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Pediatric blepharokeratoconjunctivitis: findings and outcomes in Hispanic vs. Non-Hispanic patients

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Abstract

Objective Determine blepharokeratoconjunctivitis (BKC) presentation and outcomes in Hispanic vs. Non-Hispanic pediatric patients.

Methods Retrospective review of pediatric patients (< 18 years old) with BKC and at least 2 examinations (2018–2022). Details obtained were self-reported race/ethnicity, best-corrected visual acuity (BCVA), slit lamp findings, and prescribed treatments.

Results Ninety-five patients (59 Females) presented at a median of 8.1 [IQR 5.7, 10.9] years of age and had 4 (IQR 3, 4) visits over 1.3 ([QR 0.8, 2.2] years. Sixty-five (68%) patients identified as Hispanic. There was no difference in age at presentation, number of visits, or follow-up between Hispanic and non-Hispanic patients. Initial (0.22 [IQR 0.10, 0.40] vs. 0.06 [IQR 0.00, 0.18], $p < 0.01$) and final (0.13 [IQR 0.10, 0.40] vs. 0.02 [IQR 0.00, 0.18], $p < 0.01$) LogMAR BCVA were significantly worse in Hispanic vs. Non-Hispanic patients. Logistic analysis showed an association between Hispanic ethnicity and worse initial and final BCVA. However, ethnicity did not correlate with any subset of BKC diagnoses (e.g. corneal scar or ulcer, chalazion, marginal or superficial keratitis) or slit lamp findings. The presence of corneal stromal scarring was associated with worse initial BCVA, regardless of ethnicity. There were no differences in prescribed treatments between Hispanic and Non-Hispanic patients, and no treatments were associated with visual outcomes.

Conclusions BKC was common in Hispanic patients and despite no difference in slit lamp findings or prescribed treatments, Hispanic patients had worse initial and final BCVA. The presence of corneal stromal scarring was also associated with worse visual outcomes.

Keywords Blepharokeratoconjunctivitis, Corneal scarring

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Introduction

Blepharokeratoconjunctivitis (BKC), an encompassing term describing the comorbid pairing of Meibomian gland dysfunction (MGD) with vascular changes of the conjunctiva and cornea, is both a common pediatric condition and one with severe, sight-threatening implications [1–3] Though infectious causes of keratitis are well understood in the pediatric population, non-infectious causes such as BKC are under-recognized, increasing the risk for delayed intervention and worse outcomes.4–7 Further, there is a spectrum of ocular surface diseases which overlap with BKC, including phylectenular keratoconjunctivitis and rosacea keratoconjunctivitis, but these have distinct pathophysiologies from meibomitis-related BKC.8 Pediatric BKC disease has been associated with higher corneal neovascularization scores, worse scarring, and greater impact on vision than their adult counterparts [1, 9].

Despite the presentation being described, studies in the pediatric population related to demographics, treatments, and outcomes are limited. Similarly, an effective, well-studied treatment modality is lacking in the pediatric population, and most clinicians opt for a stepwise treatment course based on adult data and the clinical appearance of the disease at presentation [8, 10–12].

Studies have attempted to elucidate the potential racial, ethnic, and gender implications in pediatric BKC, although the majority involve populations outside the United States. Teo et al. reported overrepresentation and more severe disease in Indian patients when compared to Chinese and Malay children in Singapore [13]. In the United Kingdom, Viswalingam et al. described Indian, Sri Lankan, and Middle Eastern children as having more severe disease courses when compared to white children [7]. A study based in Mexico, showed that almost 40% of Hispanic patients presented with corneal involvement and overall these patients had worse visual outcomes which may be exacerbated by higher order corneal aberrations [14, 15]. A more recent evaluation using a US-based insurance claims database found predilection towards patients of Asian and Hispanic descent, as well as location-based regional effects; however, this study included other causes of keratitis such as infectious and vernal in addition to BKC [16] In addition, many prior studies described a gender predilection for pediatric BKC, with females more commonly affected, ranging from 85% female predominance to just above 50% [1, 3, 7, 13].

