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Research Article

Prevalence of Refractive Error and Visual Impairment in the Guna Indians of Panama

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Abstract

Background: The Guna Indians, an indigenous group in Panama, face significant health disparities. The prevalence of refractive error and vision impairment have not been studied in this population and compared to other demographic groups. **Purpose:** To assess the prevalence of refractive error, visual impairment, and blindness among the Guna Indians in the Guna Nega community of Panama City. **Materials and methods:** A quantitative descriptive study was performed involving 638 Guna Indians. Presenting Visual Acuity (PVA) was measured using standard logMAR charts. Refractive errors were assessed through static and subjective retinoscopy, with cycloplegic refraction applied to children under 18 years. Myopia was defined as a Spherical Equivalent (SE) refractive error of ≤ -0.50 D, hyperopia as SE ≥ 2 D, and astigmatism as a cylinder ≥ 1 D. Visual impairment and blindness were classified according to World Health Organization criteria. **Results:** The prevalence of myopia was (40.4%), hyperopia (5.9%), and astigmatism (36.6%). The prevalence of visual impairment was 41.1%, while blindness was observed in 2.5% of the population. Myopia was most prevalent in individuals aged 21 to 40 years, hyperopia in those aged 51 to 70 years, and astigmatism in both the 21 to 30 years and 61 to > 81 years age groups. The prevalences of the refractive errors did not differ among the sexes, but they were greater than the global rates. **Conclusions:** The prevalence of refractive error, visual impairment, and blindness among the Guna people exceeds that of the global population and represents the highest rates among indigenous groups in Latin America.

Keywords: Myopia; Hyperopia; Astigmatism; Vision impairment, Latin America; Indigenous

Introduction

Visual impairment and blindness are significant public health concerns worldwide, impacting individuals' quality of life and affecting economic stability. Globally, the prevalence of visual impairment is 7.0% (95% CI 6.5 to 7.6), and that of blindness is 0.55% (95% CI 0.48 to 0.68) [1]. Uncorrected refractive errors are the leading cause of visual impairment and the second leading cause of blindness worldwide [2-5].

The indigenous population of Latin America total approximately 58 million people in the region (10% of the population) and 12% of the Panamanian population [6]. Indigenous populations often experience health disparities, including limited access to eye care services, which can exacerbate the prevalence of uncorrected refractive errors and visual impairment [7,8]. Despite their vulnerability to visual health issues, limited research exists on the prevalence of refractive errors and visual impairment among indigenous populations in the Americas [8]. A few studies have reported higher rates of refractive error and visual impairment among indigenous groups than among nonindigenous populations, yet no comprehensive study has been conducted among the Guna Indians, the second-largest indigenous group in Panama [9-15].

This study aimed to determine the prevalence of refractive error and visual impairment among the Guna Indians of Panama City. We employed the categories of visual impairment recommended by the World Health Organization [16] and defined refractive

error based on the spherical equivalent, as used in most refractive error studies [17]. Additionally, we specifically determined the refractive error among the children in our sample under cycloplegia for greater validity, in line with the recommended protocol [18]. The outcomes of this research are expected to provide valuable insights into the eye health status of the Guna Indian community, shedding light on their specific visual needs and informing targeted interventions. By addressing the unmet visual health needs of indigenous populations such as the Guna Indians, we can work toward achieving more equitable access to eye care services and ultimately improve their quality of life and economic well-being.

Materials and Methods

The Inter American University of Puerto Rico Institutional Review Board approved the project (1602789-1). Adult participants and parents of participating children provided written informed consent before enrolment and after the study protocol had been explained to them. For children older than seven years, assent was also obtained. The study followed the tenets of the Declaration of Helsinki for research on human subjects.

Study design and population

This is a quantitative descriptive study of refractive error and visual impairment in an indigenous community in Panama. The indigenous community lives in Guna Nega, a complex of approximately 125 houses in Panama City. There are approximately 1,500 indigenous people in Guna Nega, approximately 1,000 of whom are Gunas. The sample included 638 participants who self-identified as members of the Guna Indians, among whom 380 (59.6%) were examined from May 25 to May 27, 2022, while the remaining 258 participants (40.4%) were examined from August to December 2022.

Two teams examined the participants. The first team included six faculty members from the Inter American University of Puerto Rico School of Optometry (5 optometrists, one ophthalmologist, and one optician) and 15 advanced optometry students. The second team included four faculty members (3 optometrists and one ophthalmologist) and 18 advanced optometry students from the University of Las Americas of the Panama optometry program.

Ocular examination protocol

The protocol for the ocular examination included assessments of distance (6 m) and near (40 cm) visual acuities using standard logMAR charts. Patients underwent autorefraction (Quick See© in children and Retinomax 3© in adults) and static and subjective refraction examinations with portable phoropters. The phoropters had a spherical range between +20 D and -20 D and a negative cylinder range from -0.25 D to -6.00 D. All children (between 1 and 17 years of age) underwent cycloplegic refraction; cycloplegia was achieved by the initial instillation of 0.5% proparacaine hydrochloride followed by two drops of 1% cyclopentolate hydrochloride 5 minutes apart.

The outcomes were the prevalence of refractive error, visual impairment, and blindness. Refractive errors, including myopia and hyperopia, were defined using the Spherical Equivalent (SE), which was determined as SE=sphere + 0.5* cylinder. Myopia was defined as an SE≤-0.50 D, hyperopia was defined as an SE ≥+2.0 D, and astigmatism was defined as a cylinder ≥1 D. Visual impairment was defined based on the World Health Organization's recommendations, which use the Presenting Visual Acuity (PVA) [16], the visual acuity of the patient upon presentation to the examination. If the person shows up to the examination with eyeglasses or contact lenses, the PVA is taken with the correction in place; otherwise, the PVA can be considered the unaided visual acuity if the person presents without correction. This definition allows us to compare the results with those of previous studies.

