Angeles (64.4%), whereas the proportion of women was closer to that of men in the other 4 sites. The 35- to 49-year age group was relatively underrepresented in both Los Angeles (29.0%) and Shunyi (35.3%), while those ≥65 years of age were underrepresented in Durban (14.4%) and Dosso (16.1%). The study populations in Kaski (64.6%), Madurai (47.9%), and Dosso (65.2%) were predominately illiterate, while the majority of people in Guangzhou had at least a high school education (62.8%). This educational profile is important in understanding the demand and unmet need for correction of near vision impairment, given that educated people tend to be myopic and have better access to eye care.[9,10]

Examination response rates were generally lower among men and younger persons. Accordingly, this self-selection bias is expected to lead to an inflated estimate of the prevalence of near vision impairment, given the observed age and sex associations with impairment in the majority of sites. Prevalence rates would also be biased upwards if those experiencing vision problems were disproportionately more likely to participate in the examination. For example, this may help explain the relatively greater prevalence of impairment among those 35 to 49 years of age in both Madurai and Durban.

Visual acuity was tested with indoor ambient light (lighting behind the shoulder) except in Dosso, where it was tested under sunlight because indoor electricity was not reliably available in the area. This brighter illumination may in part explain the lower observed prevalence of near vision disability in Dosso, as miosis and its associated pinhole effect may improve near vision by enhancing the depth of field.[11] One should therefore be cautious in drawing conclusions about ethnic differences in the prevalence of near vision impairment based on the Dosso data.

Variations in the age-specific distributions of near vision impairment across the 7 sites were substantial, as shown in the Figure. Vision impairment in Dosso, and to a lesser extent in Guangzhou, had a delayed onset. In contrast, the populations in Madurai and Durban had a relatively early onset of impairment, with prevalence as high as 50% among those aged 35 to 39 years, and much higher than at the other 5 sites (generally less than 10%). The somewhat better near vision in Guangzhou may be explained by the documented higher rate of myopia among educated, urban Chinese populations,[12,13] while the later onset observed in Dosso may be an artifact of the measurement conditions outdoors. Other factors that would need to be considered for a better understanding of the site differences include lifestyle factors, in particular those that may lead to UV-induced lens changes.

Our findings of a higher prevalence of near vision impairment among older persons and women are consistent with studies carried out in Tanzania,[4] India,[6] and northern China,[5] although associations with sex and literacy were not observed in the northern China survey.[5]

Except in Dosso, the age- and sex-standardized prevalence of uncorrected near vision impairment was 60% or higher with a VA cutoff of ≤20/40—and 20% to 30% when the more stringent VA <20/63 cutoff was used. When the potentially confounding effects of age and sex, along with education, were adjusted for in multiple logistic regression with Shunyi as the reference site, the higher prevalence of near vision impairment in Madurai and Durban was statistically significant, as was the lower prevalence in Dosso. Similar (African) ethnicity in sites with extreme prevalence differences, such as Durban and Dosso, along with ethnic heterogeneity among sites with similar prevalence, suggests that observed variation in near vision impairment among sites was primarily attributable to sociodemographic and environmental factors rather than genetic-related ones.

Near vision impairment associated with loss of accommodation (presbyopia) is correctable, while that caused by nonrefractive abnormalities such as media opacity (cataract, corneal diseases) and fundus disease is not. The latter abnormalities are reflected in the prevalence of vision impairment with best correction. The age- and sex-standardized prevalence of near vision impairment (VA ≤20/40) with best correction was generally in the 10% to 20% range, considerably lower in the urban Guangzhou and Los Angeles settings compared to the rural sites. Presumably this rural-urban difference is attributable to more limited access to cataract surgery and other eye care services in rural as compared to urban areas, as has been documented extensively in the literature.[12–14]

Near vision impairment with best correction was dramatically lower than that based on uncorrected visual acuity. Unfortunately, as shown in the Figure, vision impairment with presenting visual acuity was little better than that with uncorrected vision, with the exception of Guangzhou and Los Angeles. In Guangzhou and Los Angeles, approximately 60% of those with near vision impairment were already corrected to VA >20/40 with spectacles, whereas less than 7% were in the other sites. Among those presenting with VA ≤20/40—the unmet need for refractive correction—at least 70% were able to benefit by ≥2 lines of visual acuity with best correction.

