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ORIGINAL RESEARCH

A Single-Center Case-Control Study of Glaucoma Severity on Initial Presentation in Haitian Americans

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Purpose: To assess relative glaucoma severity between Haitians and non-Haitians upon presentation to a tertiary referral practice using a retrospective case-control design.

Patients and Methods: All Haitian descent patients were age- and zip code-matched with non-Haitian Hispanic American controls from a tertiary glaucoma service in a 1:1 ratio. Clinical and social vulnerability characteristics were analyzed for differences in functional and structural glaucoma deficits. Those who did not return after 1 year were considered lost to follow-up. Outcome measures included a comparison of blindness, glaucoma severity [visual field and retinal nerve fiber layer (RNFL) loss], and follow-up rates between groups.

Results: At presentation, 95 Haitians had worse average mean deviation (MD) than controls in the better (-9.4 ± 9.8 vs -5.1 ± 6.4 dB, $p < 0.02$) and worse eyes (-12.7 ± 10.0 vs -7.3 ± 7.0 dB, $p < 0.01$). Haitians also had a greater percentage of functional blindness (22.4% vs 4.1%, $p < 0.02$) in the worse eye. RNFL thickness and loss to follow-up were similar between groups. Haitians were also less likely to have had a glaucoma surgery or laser prior to presentation than controls ($p \leq 0.009$). In multivariable models, Haitian descent was associated with worse MD in the worse eye. Worse neighborhood area deprivation indices were associated with higher likelihood of loss to follow-up, but Haitian descent was not.

Conclusion: Haitians had greater vision loss than controls despite similar exam findings. Higher burden of blindness and fewer prior procedures upon presentation may indicate a care disparity. Haitian patients may benefit from greater surveillance or earlier treatment for glaucoma.

Keywords: Haitian descent, glaucoma severity, blindness, follow-up, area deprivation index

Introduction

In a large survey, approximately 15% of Haitian adults were found to have glaucoma, which is the most common cause of blindness in this population.[1] Screening efforts have found high rates of glaucoma and glaucoma suspects in Haiti as well as in Haitian American communities.[1–3] However, little evidence exists about the clinical characteristics and severity of glaucoma in Haitian patients outside of health screenings. There are more than one million individuals of Haitian descent living in the United States (almost one-third of which reside in the Miami metropolitan area), representing the second largest black immigrant population in the US.[4] In addition to high ocular comorbidities, Haitian Americans are less likely to receive preventative or maintenance care for chronic conditions as compared to the general US population.[5,6] Historically, healthcare access barriers have included cultural and language differences, immigration status, and lower average household income.[5–7] Despite these known health disparities as well as higher rates of glaucoma, disparity in glaucoma care and outcomes remains poorly understood in the Haitian American community, creating an obstacle to deliver individualized care for this historically disadvantaged group.

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A majority of Haitians have ancestry originating from West and Central Africa.[8] Several studies have shown that glaucoma disproportionally affects people of West African descent, carrying features of earlier age of onset, greater severity, and higher prevalence.[9,10] This has been hypothesized to be due to a possible genetic founder effect among people of West African descent. However, previous genetic studies have focused mostly on identifying pathogenic variants in people of European descent than of West African descent.[11] Since there may be even less admixture within specific Afro-Caribbean countries, this may account for the higher prevalence of glaucoma found in previous Afro-Caribbean glaucoma studies compared to those in West Africa.[10]

Our tertiary care center is the largest eye hospital in Florida. We serve a significant portion of underrepresented minorities in our community, including first and second generation Haitian Americans. We hypothesize that Haitian patients present with greater glaucoma severity than non-Haitian Hispanic American controls. This will be the first study to examine the clinical characteristics and severity of Haitian patients referred for glaucoma evaluation. This study will help inform eye providers about the severity of glaucoma among Haitians in the United States.

Material and Methods

A retrospective, cross-sectional study of glaucoma severity among Haitian Creole speaking patients and age- plus zip-code-matched non-Haitian Hispanic American, Spanish-speaking controls seen at the Bascom Palmer Eye Institute were collected and analyzed for comparison. This study was approved by the University of Miami Health System Institutional Review Board and a waiver of consent was granted due to the study's retrospective nature. This study was also conducted in accordance with the Declaration of Helsinki and the Health Insurance Portability and Accountability Act. Haitian Creole language was chosen as a proxy for Haitian descent since it is the primary language spoken in Haiti and for most first and second generation Haitian immigrants and is not used by other ethnic groups. Spanish language was used as a proxy for the control group since patients whose primary language is Spanish are usually first or second generation immigrants from countries in the Caribbean or in Central or South America. Hispanic Americans encompass the largest group of minority communities treated at our institution.