Statistical analysis

The main demographic variables were analyzed using descriptive statistics (mean, median, standard deviation). Since the distribution of refractive error was not normal, we used primarily nonparametric tests in our analyses. The Kruskal–Wallis test was used to determine any significant differences in the spherical equivalent of the refractive error among the age groups [19]. The two-sample Mann–Whitney rank-sum test was used to determine whether there were significant differences in the prevalence of the spherical equivalent of the refractive error (myopia, hyperopia) or astigmatism) between males and females. Independent chi-square tests of independence were used to determine the associations between the prevalence of refractive errors (myopia, hyperopia, and astigmatism) and age groups. The prevalence values in the present study were compared to the findings of other studies using the binomial test. All the statistical analyses were performed using IBM SPSS© version 29 software [20]. The level of statistical significance was set at 5%.

The prevalence of refractive error, visual impairment, and blindness in our study were compared to those of other studies. Since the criteria for refractive error can differ among studies, our results were recalculated using these criteria. We used the independent chi-square test to determine if the prevalence (as a proportion) significantly differed at the 5% level.

Results

The Pearson product–moment correlation coefficient between the spherical equivalent of the refractive error of the right eye and that of the left eye was r=0.86, p<0.001 [95% confidence interval (CI) 0.83-0.88]. According to Cohen's standard, this correlation indicates a large effect [21]. Therefore, we used the right eye as

a valid representation of the refractive error of each participant in the statistical analysis.

Distribution of participants by sex and age

This study recruited six hundred thirty-eight participants who self-identified as members of the Guna indigenous community. Four hundred nineteen (65.7%) were females, and two hundred nineteen (34.5%) were males. The mean age of the participants was 40.7 ± 22.3 years, while the median age was 42.5 years. The youngest participant was 1 year old, and the oldest was 92 years old (range 91 years). Table 1 shows the distribution of participants by sex and age group.

Age group	Sex		Total, n (%)
	Male, n (%)	Female, n (%)	
1–10	27 (12.3)	35 (8.4)	62 (9.7)
11–20	30 (13.7)	64 (15.3)	94 (14.7)
21–30	18 (8.2)	70 (16.7)	88 (13.8)
31–40	8 (3.7)	52 (12.4)	60 (9.4)
41–50	34 (15.5)	67 (16)	101 (15.8)
51–60	38 (17.4)	59 (14.1)	97 (15.2)
61–70	31 (14.1)	42 (10)	73 (11.4)
71–80	23 (10.5)	19 (4.5)	42 (6.6)
> 81	10 (4.6)	11 (2.6)	21 (3.3)
Total	219 (100)	419 (100)	638 (100)
n = Number of participants by age group and sex			

Table 1: Distribution of participants by age group and sex.

Spherical equivalent of the refractive error by age group and sex

Four hundred and two participants (63%) had no previous eye exam. Ninety-eight participants (15.4%) had distance or near correction during testing. The mean SE refraction by age group is shown in Figure 1. The Kruskal–Wallis test revealed that the SE refraction significantly differed between age groups ($\chi^2(8)=107.91$, $p<.001$). Pairwise comparisons between the age groups using Dunn's procedure with Bonferroni's correction revealed that the 21- to 30-year age group was significantly more myopic than the 1- to 20-year and 41- to 70-year age groups ($p<0.05$). The individuals in the 1- to 20-year age groups were significantly more hyperopic than those in the 21- to 40-year age group ($p<0.05$). The 31-to-40-year age groups were significantly more myopic than the 41- to-60-year age groups were ($p<0.05$). Finally, the 51- to- 60-year age group was significantly more hyperopic than the 71- to 80-year age group ($p<0.05$). The two-sample Mann–Whitney rank-sum test revealed that the spherical equivalent was not significantly different between the sexes ($U=43852$, $z=-1.29$, $p=.196$).

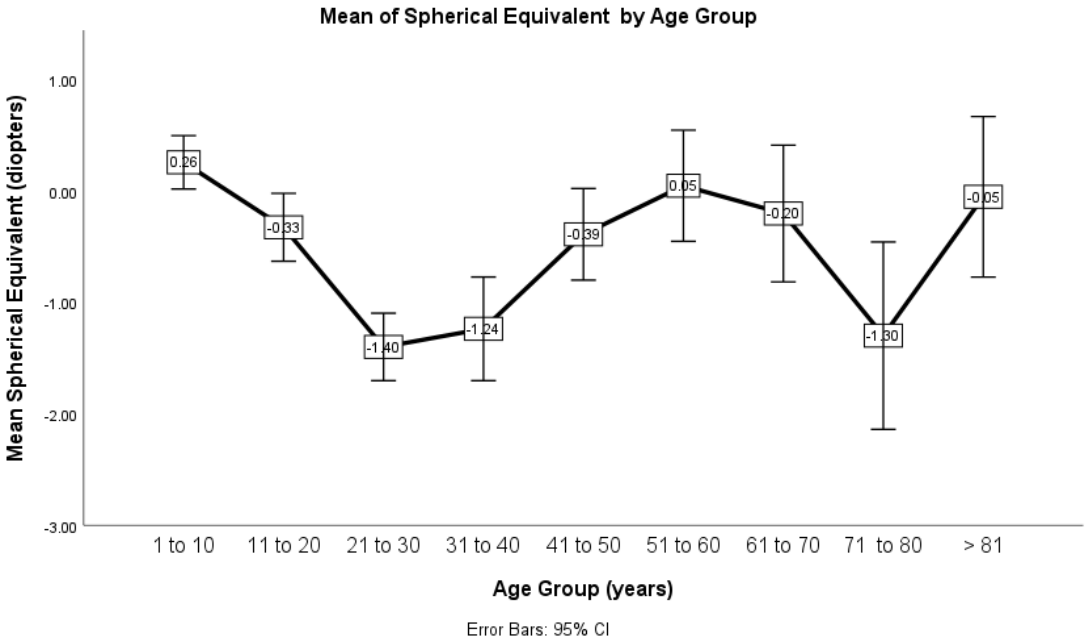


Figure 1: Spherical equivalent of the refractive error (diopters) by Age groups (years).