At our tertiary care center, we have found a disproportionate representation of Hispanic children who present with BKC. Based on previous studies which showed a higher rate of BKC and its subsequent complications in Hispanic children and in females, we aimed to understand differences in presentation and outcomes as related to both ethnicity and gender [8, 12, 14, 15]. To this end, we assessed patient demographics, ocular diagnoses, slit lamp findings, and treatments with attention to comparing visual outcomes in Hispanic vs. Non-Hispanic children and in males vs. females.

Methods

A single-center, retrospective chart review selected for pediatric patients seen at the Ann & Robert H. Lurie Children's Hospital of Chicago between 2018 and 2022 with the presence of anterior and/or posterior blepharitis or MGD in conjunction with corneal neovascularization at initial presentation and at least 6 months of follow-up. Patients with a history of corneal abnormalities unrelated to BKC as well as patients with MGD without corneal findings were excluded. This study was approved as exempt without need for informed consent due to its retrospective nature by the Ann & Robert H. Lurie Children's Hospital of Chicago. The study adhered to the tenets of the Declaration of Helsinki. Data collection was de-identified and HIPAA-compliant.

Patients were identified using the following ICD-10 diagnoses codes: H10.5XX (blepharoconjunctivitis), H01.0XX (blepharitis), H17.XX (corneal scarring), H16.4 (corneal neovascularization), H00.XX (chalazion, hordeolum) and H16.XX (marginal keratitis, corneal ulcer). Charts were reviewed to determine whether the inclusion criteria were met at initial presentation. Marginal keratitis was defined as peripheral stromal infiltrates in the presence of blepharitis.

Data including demographic information, medical and ocular history, ophthalmic diagnoses, examination findings, and BKC treatments were collected at initial presentation (baseline), 6-month, 1-year, and successive annual increments until disease clearance or final follow-up. Unilateral refractive amblyopia was defined as >2 line interocular difference in best-corrected visual acuity (BCVA) due to anisometropia (hyperopic, myopic, or astigmatic). Bilateral refractive amblyopia secondary to high hyperopia (>+3.00), high myopia (<-6.00), or high astigmatism (>+2.00) was defined as BCVA less than 20/25 in both eyes. In addition, history of eye and eyelid surgeries (e.g. chalazion incision and drainage) was recorded. BCVA for each eye was measured with age-appropriate optotypes (e.g. LEA figures, HOTV, or Snellen) and then converted into LogMAR format. Intraocular pressure (IOP) was measured by iCare tonometry (Icare USA, Inc, Raleigh, NC) or Tonopen (Reichert, Depew, NY). Cycloplegic refraction was performed by retinoscopy and when age-appropriate fine-tuned in the phoropter. Slit lamp findings included MGD, punctate epithelial erosions/superficial punctate keratopathy (PEE/SPK) as identified by fluorescein staining, eyelid scurf, chalazion/hordeolum, corneal infiltrates, corneal

Table 1 Demographics

	n = 97
Age at Presentation (years)	8.5 ± 3.8 Median 8.1 IQR 5.7, 10.9
Ophthalmic visits	3.7 ± 1.3 Median 4 IQR 3, 4
Follow-up (years)	1.8 ± 1.7 Median 1.3 IQR 0.8, 2.2
Gender	36 (38%)
Males	59 (62%)
Females	
Race	68 (72%)
White	1 (1%)
Black	10 (11%)
Asian/Native Hawaiian	8 (8%)
Not Reported/Unknown	8 (8%)
More than 1 Race	

Table 2 Odds ratios of associations with BCVA

	Initial BCVA OR [95% CI]	Final BCVA OR [95% CI]
Blepharitis	0.4 [0.1, 1.2]	0.4 [0.1, 1.5]
BKC	0.7 [0.2, 1.9]	0.4 [0.1, 1.4]
Chalazion/Hordeolum	0.4 [0.1, 1.5]	0.5 [0.1, 2.0]
Corneal stromal scar	**7.3 [2.1, 27.2]**	3.7 [0.8, 16.0]
Corneal ulcer	0.5 [0.0, 6.8]	2.8 [0.1, 26.3]
Marginal keratitis	0.6 [0.1, 2.2]	2.8 [0.1, 26.3]
Superficial keratitis	3.3 [0.4, 18.3]	**15.8 [2.1, 123.9]**
Erythromycin ointment	1.6 [0.5, 5.2]	2.9 [0.8, 12.9]
Topical steroids	0.6 [0.2, 2.6]	5.0 [0.6, 74.5]
Oral antibiotics	**3.6 [1.3, 11.10]**	2.7 [0.8, 9.4]
Hispanic ethnicity	**8.9 [2.2, 47.4]**	**14.6 [2.6, 108.9]**
Need for interpreter	2.0 [0.8, 5.8]	0.9 [0.2, 2.9]
Gender	0.5 [0.2, 1.4]	0.5 [0.2, 1.8]