Data Collection

A list of all Haitian Creole speaking patients who had been seen by any glaucoma specialist at the Bascom Palmer Eye Institute in Miami, FL for the first time between May 01, 2014, to August 05, 2019, was generated from our institution's electronic medical record. Demographic data and clinical characteristics for every patient were collected including age, gender, zip code, family history, co-morbidities, glaucoma subtype, glaucoma severity, prior lasers and surgeries, glaucoma medications, best distance visual acuity (VA), intraocular pressure (IOP), central corneal thickness, gonioscopy grading, visual field outputs (24–2 SITA Standard, HFA-II, Carl Zeiss Meditec, Dublin, CA), and optical coherence tomography (OCT, Cirrus, Carl Zeiss Meditec, Dublin, CA) retinal nerve fiber layer (RNFL) reports. These clinical characteristics were also recorded for subsequent visits out to 18 months. Patients were only excluded if during the initial visit, it was determined that the patient had been incorrectly scheduled with a glaucoma specialist for a non-glaucoma related reason such as a routine eye exam without a history of optic nerve cupping, ocular hypertension, or family history of glaucoma. However, patients were still included in the analysis if they were referred to the glaucoma specialist for a glaucoma evaluation, but it was determined at the first visit that they neither had glaucoma nor were a glaucoma suspect.

The American Academy of Ophthalmology Preferred Practice Pattern® guidelines for glaucoma care were used to stage glaucoma severity as either mild, moderate, or severe.[12] In short, this was based on both the presence of glaucomatous optic nerve damage and a characteristic visual field defect in neither, one, or both hemifields and whether it was within the central 10 degrees or not.[12] A glaucoma suspect was determined if the patient did not have glaucoma but had either a cup-to-disc ratio ≥0.6, cup to disc asymmetry of ≥0.2, ocular hypertension without cupping, a suspicious visual field, or RNFL defect.[13] A positive family history of glaucoma was recorded if the patient recalled a first or second degree relative with glaucoma during the patient intake. Zip code data was obtained from the patient's listed primary home address. Using home 9-digit zip codes, each patient's state and national 2018 area deprivation indices (ADI) were extrapolated. ADI is a validated measure of a neighborhood's social vulnerability level based on that neighborhood's

census tract data, which is derived from the US Census.[14] For the purpose of the analysis, all best VAs were converted into LogMAR. All IOPs were obtained by Goldman applanation tonometry except under very few circumstances when the patient could not position or tolerate applanation such as in infants or patients with neck mobility issues. Central corneal thickness (CCT) was obtained by pachymetry. Gonioscopy was categorized as open if the posterior trabecular meshwork was visualized in at least 2 or more quadrants or narrow/closed if the posterior trabecular meshwork was observed in less than 2 quadrants due to an occludable appearance or the presence of peripheral anterior synechiae. If a patient was taking a fixed combination glaucoma medication, each component was counted as a separate glaucoma medication. A patient was considered lost to follow-up if they were scheduled for additional return visits but did not return after one year. A patient was not considered lost to follow-up if they were referred to another provider for transfer of care or were discharged from the glaucoma service because they no longer needed follow-up.

Matching Process

In order to perform a 1:1 case-control comparison of glaucoma severity between Haitian Creole speaking patients and non-Haitian Hispanic American, Spanish-speaking patients, a list of all patients whose first language is Spanish who had been seen by a glaucoma specialist at the Bascom Palmer Eye Institute between May 01, 2014, to August 05, 2019, was generated, along with their age at first visit and home zip code. Using a greedy matching algorithm called "gmatch" in SAS 9.4 (SAS Institute, Cary NC),[15] one Spanish-speaking patient was randomly selected for every one Haitian Creole speaking patient after matching for age ± 5 years and the same zip code. A matched pairs design was a means to control for confounding by age and zip code/residence, a proxy for median household income. If no Spanish-speaking patients met the matching criteria, then Spanish-speaking patients were randomly selected for each Haitian Creole speaking patient after matching for age ± 5 years, and for their zip code's median household income ± $1000 within the same county. If no Spanish-speaking patients met the matching criteria, then the criteria was adjusted by increasing the acceptable median household income by zip code by increments of an additional $1000 within the same county, until all patients could be matched.