Prevalence of refractive error among the Guna people

A reliable measure of the refractive error was obtained for 609 participants. Twenty-nine patients had ocular conditions (principally cataracts and significant pterygia) that hindered the determination of their refractive error. Based on the SE of the refractive error, 40.4% (95% CI 36.6-44.3) of the Guna participants had myopia (SE equal to or less than -0.50 D), 5.9% (95% CI 4.3–8.1) had hyperopia, and 36.6% (95% CI 32.9–40.5) had astigmatism (Table 2).

Age group (n)	Myopia, n (%)	95% CI	Hyperopia, n (%)	95% CI	Astigmatism, n (%)	95% CI
1–10 (60)	7 (11.7)	5.5–22.5	1 (1.7)	0.0–9.7	17 (28.3)	18.4–40.8
11–20 (93)	31 (33.3)	24.6–43.4	3 (3.2)	0.7–9.5	26 (28)	19.8–37.9
21–30 (87)	62 (71.3)	61.0–79.8	0 (0)	0.0–5.1	38 (43.7)	33.7–54.2
31–40 (56)	36 (64.3)	51.1–75.6	1 (1.8)	0.0–10.3	21 (37.5)	26.0–50.6
41–50 (101)	34 (33.7)	25.2–43.4	3 (3)	0.7–8.7	29 (28.7)	20.8–38.2
51–60 (94)	21 (22.3)	15.0–31.8	10 (10.6)	5.7–18.7	35 (37.2)	28.1–47.3
61–70 (67)	26 (38.8)	28.0–50.8	15 (22.4)	14.0–33.8	28 (41.8)	30.7–53.7
71–80 (34)	21 (61.8)	45.0–76.1	2 (5.9)	0.7–20.1	20 (58.8)	42.2–73.7
> 81 (17)	8 (47.1)	26.2–69.0	1 (5.9)	0.0–2.9	9 (52.9)	31.0–73.8
Total (609)	246 (40.4)	36.6–44.3	36 (5.9)	4.3–8.1	223 (36.6)	32.9–40.5
n = Number of participants by age group, CI = Confidence interval						

Table 2: Prevalence of myopia, hyperopia, and astigmatism by age group.

Table 3 shows the prevalence of refractive error (myopia, hyperopia, and astigmatism) in the Gunas group compared to other indigenous groups in the Americas. We found nine studies of refractive error in the indigenous populations of the Americas. The criteria for refractive error and the age ranges were different across these studies. To compare our results with the results of these investigations, the prevalence of refractive error among the Guna people was recalculated using each study's refractive criteria and age ranges (Table 3). We used the independent chi-square test to determine if the prevalences (as proportions) were significantly different.

First author and year	Subjects	Number of participants	Country	Age range	Definition myopia	Prevalence myopia % (95% CI)	Our study (Gunas) % (95% CI)	Definition hyperopia	Prevalence hyperopia % (95% CI)	Our study (Gunas) % (95% CI)	Definition astigmatism	Prevalence astigmatism % (95% CI)	Our study (Gunas) % (95% CI)	Significance
Carter, 2013 [9]	Indigenous Macca children (cycloplegia)	118	Paraguay	5–16	SE ≤ −0.5 D	0 (0.0–3.4)	18 (12.0–26.0)	SE ≥ 2 D	32.2 (24.4–41.1)*	3.4 (1.1–8.8)	Cylinder ≥ 1 D	12.7 (7.8–20.0)	25.6 (18.6–34.3)*	Guna children have more myopia and astigmatism and less hyperopia than Macca children.

Thorn, 2005 [10]	Indigenous Brazilians (cycloplegia)	259	Brazil	12–59	SE ≤ −1 D	2.3 (0.9–5.1)	33.3 (28.9–39.6)*	SE ≥ 2 D	5.4 (3.2–8.9)	3.5 (2.0–5.8)	Cylinder ≥ 1 D	15 (11.2–20.0)	35.1 (30.6–39.8)*	Gunas have more myopia and astigmatism and the same hyperopia as indigenous Brazilians.
Pensyl, 1997 [11]	Indigenous Sioux (cycloplegia < 14 years)	130	USA	0–40							Cylinder ≥ 1 D	46.2 (37.8–54.7)	36.6 (32.9–40.5)*	Gunas have less astigmatism than Sioux
Pensyl, 1997 [11]	Indigenous Sioux children (cycloplegia < 14 years)	77	USA	< 19							Cylinder > 1 D	44.2 (33.6–55.3)	29.2 (22.3–37.1)*	Guna children have less astigmatism than Sioux children.
Adler-Grinberg, 1986 [13]	Indigenous Sioux of all ages (no cycloplegia)	1886	USA	0–62+							Cylinder ≥ 1 D	39.1 (36.9–41.3)	36.5 (32.8–40.5)	Gunas the same astigmatism as Sioux
Harvey, 2006 [22]	Indigenous Tohono O'odham children (no cycloplegia)	1326	USA	5–16							Cylinder ≥ 1 D	34.7 (32.2–37.3)	25.6 (18.6–34.3)*	Guna children have less astigmatism than Tohono O'odham children.
Dobson, 2008 [23]	Indigenous Tohono O'odham children (no cycloplegia)	972	USA	4–13							Cylinder ≥ 1 D	42.6 (39.5–45.7)	26.6 (19.6–35.0)*	Guna children have less astigmatism than Tohono children
Mohindra, 1977 [12]	Indigenous Zuni children (no cycloplegia)	382	USA	6–8							Cylinder ≥ 1.25 D	45.3 (40.4–50.3)	39.3 (23.5–57.6)	Guna children have the same astigmatism as Zuni children
Mohindra, 1977 [12]	Indigenous Navajo children (no cycloplegia)	337	USA	6–8							Cylinder ≥ 1.25 D	37.1 (32.1–42.4)	39.3 (23.5–57.6)	Guna children have the same astigmatism as Navajo children