neovascularization, and corneal stromal scarring. Treatments such as eyelid hygiene (e.g. warm compresses, eyelid scrubs), erythromycin ointment, topical steroids, and oral antibiotics (e.g. azithromycin, doxycycline) were recorded.

Self-reported race included the following categories: white, black, Asian/Native Hawaiian or other Pacific Islander, more than one race, and other. Ethnicity was recorded separately as either Hispanic, non-Hispanic, or not reported/unknown. Patient racial/ethnic identification data from all ophthalmology sites within the institution were acquired for comparison.

As BKC is often asymmetric in findings and treatment, both eyes were included in the analyses. Statistical analysis was performed with GraphPad (GraphPad, La Jolla, CA) and SPSS (IBM, Armonk, NY). D'Agostino and Pearson test and Histogram analysis showed that the age at presentation, length of follow-up, BCVA, IOP, and refraction did not follow normal distributions. Wilcoxon matched pairs test was used for comparison of initial and final BCVA and refraction. Mann-Whitney test, Fisher's exact test, and 2-way ANOVA were used for comparison between different groups (e.g. Hispanic vs. Non-Hispanic, Male vs. Female). Univariate logistic analysis was used to calculate the odds ratio (OR) with a 95% confidence interval (CI). Univariate linear analysis determined the slope of the regression line and calculated goodness of fit (R squared). All tests were 2-sided and p-values less than 0.05 were considered statistically significant.

Results

Ninety-five patients (Table 1) presented with BKC at a median age of 8.1 years (IQR 2.3, 17.9) and had a median 4 (IQR 3, 4) outpatient visits over a median of 1.3 years (IQR 0.8, 2.1) of follow-up. The majority of patients were female ($n = 59$, 62%) and self-reported as white ($n = 68$, 72%). Further, more than half of patients identified as Hispanic ethnicity ($n = 65$, 68%). This was a significantly higher percentage of Hispanic patients ($p < 0.01$) compared to the total proportion of Hispanic patients who presented to our practice between 2018 and 2022 (31%, 14,026/44,689), which reflected the public census population data for the greater Chicago area. Age at presentation (Supplemental Fig. 1A) was not linearly associated with initial ($p = 0.06$), final BCVA ($p = 0.59$), or amount of initial cylinder ($p = 0.47$), but was linearly associated with initial spherical equivalent of the cycloplegic refraction (SER, Supplemental Fig. 1B, $y=-0.3x+2.0$, $R^2 = 0.15$, $p < 0.01$).

Fifty-two (54%) patients had asymmetry in diagnoses and slit lamp findings. Diagnoses including blepharitis, BKC, chalazion, corneal ulcer, and marginal keratitis were not associated with worse initial or final BCVA (Table 2). Corneal stromal scarring, was associated with worse initial BCVA (OR 7.3 with 95% CI [2.1, 27.2]), but not final BCVA (OR 3.7 with 95% CI[0.8, 16.0]). In contrast, superficial keratitis was associated with worse final BCVA (OR 15.8 with 95% CI[2.1, 123.9), but not initial BCVA (OR 3.3 with 95% CI[0.4, 18.3). There was no association between erythromycin ointment or topical steroids with initial or final BCVA. Oral antibiotics were associated with worse initial BCVA (OR 3.6 with 95% CI [1.3, 11.10], but not final BCVA (OR 2.7 with 95% CI [0.8, 9.4]). The number of chalazion/hordeolum surgeries was not associated with initial or final BCVA ($p = 0.87$, $p = 0.91$).