Seventy-six Spanish-speaking patients were matched to 76 Haitian Creole speaking patients using the same exact zip code. 11 patients were matched by using their zip code's median household income (MHI) ± $1000. 1 patient was matched using MHI ± $2000. 2 patients were matched using MHI ± $6000. 1 patient was matched using MHI ± $7000. 1 patient was matched using MHI ± $9000. 1 patient was matched using MHI ± $42,000. 2 matched patients were matched by increasing the age difference ± 10 years and using MHI ± $32,000.

Primary Outcome

The primary outcome in this study was glaucoma severity and percentage with blindness at the initial visit among the Haitian group as compared to the non-Haitian control group. Besides glaucoma severity staging, we compared other functional and structural severity outcomes including mean deviation (MD), pattern standard deviation (PSD), and RNFL thickness in the better and worse eyes separately. To measure blindness, we compared the percentage of patients with a visual acuity of ≤20/200 or had a mean deviation of ≤ −22 dB in the better and worse eyes separately.[16] The secondary outcome in this study was to compare loss to follow-up rates between Haitian patients and the non-Haitian control group. Linear and binary logistic regression analyses were performed in order to detect any identifiable associations between the patients' presenting details and their outcome measures.

Assignment of Better and Worse Eye

For each patient, we classified eyes as either the "better eye" or "worse eye" for comparing eye-level characteristics of interest. For each patient's pair of eyes, the eye with the more severe baseline glaucoma severity staging was designated as the worse eye, while the eye with lower glaucoma severity was designated as the better eye (26 non-Haitian controls and 18 Haitian patients). If a patient's eyes had the same stage (60 non-Haitian controls and 70 Haitian patients), then the worse eye was identified as having the more negative baseline MD value of the two. If baseline MD was missing in either eye, then the worse eye was identified as the one with thinner baseline mean RNFL between the two (13 non-Haitian controls and 25 Haitian patients). If a patient had the same stage between eyes who had incomplete baseline MD and

RNFL variables (applicable to 7 non-Haitian controls and 19 Haitian patients), the rv.uniform function in SPSS was used to randomly select each eye as either the better or worse eye.

Few patients (3 non-Haitian controls and 4 Haitian patients) had complete data for glaucoma severity staging in one eye, but not the other. In these cases, the eye with enough data to be staged was used for both the better and worse eye analysis. For the remaining patients (6 non-Haitian controls and 3 Haitian patients) who could not be staged in either eye due to incomplete data, the next highest priority variable was used to determine the better or worse eye if data for that variable was available for both eyes. The next highest priority variables from highest to lowest were: 1. Baseline MD, 2. Baseline RNFL, 3. Baseline VA. Lastly, we used the SPSS function rv.uniform to designate better or worse eye if not enough of the above parameters were available.

Statistical Methods

For all statistical tests and regression modelling completed below, results were acknowledged as being statistically significant if the p-values were less than 0.05.

Matched Pairs Statistical Tests

From the organization of 95 Haitian case – 95 non-Haitian control matched pairs, the following tests were carried out in SPSS version 26.0 (IBM, Armonk NY):

a- For continuous variables, such as baseline MD and baseline PSD, the paired samples *t*-test was selected. The paired sample *t*-test evaluates if the average of respective pair case value minus control value differences significantly veers away from 0.

b- For ordinal variables, such as national and state ADIs, the Wilcoxon signed rank test followed. This test looks at whether, for simplicity in this description, the median of respective pair case value minus control value differences significantly veers away from 0.

c- For binary categorical variables, such as diabetic status and family history of glaucoma, we ran McNemar's test. With respect to categorical variables, McNemar's test highlights pairs in which the respective members' statuses are not the same or are dissimilar. We compared the proportions of dissimilar pair types to see whether they significantly differed.

Regression Modelling

Aside from the matched pairs tests, we treated cases and controls as independent samples. We constructed, in SPSS, univariable regression models for each independent risk factor of interest with respect to each of the following outcomes: baseline MD (continuous), baseline PSD (continuous), baseline RNFL (continuous), loss to follow-up status (categorical binary), and functional blindness status (categorical binary). The definition of functional blindness was baseline MD ≤ -22 dB.[16] In describing select regression analysis results, VA variable "VA x10" indicated expression on a 0.10 logMAR interval. Vertical cup-to-disc ratio (VCDR) variable "VCDR x10" indicated effect size expressed in 0.10 intervals or for 0.10 increase in VCDR. Use of these expressions were to generate clinically relatable effect sizes. Three types of univariable models were constructed: "worse eye" only model, "better eye" only model, and a generalized estimating equation (GEE) model, which adjusted for the correlation between patients' better and worse eyes. Continuous outcomes were incorporated in linear regression models while dichotomous outcomes utilized binary logistic regression models.