CI: Confidence interval; Notes: *P<0.05 for the independent chi-square test for the prevalence of myopia, hyperopia, and refractive astigmatism compared with Gunas.

Table 3: Comparison of the prevalence of myopia, hyperopia, and refractive astigmatism among indigenous groups and the Guna people of Guna Nega (Panama).

Refractive status by age group and sex

We conducted the independent chi-square test to determine whether the prevalence of the different refractive statuses (myopia, hyperopia, and emmetropia) was independent of age group (9 levels). All assumptions of the test were met: all cells had expected values greater than zero, and 81.5% of the cells had expected frequencies of at least five. The results were significant (χ^2 (16) =138.8, p<.001): myopia was more frequent than expected in the 21- to 40-year age group, while hyperopia was more frequent than expected in the 51- to 70-year age group.

The chi-square test was used to determine whether the prevalence of astigmatism was independent of age group. The results indicated statistical significance (χ2(8) = 19.35, p = .01); astigmatism was more frequent than expected in the 21- to 30-year and the 61- to >81-year age groups. The prevalence of myopia (alpha.05, U = 6150, z = -0.69, p = .49), hyperopia (alpha.05, U = 159.5, z = -0.07, p = .948), and astigmatism (alpha.05, U = 5711.5, z = -0.12, p = .901) was similar between males and females according to the two-tailed Mann–Whitney U test.

Visual impairment

Visual acuity data were obtained for 633 of the 638 Guna participants. According to the World Health Organization (WHO) criteria, 276 (41.1%) patients were visually impaired, and 16 (2.5%) were blind (Table 4).

Category of visual impairment	Number of participants, n (%)	95% CI
None (≥ 20/40)	357 (56.4)	52.5–60.2
Mild (< 20/40 to ≥ 20/63)	118 (18.6)	15.8–21.9
Moderate (< 20/63 to ≥ 20/200)	134 (21.2)	18.2–24.5
Severe (< 20/200 to ≥ 20/400)	8 (1.3)	0.6–2.5
Total visual impairment	260 (41.1)	37.3–45.0
Blindness (< 20/400)	16 (2.5)	1.5–4.1
Total	633 (100)	
n=Number of participants, CI=Confidence Interval		

Table 4: Visual impairment and blindness among Guna participants (Based on the eye with the best presenting distance visual acuity).

Table 5 compares the prevalence of visual impairment and blindness between the Guna people and other indigenous groups of the Americas using the data from four published studies of indigenous populations of the Americas that used the presenting visual acuity to determine visual impairment and blindness, as recommended by the WHO [16]. However, the visual impairment and blindness criteria used in those studies differed from those recommended by the WHO. The studies also used populations with age ranges different from ours. To compare our results with those of these four studies, we recalculated visual impairment using the criteria and age ranges of each study (Table 5).

First author and year	Subjects	Number of participants	Country	Age range	Definition of vision impairment	Prevalence vision impairment % (95% CI)	Our study (Gunas)	Definition of blindness	Prevalence blindness % (95% CI)	Our study (Gunas)
Fernandes, 2021 [24]	Indigenous (Xingu)	2099	Brazil	0–45+	< 20/32 to ≥ 20/400	8.3 (7.1–9.5)	52.4 (48.5–56.2)*	< 20/400	1.8 (1.3–2.4)	2.5 (1.5–4.1)
Jimenez-Corona, 2014 [14]	Indigenous (Chiapas)	512	Mexico	≥ 20	< 20/60 to ≥ 20/400	10 (6.9–14.3)	24.9 (21.2–28.9)*	< 20/400	0 (0.0–3.8)	3.3 (1.9–5.3)*
Carter, 2013 [9]	Indigenous (Asunción)	117	Paraguay	0–17	< 20/40	6 (2.7–12.0)	18.1 (12.3–25.8)*			
McClure, 2009 [15]	Native Americans/Alaska Natives (Pacific Northwest)	414	United States of America	≥ 40	≤ 20/40	12.8 (9.9–16.4)	66.4 (61.2–71.2)*	≤ 20/200	0.5 (0.1–1.54)	9.1 (6.4–12.6)*
CI: Confidence Interval; Notes: * P<0.05 for the independent chi-square test of independence for the prevalence of visual impairment and blindness.										

Table 5: Prevalence of visual impairment and blindness among indigenous groups of the Americas and the Guna of Guna Nega (Panama).

Discussion

Comparison of refractive error among the Gunas to global refractive error estimates

The estimated global prevalence of myopia in children under 20 years of age, according to the criterion of a cycloplegic SE ≤ -0.5 D, was 11.7% (95% CI 10.5 to 13.0) [25]. The prevalence among Guna children of the same age and using the same criteria was significantly greater ($p<0.001$), at 24.3% (95% CI 18.0 to 32.0). For adults over 30 years of age, according to the criterion of SE < -0.5 D, the estimated global prevalence of myopia is 26.5% (95% CI 23.4 to 29.6). For Gunas in the same age group and using the same refractive criteria, the prevalence is significantly greater ($p<0.001$), at 35.8% (95% CI 31.1 to 40.8). A tendency toward increasing myopia from early childhood to adolescence has been observed in other studies [17,26-36]. Among the Gunas, the trend toward myopia persists until the fourth decade. A second trend toward myopia in the 71- to 80-year age group is likely related to cataract formation [37].