Comparing Hispanic and non-Hispanic patients (Table 3), the gender distribution was different with a higher percentage of females in the Hispanic population ($p < 0.01$). There was no difference in age at presentation ($p = 0.53$), number of visits ($p = 0.36$), and length of follow-up ($p = 0.60$). Hispanic patients had worse initial and final ($p < 0.01$) LogMAR BCVA compared

Table 3 Ethnicity differences in BCVA and refraction

	Hispanic ($n=65$)	Non-Hispanic or Not Reported ($n=30$)	*P* value (Mann-Whitney Test)
Gender	22 Males: 43 Females	14 Males: 16 Females	< **0.01**
Age at First Visit (years)	8.7 ± 3.9 Median 8.2 IQR 5.6, 10.9	8.2 ± 3.6 Median 6.9 IQR 5.9, 10.4	0.53
Number of Visits	3.8 ± 1.2 Median 4.0 IQR 3, 4	3.6 ± 1.6 Median 4 IQR 2, 4	0.36
Time of Follow-up (years)	1.7 ± 1.6 Median 1.3 IQR 0.9, 2.0	2.0 ± 1.9 Median 1.5 IQR 0.5, 2.7	0.60
Initial LogMAR BCVA	0.30 ± 0.32 Median 0.22 IQR 0.10, 0.40	0.16 ± 0.22 Median 0.06 IQR 0.00, 0.18	**< 0.01**
Final LogMar BCVA	0.23 ± 0.26* Median 0.13 IQR 0.06, 0.33	0.11 ± 0.20 Median 0.02 IQR 0.00 to 0.18	**< 0.01**
Change in LogMar BCVA	-0.07 ± 0.25 Median − 0.06 IQR − 0.20, 0.06	-0.05 ± 0.18 Median − 0.01 IQR − 0.10 to 0.02	0.32
Maximum IOP (mmHg)	16.1 ± 3.4 Median 16.0 IQR 14.0, 19.0	16.6 ± 4.2 Median 16.0 IQR 14.3, 18.8	0.70
Initial Spherical Equivalent Crx (Diopter)	-0.56 ± 2.30 Median − 0.38 IQR − 1.38, 0.94	-0.47 ± 3.50 Median 0.25 IQR − 0.63, 1.00	0.24
Final Spherical Equivalent Crx (Diopter)	-1.05 ± 2.94 Median − 0.75 Range − 1.56, 0.56	-0.86 ± 3.56 Median 0.13 IQR − 0.63, 1.00	0.42
Initial Cylinder (Diopter)	1.76 ± 1.36 Median 1.50 IQR 0.75, 2.5	0.93 ± 0.92 Median 0.75 IQR 0.25, 1.00	**< 0.01**
Final Cylinder (Diopter)	1.84 ± 1.40 Median 1.88 IQR 0.50, 3.0	1.01 ± 1.07 Median 0.75 IQR 0.25, 1.50	**< 0.01**

* Initial vs. Final BCVA, $p < 0.01$

to non-Hispanic patients. At the final follow-up, Hispanic patients showed significant improvement in LogMAR BCVA ($p < 0.01$) compared to presentation while non-Hispanic patients showed no significant difference ($p = 0.06$). Univariate logistic analysis (Table 2) showed that Hispanic ethnicity, but not need for interpreter, was associated with worse initial BCVA (OR 8.9 with 95% CI[2.2, 47.4] and final BCVA [OR 14.6 with 95% CI {2.6, 108.9]. By 2-way ANOVA there was no interaction between ethnicity (Hispanic vs. Non-Hispanic) and corneal scarring or superficial keratitis on initial BCVA ($p = 0.62$, $p = 0.19$) or final BCVA ($p = 0.28$, $p = 0.08$).

There was also no significant difference in initial ($p = 0.24$) or final SER ($p = 0.42$) between Hispanic and Non-Hispanic patients (Table 3). However, initial and final cylinder (in diopters) was greater in Hispanic patients than non-Hispanic patients ($p < 0.01$). Further, there was a trend of a higher percentage of Hispanic patients with refractive amblyopia (28%) compared to Non-Hispanic patients (13%, $p = 0.19$). The spherical equivalent, astigmatism amount, or astigmatism axis in either Hispanic or non-Hispanic patients did not significantly change, although there was a trend towards a myopic shift in both sub-populations. There was no significant difference in the percentage of Hispanic and non-Hispanic patients with BKC and associated diagnoses (Table 4) including blepharitis, chalazion/hordeolum, corneal scar, corneal ulcer, and keratitis (marginal and superficial). The percentage of patients with various slit lamp findings including MGD, PEE/SPK, eyelid scurf, chalazion/hordeolum, corneal infiltrates, corneal neovascularization, or corneal stromal scarring was also similar between Hispanic and non-Hispanic patients (Table 4). Eyelid hygiene was recommended for all patients and there was similar rates of prescribing topical steroids and oral antibiotics between Hispanic and non-Hispanic patients (Table 4). More Hispanic patients had erythromycin ointment compared to non-Hispanic patients ($p = 0.01$).