We then performed SPSS automated forward stepwise variable selection (with respect to regression modelling) to arrive at multivariable models for better eyes and worse eyes separately. Given that the SPSS forward stepwise algorithm is not available for GEE modelling, forward stepwise regression was manually performed to arrive at the final GEE model. If associations between individual explanatory variables and an outcome of interest were statistically significant or marginally significant ($p < 0.15$), then these variables were considered in the manual execution of forward stepwise regression. Since State ADI and National ADI were strongly correlated with each other ($r = 0.99$, $p < 0.001$), only State ADI was used as an independent variable during regression modelling.

Results

In total, 95 Haitian patients met the inclusion criteria for this study. 106 unique Haitian patients who identified Haitian Creole as their primary language were seen by the glaucoma service during the 5-year period. 10 patients were excluded because they were incorrectly scheduled for a glaucoma evaluation. 1 patient was excluded because they did not have a US address. Out of 2760 non-Haitian Hispanic American, Spanish-speaking patients seen by the glaucoma service, 95 non-Haitian controls were matched with each Haitian patient. There was no statistical difference between age, gender, state and national ADI, and diabetic status. The average age of Haitian patients was 57.9 ± 22.5 years and their average State ADI score was 5.90 ± 2.56 (Table 1). Although more Haitian patients (45.3%) were lost to follow-up at 1 year than non-Haitian controls (38.9%), this was not statistically significant (paired samples test, p = 0.42). Primary Open Angle Glaucoma (POAG) was the most common glaucoma subtype in both groups. There was also no statistical difference in the percentage of patients presenting with POAG versus non-POAG diagnoses between both groups (Table 2).

Table 1 Patient Level Characteristics Between Haitian and Control Groups

Patient-Level Characteristic	Haitian Group	Control Group	Statistical Test P-Value
Age (mean ± SD)	57.9 ± 22.5	58.4 ± 22.0	Paired Samples *T*-test p = 0.075
Gender, N (%)	Female, 47 (49.5) Male, 48 (50.5)	Female, 57 (60.0) Male, 38 (40.0)	McNemar's Test p = 0.21
State ADI (mean ± SD) [median]	5.90 ± 2.56 [6.00]	6.14 ± 2.69 [7.00]	Wilcoxon Signed Rank Test p = 0.34
National ADI (mean ± SD) [median]	60.5 ± 23.3 [64.0]	62.6 ± 25.2 [68.5]	Wilcoxon Signed Rank Test p = 0.36
Family History of Glaucoma, N (%)	Yes, 12 (30.0) No, 28 (70.08)	Yes, 24 (60.0) No, 16 (40.0)	McNemar's Test p = 0.023
Diabetes, N (%)	Yes, 26 (28.0) No, 67 (72.0)	Yes, 30 (32.3) No, 63 (67.7)	McNemar's Test p = 0.64
Loss to Follow-up After 1 Year, N (%)	Yes, 43 (45.3) No, 52 (54.7)	Yes, 37 (38.9) No, 58 (61.1)	McNemar's Test p = 0.42

Abbreviations: SD, standard deviation; N, total number of patients; ADI, Area Deprivation Index.

Table 2 Distribution of Right Eye Glaucoma Diagnoses Between Haitian and Control Groups

	Frequency (%) Among Haitian Group	Frequency (%) of Haitian Glaucoma Suspects Within Diagnosis Category	Frequency (%) among Control group	Frequency (%) of Control group Glaucoma Suspects Within Diagnosis Category
No Glaucoma	2 (2.1%)		3 (3.2%)	
Glaucoma Suspects	33 (34.7%)	–	37 (38.9%)	–
POAG (includes suspects)	45 (47.4%)	21 (31.8 %)	35 (36.8%)	20 (36.4%)
NTG	1 (1.1%)	0 (0%)	3 (3.2%)	1 (25.0%)
Pseudoexfoliation	0 (0%)	1 (100%)	1 (1.1%)	1 (50.0%)
Pigmentary dispersion	1 (1.1%)	0 (0%)	1 (1.1%)	1 (50.0%)
CACG (includes Suspects)	4 (4.2%)	2 (33.3%)	5 (5.3%)	7 (58.3%)

(*Continued*)

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Table 2 (Continued).