Comparison of refractive error between the Gunas and other indigenous groups of the Americas

Two previous refractive error studies involved indigenous populations in Latin America. Both studies used the cycloplegia refraction for the paediatric participants. In children 5 to 16 years of age, we found a significantly greater prevalence of myopia and refractive astigmatism in the Guna children than in the Macca children of Paraguay. We found significantly less hyperopia among the Guna children than among the Macca children [9]. Among individuals aged 12 to 59 years, our resulted revealed a significantly greater prevalence of myopia and refractive astigmatism in the Guna population than in the Brazilian indigenous population, while there was no significant difference in the prevalence of hyperopia [10]. There are seven refractive studies involving indigenous populations in the United States addressing refractive astigmatism. Only one study used cycloplegia when assessing refractive error in children [11]. A study on 130 Sioux in the United States revealed significantly more refractive astigmatism among participants of all ages and participants aged at least 19 years than among Gunas of the same age ranges [11]. However, a study with a larger sample of 1886 Sioux patients aged 0 to 62 years indicated that the prevalence of refractive astigmatism was comparable to what we observed among the Guna peoples [13]. Two studies among Tohono O'odham children (5 to 16 years and 2 to 15 years) also showed that significantly more had refractive astigmatism with respect to the Guna children in our study [22,38]. A study involving young Zuni and Navajo children (6 to 8 years old) yielded a similar prevalence of refractive astigmatism to what we observed among Guna children [12].

The above studies indicate that Gunas have a greater prevalence of myopia and refractive astigmatism than the two mentioned indigenous groups in the Latin American region. However, refractive astigmatism is equally or less likely than among the four indigenous groups in the United States described above.

Comparison of refractive error between the Gunas and nonindigenous groups in Latin America

The prevalence of myopia among Guna children under cycloplegia between 5 and 17 years of age was 19.7% (95% CI 13.5 to 27.7), which is not significantly different from that of a sample of same-aged children assessed under cycloplegia in Puerto Rico, 20.7% (95% CI 19.2 to 22.2). However, the prevalence of astigmatism among the Guna children was 27.1% (95% CI 19.9 to 35.6), which was significantly greater ($p<0.001$) than that among nonindigenous Puerto Rican children (10.4%, 95% CI 9.3 to 11.5) [17].

The prevalence of myopia among the Guna children between 6 and 18 years of age was 22.5% (95% CI 16.1 to 30.5), which was significantly greater ($p<0.001$) than the 14.6% (95% CI 13.3 to 15.9) prevalence among children from Northwest Mexico. Among those with a cylinder equal to or greater than 0.75 D, Gunas had a prevalence of myopia of 68.9% (95% CI 56.4 to 79.1), which is significantly greater ($p<0.001$) than the prevalence of 18.6% (95% CI 17.2 to 20.1) among Mexican children. Regarding hyperopia (an SE equal to or greater than 1 D), the prevalence among the Guna children was 14.0% (95% CI 8.9 to 21.1), which was significantly greater ($p<0.001$) than the prevalence among Mexican children (3.2%; 95% CI 2.6 to 4.0). However, the Mexican study only used cycloplegia in children with poor distance visual acuity (≤ 20/40), which may have led to an underestimation of the prevalence of hyperopia in that group [39].

Among adults aged ≥40 years, the prevalence of myopia (SE < -0.5 D) among the Gunas was significantly greater ($p<0.001$) (30.9%, 95% CI 26.1 to 36.2) than that among adults in Puerto Rico (14.7%, 95% CI 12.4 to 17.3). In the same age group, the prevalence of hyperopia (SE > 0.5 D) among the Gunas was 35.9% (95% CI 30.9 to 41.3), which was significantly lower ($p<0.001$) than the 51.5% (95% CI 48.0 to 55.0) prevalence among adults in Puerto Rico. The prevalence of astigmatism (Cylinder ≥ 1 D) among the Gunas was 76.6% (95% CI 71.6 to 80.9), which was significantly greater ($p<0.001$) than that among adults in Puerto Rico (69.6%, 95% CI 66.3 to 72.8) [40].

In summary, Guna children and adults have a greater prevalence of refractive astigmatism than the values reported in Latin American refractive error studies. The prevalence of myopia in Guna children is similar to or greater than that in nonindigenous children. Finally, the prevalence of myopia in Guna adults is greater than that in the adult clinical population of Puerto Rico.

Myopia could be considered a pandemic condition, with a predicted prevalence of 50% by 2050 [41,42]. Genetic and environmental factors contribute to the risk of myopia, such as Asian ancestry, long periods of near work, decreased time outdoors, and a high-fat diet [43,44].

Several factors are potentially related to the high prevalence of myopia among the Gunas. The ancestors of the indigenous populations of the Americas came from Asia [45]. The original diet in San Blas included seafood and coconuts, which the Guna people found nearby when they arrived. However, the scarcity of some traditional ingredients and loss of traditional knowledge have increased the consumption of processed foods high in fat and instant beverages high in sugar [46]. The native environment of the Gunas is the San Blas Islands, which have open seashores. At Guna Nega, they live in a densely populated and closed environment, with up to 12 people per home. Children are exposed to traditional schools, decreasing their time outdoors. Further research should seek to clarify the associations of these factors with the prevalence of myopia among Gunas.