Table 4 Ethnicity differences in diagnoses, slit lamp findings, and treatments

	Hispanic (n = 65)	Non-Hispanic (n = 30)	P-value (Fisher's exact test)
Blepharitis	65%	77%	0.34
BKC	65%	77%	0.27
Chalazion	47%	27%	0.12
Corneal Scar	15%	13%	1.00
Corneal Ulcer	6%	3%	0.66
Marginal Keratitis	29%	17%	0.22
Superficial Keratitis	2%	10%	0.09
MGD	83%	85%	0.83
PEE/SPK	44%	30%	0.08
Eyelid Scurf	55%	43%	0.21
Chalazion/Hordeolum	17%	15%	0.83
Corneal Infiltrates	42%	39%	0.75
Corneal Neovascularization	49%	50%	1.00
Corneal Stromal Scarring	25%	18%	0.36
Eyelid Hygiene	100%	100%	1.00
Erythromycin ointment	72%	53%	0.01
Topical Steroids	86%	83%	0.66
Oral Antibiotics	38%	30%	0.33

Comparing Hispanic and non-Hispanic patients (Table 3), the gender distribution was different with a higher percentage of females in the Hispanic population ($p < 0.01$). There was no difference in age at presentation ($p = 0.53$), number of visits ($p = 0.36$), and length of follow-up ($p = 0.60$). Hispanic patients had worse initial and final ($p < 0.01$) LogMAR BCVA compared to non-Hispanic patients. At the final follow-up, Hispanic patients showed significant improvement in LogMAR BCVA ($p < 0.01$) compared to presentation while non-Hispanic patients showed no significant difference ($p = 0.06$). Univariate logistic analysis (Table 2) showed that Hispanic ethnicity, but not need for interpreter, was associated with worse initial BCVA (OR 8.9 with 95% CI[2.2, 47.4] and final BCVA [OR 14.6 with 95% CI {2.6, 108.9]. By 2-way ANOVA there was no interaction between ethnicity (Hispanic vs. Non-Hispanic) and corneal scarring or superficial keratitis on initial BCVA ($p = 0.62$, $p = 0.19$) or final BCVA ($p = 0.28$, $p = 0.08$).

Based on other reports that females have worse disease than males, we found no significant gender difference in initial age, number of visits, time of follow-up, or initial or final BCVA (Table 5). Similarly, there was no linear association between gender and initial or final BCVA (Table 2). Final BCVA was improved in both genders compared to the initial BCVA ($p < 0.01$). Initial or final SER and cylinder also showed no gender differences. Males and females had similar rates of BKC diagnoses and prescribed treatments (Table 6). The only slit lamp finding that was more prevalent in females was corneal infiltrates ($p < 0.01$).