	Frequency (%) Among Haitian Group	Frequency (%) of Haitian Glaucoma Suspects Within Diagnosis Category	Frequency (%) among Control group	Frequency (%) of Control group Glaucoma Suspects Within Diagnosis Category
Mixed mechanism glaucoma	1 (1.1%)	0 (0%)	4 (4.2%)	0 (0%)
JOAG	1 (2.1%)	9 (90.0%)	0 (0%)	7 (100.0%)
Uveitic Glaucoma	3 (3.2%)	0 (0%)	1 (1.1%)	0 (0%)
Other	4 (4.2%)		5 (5.3%)	

Abbreviations: POAG, Primary Open Angle Glaucoma; NTG, Normal Tension Glaucoma; CACG, Chronic Angle Closure Glaucoma; JOAG, Juvenile Open Angle Glaucoma.

The Haitian group presented with a greater percentage of severe-stage glaucoma diagnoses than the control group (32.2% vs 19.5%, paired samples test, p = 0.005) in the better eye but not in the worse eye (44.8% vs 33.3% p = 0.12). Also, Haitians were more likely to be blind in at least one eye compared to the control group (35.8% vs 17.9%; baseline visual field MD ≤ −22 dB or baseline VA ≤ 20/200). Although not statistically significant, the Haitian group had a higher percentage of patients with a baseline VA ≤ 20/200 than the control group (12.4% vs 3.4%, paired samples test, p = 0.057) in the better eye, but not the worse eye (p = 0.83). Lastly, the control group was more likely to have had a prior glaucoma surgery or laser procedure than the Haitian group in both the better (paired samples test, p = 0.004) and worse (p = 0.009) eyes at presentation (Table 3).

While both groups presented with similar baseline IOPs and number of glaucoma medications, the Haitian group presented with a worse baseline mean visual field MD than control group patients (−9.39 ± 9.75 vs −5.05 ± 6.44 dB, paired samples test, p = 0.012) in the better eye and (−12.70 ± 9.97 vs −7.29 ± 7.00 dB, p = 0.003) in the worse eye. There was a greater percentage of Haitian patients who had functional blindness by visual field testing (baseline visual field MD ≤ −22 dB) than control group patients (22.4% vs 4.1%, paired samples test, p = 0.012) in the worse eye, but not the better eye (p = 0.11). Lastly, there was no statistical difference in the mean baseline RNFL thickness or VCDR as measured by OCT between groups in either better or worse eyes (Table 4).

Table 3 Eye Level Characteristics Between Haitian and Control Groups

Eye-Level Characteristic	Best Eyes		Worst Eyes		Statistical Test P-Values
	Haitian	*Control*	*Haitian*	*Control*	
Prior Glaucoma Surgery					
Yes, N (%)	8 (8.8)	21 (23.1)	9 (9.9)	23 (25.3)	McNemar's Test p = 0.004 (Best Eyes); p = 0.009
No, N (%)	83 (91.2)	70 (76.9)	82 (90.1)	68 (74.7)	(Worst Eyes)
Number of Previous Glaucoma Surgeries (mean ± SD)	0.1 ± 0.3	0.3 ± 0.5	0.1 ± 0.4	0.3 ± 0.5	Paired Samples *T*-test p = 0.001 (Best Eyes); p = 0.007 (Worst Eyes)
With Glaucoma Medications at Baseline, N (%)					
Yes, N (%)	42 (48.8)	44 (51.2)	43 (50.0)	45 (52.3)	McNemar's Test p = 0.87 (Best Eyes); p = 0.87 (Worst Eyes)
No, N (%)	44 (51.2)	42 (48.8)	43 (50.0)	41 (47.7)	
Number of Glaucoma Medications at Baseline (mean ± SD)	1.1 ± 1.4	1.1 ± 1.3	1.1 ± 1.4	1.1 ± 1.3	Paired Samples *T*-test p = 0.80 (Best Eyes); p = 0.80 (Worst Eyes)

(*Continued*)

Table 3 (Continued).

Eye-Level Characteristic	Best Eyes		Worst Eyes		Statistical Test P-Values
	Haitian	*Control*	*Haitian*	*Control*	
Baseline Glaucoma Severity					
Suspect, N (%)	34 (39.0)	46 (52.9)	29 (33.3)	33 (37.9)	Wilcoxon Signed Rank Test p = 0.005 (Best Eyes); p = 0.12 (Worst Eyes)
Mild, N (%)	13 (14.9)	21 (24.1)	8 (9.2)	16 (18.4)	
Moderate, N (%)	12 (13.8)	3 (3.4)	11 (12.6)	9 (10.3)	
Severe, N (%)	28 (32.2)	17 (19.5)	39 (44.8)	29 (33.3)	
Baseline VA of NLP					
Yes, N (%)	2 (2.2)	1 (1.1)	6 (6.7)	2 (2.2)	McNemar's Test p = 1.00 (Best Eyes); p = 0.29 (Worst Eyes)
No, N (%)	87 (97.8)	88 (98.9)	83(93.3)	87 (97.8)	
Baseline VA of 20/200 or Worse					
Yes, N (%)	11 (12.4)	3 (3.4)	15 (16.9)	13 (14.6)	McNemar's Test p = 0.057 (Best Eyes); p = 0.83 (Worst Eyes)
No, N (%)	78 (87.6)	86 (96.6)	74 (83.1)	76 (85.4)	

Abbreviations: N, total number of eyes; SD, standard deviation; VA, visual acuity; NLP, No light perception.