High myopia is associated with retinal detachment, glaucoma, myopic macular degeneration, and cataracts [47]. Guna children are particularly vulnerable to myopia progression, which should be mitigated through ophthalmic and pharmacologic treatments to avoid the development of high myopia during adolescence [48,49]. Guna children should receive annual visual examinations to determine their refractive status and ocular health.

The estimated global prevalence of astigmatism, using the criterion of a cylinder of more than 0.5 D, was 14.9% (95% CI 12.7 to 17.1) in children less than 20 years of age [25]. The prevalence among Guna children of the same age and using the same criterion was significantly greater ($p<0.001$), at 41.0% (95% CI 33.2 to 49.1). Astigmatism in children can significantly impact their reading and visual information processing [23,50].

Among adults over 30 years of age, the global prevalence of astigmatism of more than 0.5 D was 40.4% (95% CI 34.3 to 46.6) [25]. In the Guna sample, the prevalence of this astigmatism in the same age range was significantly greater ($p<0.001$), at 51.8% (95% CI 46.7 to 56.8). As shown in other studies, the Gunas in our study demonstrated a greater prevalence of astigmatism among older individuals (those above 61 years of age). In adults, uncorrected astigmatism is related to visual phenomena such as haloes, glare, diplopia, and decreased quality of life [51].

The global prevalence of hyperopia in those under 20 years of age, according to the SE ≥ 2D criterion, is 4.6% (95% CI 3.9 to 5.2) [25]. Among the Gunas in our study, the prevalence of hyperopia in those under 20 years of age who met the same refractive error criterion was not significantly different, at 2.8% (95% CI 0.84 to 7.2). Among adults over 30 years of age and using the criterion of SE ≥ 0.5 D, the global prevalence of hyperopia was 30.6% (95% CI 26.1 to 35.2) [25]. The Gunan participants of the same age range and meeting the same criterion demonstrated a significantly greater hyperopia prevalence ($p<0.001$), at 37.4% (95% CI 32.6 to 42.4).

In summary, Gunan children and adults were significantly more likely to be myopic and astigmatic than the global population. In contrast, compared to the global population, while Gunan adults were significantly more likely to be hyperopic, Gunan children had approximately the same prevalence of hyperopia. Providing primary eye care and ophthalmic correction can significantly increase the productivity and quality of life of indigenous people [15,52].

Comparison of visual impairment between the Gunas and the worldwide population

The prevalence of visual impairment among the Gunas was 41.1% (95% CI 37.3 to 45.0), approximately six times greater than that of the overall global population (7.0%, 95% CI 6.5 to 7.6). The prevalence of blindness in the Guna sample was 2.5% (95% CI 1.5 to 4.1), approximately 4.5 times that of the global population (0.55%, 95% CI 0.48 to 0.61) [1].

Comparison of visual impairment between the Gunas and other indigenous groups of the Americas

Table 5 summarizes the prevalence of visual impairment among Gunas relative to other indigenous groups of the Americas. Among children aged 0 to 17 years, Guna children had a significantly greater prevalence of visual impairment than did indigenous children of Paraguay [9]. Across all age groups, the Gunas had a significantly greater prevalence of visual impairment than did the indigenous groups from the Xingu Indigenous Park in Brazil, while no differences were observed in terms of the prevalence of blindness [24]. Among adults above 20 years of age, Gunas had a greater prevalence of visual impairment and blindness than did the Chiapas indigenous group in Mexico [14]. Among adults over 40 years of age, Gunas also had a greater prevalence of visual impairment and blindness than did American Indians and Alaskan Natives from the Pacific Northwest [15].

In summary, the prevalence of visual impairment in our sample of Gunas was significantly greater than that in any other Latin American or North American indigenous group. The prevalence of blindness among the Gunas was greater than that of a Mexican Chiapas indigenous group but lower than that of the Brazilian Xingu indigenous group.

Comparison of visual impairment between the Gunas and the Panamanian population

A study using the Rapid Assessment of Avoidable Blindness (RAAB) survey in Panama revealed that among people 50 years of age and older, the prevalence of moderate and severe visual impairment was 13.1% (95% CI 12.1 to 14.2), while that among our Panamanian Guna sample population in this age group was 31% (95% CI 25.6 to 37.1), which was significantly greater than that reported in the RAAB study ($p<0.001$). For adults in the same age group, the RAAB study revealed a prevalence of blindness of 4.5%, 3.0% (95% CI 2.5 to 3.6), which was not significantly different from that of the Guna sample (4.5%, 95% CI 2.4 to 8.0) [53].

The Gunas had a significantly greater prevalence of visual impairment than other indigenous groups of Latin America. They also had a greater prevalence of visual impairment than the overall Panamanian population and the global population.

Conclusions

The Gunas in the Guna Nega community of Panama have one of the highest prevalences of myopia and astigmatism worldwide; they also demonstrate one of the highest prevalences of visual impairment globally. The indigenous people of Panama suffer significant health disparities. The life expectancy is nine years less than that of the nonindigenous population (72 versus 63.2 years); furthermore, approximately 98% of these indigenous peoples live in poverty, and 86% live in extreme poverty [54]. Panama invests approximately 8.1% of its gross domestic product in health, which is below the median for countries in the Americas [55]. Panama's public health system covers most citizens but does not offer eye care services (exams or eyewear) [56].

Eye health promotes the achievement of the United Nations Sustainable Development Goals [57,58]. The provision of eye care services increases work productivity, income, and educational outcomes and care also helps reduce poverty and hunger [1,59]. Therefore, the provision of eye care services to the Guna and other indigenous populations should be a priority within the public health system of Panama.