Table 5 Gender Differences in BCVA and Refraction

	Males ($n = 36$)	Females ($n = 59$)	*P*-value
Age at First Visit (years)	8.9 ± 4.2 Median 8.3 IQR [5.3, 12.8]	8.3 ± 3.5 Median 8.1 IQR [5.8, 10.3]	0.48
Number of Visits	4 ± 1.5 Median 4 IQR [3,4]	3.6 ± 1.1 Median 4 IQR [3, 4]	0.09
Time of Follow-up (Years)	1.9 ± 1.8 Median 1.4 IQR [1.0, 2.0]	1.7 ± 1.5 Median 1.2 IQR [0.6, 2.2]	0.18
Initial LogMAR BCVA	0.29 ± 0.35 Median 0.18 IQR [0.06, 0.44]	0.23 ± 0.26 Median 0.14 IQR [0.04, 0.32]	0.46
Final LogMAR BCVA	0.21 ± 0.28* Median 0.10 IQR [0.02, 0.30]	0.18 ± 0.22* Median 0.10 IQR [0.02, 0.29]	0.71
Change in LogMAR BCVA	-0.08 ± 0.23 Median − 0.06 IQR [-0.16, 0.03]	-0.06 ± 0.22 Median − 0.04 IQR [0.15, 0.05]	0.67
Maximum IOP (mmHg)	15.5 ± 4.0 Median 16.0 IQR [13.3, 17.0]	16.7 ± 3.4 Median 17.0 IQR [14.0, 19.0]	0.92
Initial Spherical Equivalent (Diopter)	-0.91 ± 3.58 Median − 0.50 IQR [-2.00, 0.75]	-0.31 ± 1.98 Median 0.13 IQR [-1.00, 1.00]	0.18
Final Spherical Equivalent (Diopter)	-1.20 ± 3.65 Median − 0.88 IQR [-3.00, 1.00]	-0.88 ± 2.73** Median − 0.25 IQR [-1.38, 0.50]	0.60
Initial Cylinder (Diopters)	1.51 ± 1.16 Median 1.50 IQR [0.56, 2.19]	1.50 ± 1.39 Median 1.00 IQR [0.50, 2.50]	0.51
Final Cylinder (Diopters)	1.72 ± 1.36 Median 1.50 IQR [0.50, 2.75]	1.57 ± 1.38 Median 1.00 IQR [0.50, 2.50]	0.50

*Final vs. Initial LogMAR VA, $p < 0.01$

Discussion

BKC is a spectrum of chronic and recurrent eye diseases that can cause pain, discomfort, redness, light sensitivity, and visual impairment. However, the term BKC has typically encompassed several diagnoses with varied and overlapping pathogenic origins such as atopy, bacterial toxins, and *Demodex* infestation. Only recently was a consensus published stating that the criteria for pediatric BKC includes 1 or more symptoms of recurrent chalazia/stye/hordeolum, irritation/burning, tearing, discomfort, photophobia, blurred vision, or redness and signs involving 3 anatomical regions: the eyelid margin, conjunctiva, and cornea [17].

Due to the previous lack of a unified definition, the incidence of BKC is likely to be higher than the prevalence of 0.59 per 10,000 found in a US-based insurance claims database [16]. Retrospective studies in both the United States (US) and India estimated a rate of 10–25%, thus making BKC one of the most common ocular diagnoses in the pediatric population [1, 18, 19]. Hammersmith et al. found that over half of 29 children with BKC

Table 6 Gender differences in diagnoses, Slit lamp findings, and treatments

	Males (*n* = 36)	Females (*n* = 59)	*P*-value (Fisher's exact test)
Blepharitis	81%	69%	0.13
BKC	74%	75%	1.00
Chalazion	36%	36%	1.00
Corneal Scar	14%	15%	0.84
Corneal Ulcer	6%	5%	1.00
Marginal Keratitis	19%	29%	0.17
Phylectenulosis	22%	20%	0.85
Rosacea Keratitis	3%	5%	0.71
Superficial Keratitis	8%	2%	0.06
MGD	88%	81%	0.32
PEE/SPK	40%	39%	0.88
Eyelid Scurf	65%	52%	0.07
Chalazion/Hordeolum	15%	17%	0.84
Corneal Infiltrates	20%	45%	**< 0.01**
Corneal Neovascularization	51%	48%	0.77
Corneal Stromal Scarring	22%	22%	1.00
Eyelid Hygiene	100%	100%	1.00
Erythromycin ointment	67%	66%	1.00
Topical Steroids	89%	86%	0.66
Oral Antibiotics	42%	39%	0.66

had corneal vascularization (52%) and over one-third had corneal scarring (38%) [6]. In a larger Korean cohort of 137 children, Moon et al. reported that conjunctival injection (82%) followed by corneal neovascularization (77%) were most common.20 Further, corneal scarring was present in 43% and 28% of their BKC patients, respectively. We found similar rates of corneal neovascularization (67%) and stromal scarring (39%) in our cohort of 95 patients.