Although we did not attempt to assess accommodation loss, it is reasonable to connect the dramatic age-specific rise in uncorrected near vision impairment with the onset of presbyopia. Ascertaining presbyopia requires a full refraction with determination of the power of added near optical correction over that used to correct distance vision,[4,5] or more precisely measurement of accommodative amplitude. (The latter measurement would have been particularly difficult in most of the field settings.) Our interest was not in presbyopia, but in the age-specific prevalence of near vision impairment, whatever the cause, because it is directly related to the need for correction and the unmet need for correction.

The current investigation is among the first population-based studies demonstrating the magnitude of uncorrected near vision impairment, particularly in rural areas. Recognizing that some may argue that near vision tasks are less demanding in rural areas, that they vary across different cultural backgrounds, or that a tumbling E chart at a fixed distance of 40 cm may not be the best way to assess actual need for near vision correction, the study protocol included subjective assessments of vision impairment. This was done through administration of a 12-item visual function questionnaire and numerical (0–100) weighting of the "disability" associated with visual impairment as perceived by the participant. These data and their correlation with clinically measured vision impairment will be reported in separate articles.

For those with a perceived need, barriers to accessing near vision correction include cost,[6,7] knowledge,[5] and difficulty in accessing high-quality refractive services.[6] The success of a business model based on selling presbyopic spectacles in the community highlights the fact that demand for near vision correction exists, even in rural areas.[15]

In summary, our study demonstrates that 60% or more of those aged 35 years and over suffer from at least mild near vision impairment, with prevalence rates increasing with age and exceeding 90% in those aged 70 years and over. Populations in India and South Africa appear to have a relatively early onset of near vision impairment (likely related to an early onset of presbyopia), in contrast to an apparent delayed onset in Niger. The large differences in prevalence between uncorrected near vision impairment and that with best correction demonstrate that much of near vision impairment is because of correctable presbyopia and other refractive causes. By the age of 50 most people suffer from near vision impairment, but unfortunately, 90% of those in need of near optical correction may not have access to spectacles in rural areas, while the prevalence of unmet need in urban settings is more on the order of 40%.

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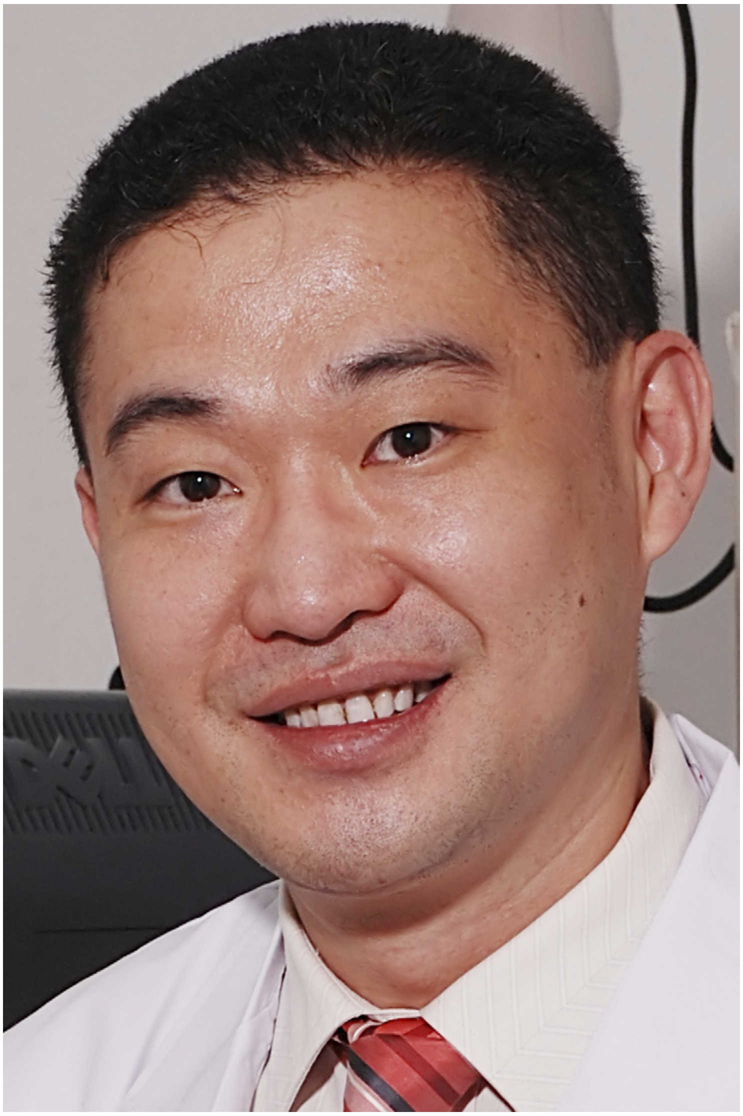

Biosketch

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