Table 4 Exam Level Characteristics Between Haitian and Control Groups

Exam Level Characteristic	Best Eyes		Worst Eyes		Statistical Test P-values
	Haitian	*Control*	*Haitian*	*Control*	
Baseline Gonioscopy					
Closed, N (%)	2 (3.7)	1 (1.9)	0 (0)	0 (0)	McNemar's Test p = 1.00 (Best Eyes); p = 1.00 (Worst Eyes)
Open, N (%)	52 (96.3)	53 (98.1)	29 (100.0)	29 (100.0)	
Baseline IOP, mm Hg (mean ± SD)	18.2 ± 8.7	16.4 ± 5.3	19.9 ± 10.6	17.9 ± 6.3	Paired Samples *T*-test p = 0.098 (Best Eyes); p = 0.28 (Worst Eyes)
Baseline CCT, micrometers (mean ± SD)	530.33 ± 40.34	538.28 ± 74.45	529.29 ± 39.07	534.77 ± 73.42	Paired Samples *T*-test p = 0.45 (Best Eyes); p = 0.62 (Worst Eyes)
Baseline MD, dB (mean ± SD)	−9.39 ± 9.75	−5.05 ± 6.44	−12.70 ± 9.97	−7.29 ± 7.00	Paired Samples *T*-test p = 0.012 (Best Eyes); p = 0.003 (Worst Eyes)
Eyes With Baseline MD ≤ −22.0 dB, N (%)					
yes, N (%)	8 (14.8)	2 (3.7)	11 (22.4)	2 (4.1)	McNemar's Test p = 0.11 (Best Eyes); p = 0.012 (Worst Eyes)
no, N (%)	46 (85.2)	52 (96.3)	38 (77.6)	47 (95.9)	
Baseline PSD, dB (mean ± SD)	4.54 ± 3.58	4.02 ± 3.28	5.72 ± 3.41	5.60 ± 3.98	Paired Samples *T*-test p = 0.44 (Best Eyes); p = 0.89 (Worst Eyes)
Baseline VFI, % (mean ± SD)	75.30 ± 31.68	85.85 ± 22.80	64.04 ± 34.33	82.24 ± 21.56	Paired Samples *T*-test p = 0.067 (Best Eyes); p = 0.002 (Worst Eyes)
Eyes With Baseline VFI ≤ 30.0%, N (%)					
Yes, N (%)	7 (13.0)	3 (5.6)	12 (24.5)	3 (6.1)	McNemar's Test p = 0.34 (Best Eyes); p = 0.022 (Worst Eyes)
No, N (%)	47 (87.0)	51 (94.4)	37 (75.5)	46 (93.9)	
Baseline RNFL, micrometers (mean ± SD)	78.85 ± 17.36	84.93 ± 20.34	74.67 ± 18.07	76.56 ± 20.00	Paired Samples *T*-test p = 0.20 (Best Eyes); p = 0.67 (Worst Eyes)
Baseline VCDR (mean ± SD)	0.67 ± 0.13	0.63 ± 0.17	0.70 ± 0.13	0.69 ± 0.15	Paired Samples *T*-test p = 0.23 (Best Eyes); p = 0.70 (Worst Eyes)

Abbreviations: N, total number of eyes; IOP, intraocular pressure; SD, standard deviation; CCT, central corneal thickness; MD, mean deviation; dB, decibels; PSD, pattern standard deviation; VFI, Visual Field Index; RNFL, retinal nerve fiber layer thickness; VCDR, vertical cup-to-disc ratio.