There is limited data describing associations of either ocular diagnoses or slit lamp findings in children with BKC with initial and final visual outcomes. Rodriguez-Garcia et al. showed that patients with corneal involvement had worse VA at presentation compared to unaffected children [14]. Additionally, reports of both Korean and Singaporean children demonstrated that disease resolution improved VA compared to presentation [13, 20]. While we found that corneal stromal scarring was associated with worse VA at presentation (OR 7.3 with 95% CI [2.1, 27.2], it was not significantly associated with final BCVA. Corneal scarring does not typically resolve, but treatment with steroids can decrease density leading to improved vision. Further, some of these children at presentation may not have had not been in their optimal refractive correction due to astigmatism from the scarring. At final follow-up, their BCVA may have improved due to updated refractions. Interestingly, the presence of SPK at presentation was the only finding that was associated with worse VA at final follow-up (OR 15.8 with 95% CI [2.1, 123.9]. As SPK is an indicator of dry eyes as well as ongoing keratitis, this may be due to ongoing surface irritation and inflammation that despite treatment of anterior and posterior blepharitis can be exacerbated by environmental and lifestyle factors (e.g. increased screen time, contact lens wear, low humidity). These results suggest that treatment of BKC is important for decreasing the risk of worse visual outcomes.

The rates of BKC in children vary based on race and ethnicity as well as geographic location [1, 13, 18, 19]. Some of the largest retrospective studies have originated from India, (*n* = 615), South Korea, (*n* = 137), and Mexico (*n* = 114) [14, 18, 20]. This is consistent with the population level insurance claims database study by Fung et al. which showed that pediatric ocular surface inflammatory diseases in the US were associated with Asian descent (OR 3.12) and Black descent (OR 1.26) [16]. Nevertheless, the health claims and dataset utilized in that study grouped BKC with other inflammatory diseases such as vernal keratoconjunctivitis and herpes simplex keratoconjunctivitis, which could have skewed the racial outcomes. Further, Fung et al. does not include ethnic (Hispanic vs. Non-Hispanic) information, and the overall reported rate (0.59 of 10,000) is likely to under predict the prevalence due to the multiple diagnoses used to bill and code BKC [16].

Our study reported a disproportionate number of Hispanic children who presented with BKC. 68% of children in our cohort were Hispanic. This is higher than the ethnic distribution of all patients who presented to our clinic during that time frame (44,689 patients), which reflects the census data for the greater Chicago area (31% Hispanic and 69% non-Hispanic). A study by Evans et al. found that Hispanic, American Indian and Asian children had a 2x greater rate of chalazia compared to non-Hispanic and White children [21]. In addition, prior studies in adults have shown a higher incidence of blepharitis in Hispanic populations as well as more severe presentation [22, 23]. Another study based in Chicago, Kaufman et al. also found a disproportionately higher percentage of Hispanic children (77%) with phlyctenular keratoconjunctivitis, which overlaps in presentation with BKC, but is pathophysiologically distinct [8, 24]. Unlike our study which showed a significant association between Hispanic ethnicity and worse visual outcomes, the visual outcomes were similar between Hispanic and non-Hispanic children with phlyctenular keratoconjunctivitis. This may be due to differences between BKC and phlctenular keratoconjunctivitis and their responsiveness to treatment regimens.

It is important to note that our inclusion criteria, which was blepharitis in conjunction with corneal neovascularization, may have skewed our cohort to include a higher percentage of Hispanic children since this is a

more severe presentation of BKC. Nevertheless, these are the children who are at highest risk for poorer visual outcomes. The basis for an increased prevalence of BKC in Hispanic children is unknown, largely due to our overall lack of understanding of the disease pathogenesis. The inflammatory inciting factors may be environmental (e.g. bacterial exotoxins) but also are likely influenced by genetic factors. In addition, socioeconomic factors, such as access to healthcare, transportation, and affordability of treatments may play a role in a higher percentage of Hispanic children presenting with worse disease. Additional studies are required to assess the genetic backgrounds and environmental factors in patients affected with BKC, especially those of Hispanic ethnicity.