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Ethical Guidelines

This study was approved by the Institutional Review Board (IRB) of the Inter American University of Puerto Rico School of Optometry, in accordance with the ethical principles outlined in the Declaration of Helsinki. This approval ensures that the rights and welfare of human subjects involved in the research were protected, and that the study complies with all relevant federal and state regulations.

Conflict of Interest

The authors have no conflict of interest to disclose related to the study.

References

1. Burton MJ, Ramke J, Marques AP, Bourne RRA, Congdon N, et al. (2021) The Lancet global health commission on global eye health: Vision beyond 2020. Lancet Glob Health 9: e489-e551.
2. Flaxman SR, Bourne RRA, Resnikoff S, Ackland P, Braithwaite T, et al. (2017) Global causes of blindness and distance vision impairment 1990-2020: A systematic review and meta-analysis. Lancet Glob Health 5: e1221-e1234.
3. Steinmetz JD, Bourne RRA, Briant PS, Flaxman SR, Taylor HRB, et al. (2021) Causes of blindness and vision impairment in 2020 and trends over 30 years, and prevalence of avoidable blindness in relation to VISION 2020: The right to sight: An analysis for the global burden of disease study. Lancet Glob Health 9: e144-e160.
4. Amador MLR, Torres JEE (2021) Visual disability and causes of preventable blindness. In: Heston TF, editor. Topics in primary care medicine. UK: IntechOpen p. 81-96.
5. Bourne R, Steinmetz JD, Flaxman S, Briant PS, Taylor HR, et al. (2021) Trends in prevalence of blindness and distance and near vision impairment over 30 years: An analysis for the global burden of disease study. Lancet Glob Health 9: e130-e143.
6. Pan American Health Organization (2023) The sociodemographic situation of indigenous peoples in Latin America and the Caribbean. Analysis in the context of aging and COVID-19. Washington, DC: PAHO.
7. Montenegro RA, Stephens C (2006) Indigenous health in Latin America and the Caribbean. Lancet 367: 1859-1869.
8. Furtado JM, Fernandes AG, Silva JC, Del Pino S, Hommes C (2023) Indigenous eye health in the Americas: The burden of vision impairment and ocular diseases. Int J Environ Res Public Health 20: 3820.
9. Carter MJ, Lansingh VC, Schacht G, del Amo MR, Scalamogna M, et al. (2013) Visual acuity and refraction by age for children of three different ethnic groups in Paraguay. Arq Bras Oftalmol 76: 94-97.
10. Thorn F, Cruz AAV, Machado AJ, Carvalho RAC (2005) Refractive status of indigenous people in the Northwestern Amazon region of Brazil. Optom Vis Sci 82: 267-272.
11. Pensyl CD, Harrison RA, Simpson P, Waterbor JW (1997) Astigmatism of Sioux Indians of South Dakota. J Am Optom Assoc 68: 425-431.

12. Mohindra I, Nagara S (1977) Astigmatism in Zuni and Navajo Indians. Optom Vis Sci 53: 121-124.

13. Adler-Grinberg D (1986) Need for eye and vision care in an underserved population: Refractive errors and other ocular anomalies in the Sioux. Optom Vis Sci 63: 553-558.

14. Jimenez-Corona A, Jimenez-Corona ME, Ponce-de-Leon S, Chavez-Rodriguez M, Graue-Hernandez EO (20147) Social determinants and their impact on visual impairment in Southern Mexico. Ophthalmic Epidemiol 22: 342-348.

15. McClure TM, Choi D, Becker T, Cioffi GA, Mansberger SL (2009) The effect of visual impairment on vision-related quality of life in American Indian/Alaska natives. Ophthalmic Epidemiol 16: 128-135.

16. World Health Organization (2022) World report on vision.

17. Santiago HC, Rullán M, Ortiz K, Rivera A, Nieves M, et al. (2023) Prevalence of refractive errors in children of Puerto Rico. Int J Ophthalmol 16: 434-441.

18. Sankaridurg P, He X, Naduvilath T, Lv M, Ho A, et al. (2017) Comparison of noncycloplegic and cycloplegic autorefraction in categorizing refractive error data in children. Acta Ophthalmol 95: e633-e640.

19. Laerd's Statistics. Kruskal-Wallis H test using SPSS statistics. Statistical Tutorials and Software Guides.

20. IBM Corp (2022) IBM SPSS statistics for windows, version 22.0. Armonk, NY.

21. Cohen J (1988) Statistical power analysis for the behavioral sciences. Hillsdale, NJ: Lawrence Erlbaum Associates.

22. Harvey EM, Dobson V, Miller JM (2006) Prevalence of high astigmatism, eyeglass wear, and poor visual acuity among native American grade school children. Optom Vis Sci 83: 206-212.

23. Dobson V, Miller JM, Clifford-Donaldson CE, Harvey EM (2008) Associations between anisometropia, amblyopia, and reduced stereoacuity in a school-aged population with a high prevalence of astigmatism. Invest Opthalmol Vis Sci 49: 4427-4436.

24. Fernandes AG, Alves M, Nascimento RAE, Valdrighi NY, de Almeida RC, et al. (2021) Visual impairment and blindness in the Xingu Indigenous Park – Brazil. Int J Equity Health 20: 197.

25. Hashemi H, Fotouhi A, Yekta A, Pakzad R, Ostadimoghaddam H, et al. (2018) Global and regional estimates of prevalence of refractive errors: Systematic review and meta-analysis. J Curr Ophthalmol 30: 3-22.

26. Bhutia K, Bhutia S, Gupta N, Shenga D (2021) Prevalence of refractive errors among the school-going children in East Sikkim. Indian J Ophthalmol 69: 2018-2020.