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Factors Associated With Humphrey Visual Field Loss

Overall, Haitian patients had greater mean baseline visual field loss in both eyes and a greater percentage of patients with functional blindness by visual field testing in the worse eye than control patients. In the better eye, larger VCDR, greater number of glaucoma medications, Haitian Creole language, higher IOP, worse VA, and thinner CCT were each associated with worse baseline visual field MD ($p < 0.05$) in univariable models, while age, family history of glaucoma, and state ADI were not ($p > 0.09$). In the final multivariable model using forward stepwise variable selection, only VCDR (B = −13.8, 95% CI −24.0 to −3.5, p = 0.009), number of glaucoma medications (B = −1.8, CI −3.0 to −0.6, p = 0.005), and IOP (B = −0.4, CI −0.7 to −0.1, p = 0.003) remained statistically associated with baseline visual field MD in the better eye. In the worse eye, larger VCDR, greater number of glaucoma medications, Haitian Creole language, older age, worse VA, and thinner CCT were associated with worse baseline visual field MD ($p < 0.05$) in univariable models, while family history of glaucoma, state ADI, and IOP were not ($p > 0.05$). In the final multivariable model, VCDR (B = −21.2, CI −33.2 to −9.1, p = −0.001), logMAR VA (B = −8.4, CI −13.7 to −3.2, p = 0.002), number of medications (B = −2.0, CI −3.4 to −0.7, p = 0.004), and Haitian Creole language (B = −3.7, CI −7.0 to −0.4, p = 0.03) remained statistically associated with baseline visual field MD in the worse eye. Also, in the worse eye, larger VCDR, greater number of glaucoma medications, Haitian Creole language, and worse VA were all associated with greater odds of functional blindness (p all < 0.02), but age, State ADI, CCT, and family history of glaucoma were not (p all > 0.05). In the final multivariable model, VCDR x10 (Larger VCDR, OR = 4.2, CI 1.5 to 11.6, p = 0.006) and logMAR VA x10 (Worse VA, OR = 1.3, CI 1.0 to 1.6, p = 0.024) were still significantly associated with greater odds of functional blindness in the worse eye.

Factors Associated With Circumpapillary RNFL Thickness

In the better eye, older age, larger VCDR, and greater number of glaucoma medications were associated with lower baseline RNFL thickness (p all < 0.004) in univariable models, but State ADI, IOP, logMAR VA, CCT, family history of glaucoma, and Haitian Creole language were not (p all > 0.08). In the final multivariable model, only number of glaucoma medications (B = −5.7, CI −8.6 to −2.7, $p < 0.001$) remained statistically associated with RNFL thickness in the better eye. In the worse eye, older age, worse logMAR VA, thin CCT, large VCDR, and greater number of medications were associated with lower RNFL thickness ($p < 0.05$) in univariable models, but State ADI, IOP, family history of glaucoma, and Haitian Creole language were not (p all > 0.3). In the final multivariable model, only VCDR x10 (B = −6.9, CI −9.7 to −4.2, $p < 0.001$) remained statistically associated with RNFL thickness in the worse eye.

Factors Associated With Loss to Follow-up After 1 year

Using generalized estimating equations that accounted for the relationship between both eyes, higher State ADI (OR = 1.2, CI 1.0 to 1.3 p = 0.008) was associated with greater odds of loss to follow-up after 1 year. This was left as the final model. Variables that were not associated with loss to follow-up included age, IOP, logMAR VA, CCT, VCDR, number of glaucoma medications, family history of glaucoma, Haitian Creole language, RNFL thickness, visual field MD, and whether an eye was functionally blind by visual field testing (all $p > 0.10$).

Discussion

In this study, 44.8% of all Haitian patients who first presented to a tertiary glaucoma service met criteria for severe glaucoma staging and 35.8% were functionally blind in at least one eye, compared to 33.3% and 17.9% in the control group, respectively. Although average RNFL thickness and VCDR were similar between Haitian and non-Haitian Hispanic American controls, Haitians were more likely to have greater peripheral vision loss in both eyes and be functionally blind in the worse eye. Haitians were also less likely to have had a glaucoma surgery or laser prior to presentation. Loss to follow-up from the tertiary glaucoma service after 1 year was high in this cohort, but it was not significantly different than non-Haitian controls who had similar ADI scores. Haitians were disproportionally affected by glaucoma in this cohort, which may indicate greater disease burden or a care disparity in this population.

This is the first study to examine relative glaucoma severity in a Haitian population versus a control group. There are several possible explanations for our observation of more severe glaucoma disease in the Haitian cohort. First, previous

studies have suggested that Haitians have high glaucoma prevalence levels, which may imply an increased glaucoma susceptibility. In 2012, Duong et al reviewed medical mission data over six years in one rural community in Haiti and found the prevalence was 14.6% for glaucoma (compared to 6.8% in the neighboring island of Barbados).[1,17] In 2014, Bokman et al found that 25.5% of Haitians screened in the Little Haiti community of Miami, FL were glaucoma suspects with elevated IOP.[3] Since these surveys were not population studies, it is unclear whether these rates are generalizable, but it suggests an increased glaucoma burden among Haitian communities overall. Second, since we measured glaucoma severity at the initial visit for both case and control groups, the Haitian cohort may have received disparate levels of primary or secondary eye care prior to referral to our tertiary care center. Perhaps, Haitians had less access to community eye care than non-Haitian controls did. Our study adds to the literature by determining that Haitians are more likely to present with advanced glaucoma and were less likely to have had a glaucoma procedure using our matching design.