In our cohort, we also found that Hispanic children had worse initial and final BCVA compared to non-Hispanic children, although Hispanic patients did show an improvement in BCVA with BKC treatment. Nevertheless, there were 8.9- and 14.6- fold increased risks of worse initial BCVA and final BCVA associated with Hispanic ethnicity, despite no difference in age, number of eye visits, or length of follow-up. The ethnicity difference in BCVA may be due to BKC as well as refractive amblyopia. Prior studies have shown that Hispanic patients present with worse disease, and this could be due to longer duration of disease prior to treatment [22, 23]. Nevertheless, in our study there was no significant difference in percentage of Hispanic vs. Non-Hispanic patients with various slit lamp findings or ocular diagnoses. It is important to note that due to our study's retrospective nature and the multiple examining ophthalmologists, we were not able to reproducibly grade the disease severity as in some previous studies and this may account for this discrepancy. In our cohort, there was a trend, albeit not statistically significant, toward a higher percentage of Hispanic patients with refractive amblyopia, with the majority due to astigmatism. Consistent with this and similar to other studies, the Hispanic patients in our cohort showed greater astigmatism compared to Non-Hispanic patients [25–28]. Interestingly, Mendoza-Zamora et al. reported higher rates of astigmatism and higher order aberrations secondary to corneal changes such as scarring and vascularization. These may also negatively influence visual acuity and exacerbate amblyopia [15]. Thus, there are multiple factors which likely contributed to the difference in VA between Hispanic and Non-Hispanic patients.

The recommended treatments for BKC is long term eyelid hygiene (e.g. warm compresses, meibomian gland, eyelid scrubs) in combination with antibiotic and steroids as needed [8, 12]. Despite this consensus, there is a lack of randomized controlled trials in pediatric BKC.3 Most of the pediatric studies showed improvement in the majority of patients with various treatments, but a high recurrence rate ranging from 40 to 60% [19, 20]. Eyelid hygiene was recommended for all patients in our study, but compliance is difficult to ascertain. However, the majority of patients also received erythromycin ointment and/or topical steroids, with a smaller percentage placed on oral antibiotics. Importantly, there was no difference between Hispanic and non-Hispanic children in the percentage recommended/prescribed erythromycin ointment, topical steroids, or oral antibiotics, yet the Hispanic children had worse visual outcomes. This may be due to worse initial BCVA in the Hispanic children or better compliance to treatments in the non-Hispanic children.

Though this is one of the largest US-based studies focused on BKC epidemiology with clinical data, it is limited by the relatively small cohort ($n = 95$) and no control group. In addition, due to its retrospective nature, there are various lengths of follow-up and differences in charting between multiple ophthalmologists within the practice. The exam findings reported in this study are limited to a binary nature, when elements such as corneal scarring occur on a spectrum regarding the effect on vision and eye health. Other studies have graded the severity of the BKC (mild, moderate, and severe); however these grading systems were arbitrary and not dictated by the consensus statement. In addition, as this was a chart review, grading the severity was challenging and thus not included. Several studied factors, including diagnoses of chalazion, PEE/SPK, presence of stromal scarring, and use of traditionally more aggressive treatments were deemed not significant, though greater disparities could be seen with a higher-powered investigation given the significant impact seen on BCVA seen in the Hispanic population compared to the non-Hispanic population. Further, our study did not include the socioeconomoic status, insurance type, or other markers for social determinants of health which could certainly affect access to care and compliance with treatments and ultimately outcomes.

This study presents important information on the epidemiologic disparity seen in children with corneal involving BKC in regard to the Hispanic population. Providers should be cognizant of utilizing aggressive treatments such as oral antibiotics, topical steroids, and cyclosporine in children with severe BKC. Secondly, with this knowledge of more prevalent and worse vision in the Hispanic population, future investigation into possible genetic, environmental, and socioeconomic factors may further elucidate the disease process and lead to better treatment options for BKC.

Abbreviations

BCVA	Best-corrected visual acuity
BKC	Blepharokeratoconjunctivitis
CI	Confidence interval

IOP Intraocular pressure
IQR Interquartile range
MGD Meibomian gland dysfunction
OR Odds ratio
PEE Punctate epithelial erosions
SPK Superficial punctate keratopathy

Supplementary Information

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Supplementary Material 1

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None.

Author contributions
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Data availability
The datasets used and/or analyzed during the current study are available form the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved due to its retrospective nature, approval and informed consent have been waived by the Institutional Review Board of the Ann & Robert H. Lurie Children's Hospital of Chicago. The study adhered to the tenets of the Declaration of Helsinki. Data collection was de-identified and HIPAA-compliant.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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