27. Ahmed ZA, Alrasheed SH, Alghamdi W (2020) Prevalence of refractive error and visual impairment among school-age children of Hargesia, Somaliland, Somalia. East Mediterr Health J 26: 1362-1370.

28. He M, Huang W, Zheng Y, Huang L, Ellwein LB (2007) Refractive error and visual impairment in school children in rural Southern China. Ophthalmology 114: 374-382.e1.

29. Zhao J, Pan X, Sui R, Munoz SR, Sperduto RD, et al. (2000) Refractive error study in children: Results from Shunyi district, China. Am J Ophthalmol 129: 427-435.

30. Kassa T, Alene GD (2003) Prevalence of refractive errors in pre-school and school children of Debark and Kola Diba towns, North-Western Ethiopia. Ethiop J Health Dev 17: 117-124.

31. Wang J, Ying G-S, Fu X, Zhang R, Meng J, et al. (2020) Prevalence of myopia and vision impairment in school students in Eastern China. BMC Ophthalmol 20: 2.

32. Németh J, Dankovics G, Barna I, Limburg H, Nagy ZZ (2022) Prevalence of refractive errors in Hungary reveals three-fold increase in myopia. Int J Ophthalmol 15: 1174-1179.

33. Galvis V, Tello A, Otero J, Serrano AA, Gomez LM, et al. (2018) Prevalence of refractive errors in Colombia: MIOPUR study. Br J Ophthalmol 102: 1320-1323.

34. Ovenseri-Ogbomo G, Omuemu V (2010) Prevalence of refractive error among school children in the Cape Coast Municipality, Ghana. Clin Optom 2: 59-66.

35. Mabaso RG, Oduntan AO, Mpolokeng MBL (2006) Refractive status of primary school children in Mopani district, Limpopo Province, South Africa. Afr Vis Eye Health 65: 125-133.

36. Atowa UC, Hansraj R, Wajuihian SO (2019) Visual problems: A review of prevalence studies on visual impairment in school-age children. Int J Ophthalmol 12: 1037-1043.

37. Brown NA, Hill AR (1987) Cataract: The relation between myopia and cataract morphology. Br J Ophthalmol 71: 405-414.

38. Dobson V, Harvey EM, Miller JM, Clifford-Donaldson CE (2008) Anisometropia prevalence in a highly astigmatic school-aged population. Optom Vis Sci 85: E512-E519.

39. Teran E, Romo-Garcia E, Santiago HC (2024) Refractive errors of school children from economically disadvantaged areas of Northwest Mexico. J Clin Med 13: 3094.

40. Rodriguez NM, Romero AF (2014) The prevalence of refractive conditions in Puerto Rican adults attending an eye clinic system. J Optom 7: 161-167.

41. Holden BA, Fricke TR, Wilson DA, Jong M, Naidoo KS, et al. (2016) Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. Ophthalmology 123: 1036-1042.

42. Flanagan J, Fricke T, Morjaria P, Yasmin S (2019) Myopia: A growing epidemic. Community Eye Health 32: 9.

43. Kaiti R, Shyangbo R, Sharma IP, Dahal M (2021) Review on current concepts of myopia and its control strategies. Int J Ophthalmol 14: 606-615.

44. Lim LS, Gazzard G, Low Y-L, Choo R, Tan DTH, et al. (2010) Dietary factors, myopia, and axial dimensions in children. Ophthalmology 117: 993-997.e4.

45. Migliore NR, Colombo G, Capodiferro MR, Mazzocchi L, Osorio AMC, et al. (2021) Weaving mitochondrial DNA and Y-chromosome variation in the Panamanian genetic canvas. Genes 12: 1921.

46. Lam RD, Huynh LT, Lozano DP, Gasparatos A (2023) Diet change and sustainability in indigenous areas: Characteristics, drivers, and impacts of diet change in Gunayala, Panama. Sustain Sci 1-23.

47. American Optometric Association (2017) Comprehensive pediatric eye and vision examination. Evidence -based clinical practice guideline. St. Louis, MO.

48. Tay SA, Farzavandi S, Tan D (2017) Interventions to reduce myopia progression in children. Strabismus 25: 23-32.

49. Martins A (2022) New optical approaches to improve myopia control in children. Rev Soc Port Oftalmol 46: 65-68.

50. Narayanasamy S, Vincent SJ, Sampson GP, Wood JM (2014) Simulated astigmatism impairs academic-related performance in children. Ophthalmic Physiol Opt 35: 8-18.

51. Zhang J, Wu Y, Sharma B, Gupta R, Jawla S, et al. (2023) Epidemiology and burden of astigmatism: A systematic literature review. Optom Vis Sci 100: 218-231.

52. McClure TM, Choi D, Wooten K, Nield C, Becker TM, et al. (2011) The impact of eyeglasses on vision-related quality of life in American Indian/Alaska Natives. Am J Ophthalmol 151: 175-182.e2.

53. Silva JC, Mújica OJ, Vega E, Barcelo A, Lansingh VC, et al. (2015) A comparative assessment of avoidable blindness and visual impairment in seven Latin American countries: Prevalence, coverage, and inequality. Rev Panam Salud Pública 37: 13-20.

54. Pan American Health Organization. Panama - health in the Americas 2007 - volume II.

55. Romero LI, Quental C (2013) The Panamanian health research system: A baseline analysis for the construction of a new phase. Health Res Policy Syst 11: 1-10.

56. International Citizens Insurance (2024) The Panama healthcare system.

57. United Nations (2024) Take action for the sustainable development goals - United Nations sustainable development.

58. United Nations Foundation (2024) Sustainable development goals.

59. Zhang JH, Ramke J, Mwangi N, Furtado J, Yasmin S, et al. (2020) Global eye health and the sustainable development goals: Protocol for a scoping review. BMJ Open 10: e035789.