Here, Haitians had worse baseline visual field MD than non-Haitian controls, despite similar RNFL thickness and VCDR. This implies greater functional loss for each increment of structural damage and supports the notion that glaucoma may progress at a more rapid pace in Haitians when compared to non-Haitian controls. In the Salisbury Eye Evaluation, there were higher rates of blindness among black individuals with glaucoma than white individuals.[18] The authors reported a blindness rate of 5.3% among black individuals whereas we reported a blindness rate of 12.4% in the better eye (bilateral blindness) in a Haitian cohort. However, their study was population-based and in Salisbury, Maryland. High rates of blindness have also been reported in several population-based studies in Afro-Caribbean countries including St. Lucia and Barbados.[17,19–21] In the Barbados Eye Study, 1.7% of black individuals were bilaterally blind, mainly due to glaucoma or cataracts.[19] Glaucoma is the leading cause of irreversible blindness in people of Afro-Caribbean descent, and therefore is a public health concern.[1,19] Haitians may benefit from stronger screening efforts to detect undiagnosed glaucoma before significant field loss has begun. While glaucoma screening has not been found to be cost-effective, targeted glaucoma screening in high-risk neighborhoods or populations may be more practical.[22] In a study from our institution, cascade screening of Haitian patients' first degree relatives also yielded a high catchment rate of previously undiagnosed glaucoma.[23]

Worse ADI score, which accounts for neighborhood deprivation levels, was associated with higher likelihood of loss to follow-up in this study. In other glaucoma studies, loss to follow-up has been associated with blindness progression.[24,25] In recent years, social determinants of health have been recognized for their greater role in racial disparities observed in healthcare.[7] In one survey of elderly individuals in Miami, Haitian Americans in Little Haiti were found to have greater poverty rates, lower rates of health insurance, and lower rates of high school completion compared to African Americans and White Non-Hispanics.[6] We suppose that Haitians living in areas with worse ADI score in our study had increased socioeconomic barriers, making follow-up adherence more challenging. Therefore, continuity of care and accessible care are just as important as any glaucoma screening initiatives aimed towards Haitians living in disadvantaged communities. In addition, individuals living in high ADI areas who present to the clinic should prompt physicians to screen for possible healthcare barriers such as healthcare literacy, access to medications, and transportation.[26] Social work screening may be necessary for those living in high ADI neighborhoods.

There were several limitations to this study. Haitian descent was extrapolated from electronic medical records in which individuals indicated Haitian Creole as their primary language. Therefore, Haitian individuals whose primary language was not Haitian Creole were not recorded, which likely reduced the sample size. Not all Haitians could be matched to a non-Haitian Hispanic American control using exact zip codes. Since many immigrants in Miami live within ethnic neighborhoods, densely populated Haitian communities may not have many non-Haitians and vice versa. Despite controlling for neighborhood deprivation levels, cultural differences might have had a confounding neighborhood effect. There may also be discrepancies in travel distance and transportation infrastructure to a glaucoma provider between these communities.[27] Most patients in this cohort were insured, while previous community health fairs have focused on uninsured populations, who may be at higher risk of vision loss.[28] Our data was from a single center, so these results may not generalize to other parts of the United States. However, our institution is located in the city and state with the largest population of Haitian Americans, and thus these results may be of interest to other metropolitans with a large Haitian American community. Lastly, this was a cross-sectional study, so longitudinal outcomes such as glaucoma progression were not assessed. A longer, prospective study would be needed to detect population-level differences in visual field or RNFL changes.

Conclusion

Glaucoma disproportionally affected Haitians upon presentation at a functional level, adjusting for age and zip code. There was a high rate of blindness and history of having fewer glaucoma procedures at presentation among this cohort. Additionally, greater neighborhood deprivation scores were associated with higher loss to follow-up. Many Haitian Americans live in historically disadvantaged communities, which further compound those at risk. Stronger efforts towards wider genetic testing, cascade screening, and outreach with community leaders may help improve detection and earlier treatment.

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Disclosure

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