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Sociodemographic Factors Associated with Delayed Presentation in Craniosynostosis Surgery at a Tertiary Children's Hospital

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Background: Craniosynostosis is a common diagnosis requiring early referral to a pediatric plastic surgeon; however, disparities in healthcare may influence presentation timing and affect treatment options and outcomes. This study aimed to explore sociodemographic factors contributing to delay in craniosynostosis surgical consultation.

Methods: A retrospective cohort study of 694 California-based craniosynostosis patients at a tertiary children's hospital was performed from 2006 to 2023. State-specific Area Deprivation Index (ADI) and distance to the hospital were calculated using ZIP codes. Multivariate linear and logistic regressions considered race, insurance type, syndromic status, suture type, and ZIP code-based socioeconomic factors.

Results: Median age of presentation was 4.5 [interquartile range: 2.6–7.6] months with racial/ethnic breakdown of Hispanic/Latinx (41.2%), White (23.6%), Asian (3.7%), Black/African American (2.0%), or other/unreported (29.5%) with 58.4% having public insurance and an average distance to the hospital of 48.3 km. Median ADI was 5.4 [interquartile range: 4.0–7.1]. By linear regression, public insurance ($P < 0.001$) and higher ADI decile ($P < 0.001$) independently contributed to an older age of presentation. Patients with public insurance (odds ratio 1.90; $P = 0.002$) were more likely to present after 4 months of age.

Conclusions: Patients who had public insurance or resided in more disadvantaged areas presented later for craniosynostosis surgical consultation. Eliminating disparities in these populations ensures more equitable access to surgical options and can improve patient outcomes. *(Plast Reconstr Surg Glob Open 2024; 12:e6035; doi: 10.1097/GOX.0000000000006035; Published online 30 August 2024.)*

INTRODUCTION

Craniosynostosis, characterized by premature fusion of one or more cranial sutures, poses a significant threat to the optimal growth of the brain and development of a normocephalic head shape.[1–4] Recent literature cites optimal timing for surgical repair of craniosynostosis between 4 and 8 months of age.[5] Delayed surgical intervention may lead to elevated intracranial pressure (ICP), impacting long-term neuropsychological development and outcomes.[6–9] Given the importance of timely surgical intervention, prompt diagnosis and evaluation by a surgical provider is crucial. As a result, disparities in access to care have become an important area of study to ensure equitable care delivery to all children with craniosynostosis.

Prior studies in the craniofacial literature have mirrored many other disciplines, where inequities in healthcare access and treatment outcomes disproportionately affect individuals from marginalized backgrounds. Racial and insurance-based disparities in the care of craniosynostosis

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patients are evident at multiple levels, from delayed diagnosis to variations in treatment approaches. These disparities are posited to result from a complex interplay of socioeconomic factors, implicit biases, and systemic barriers hindering equitable healthcare delivery.[10–13] Despite increased efforts to address disparities,[14] institutional inequities continue to perpetuate these inequalities, contributing to patients experiencing diminished health outcomes.

Although existing studies have brought awareness to healthcare disparities,[10,12,13,15–18] there remains a paucity of literature addressing demographic factors leading to delayed craniosynostosis care and subsequent surgical outcomes. Specifically, a comprehensive examination of disparities based on geography and wealth is necessary. Evidence suggests that neighborhood-level metrics can help characterize healthcare accessibility and correlate to individual socioeconomic status and child health.[18–20] For example, the Area Deprivation Index (ADI) is a composite measure designed to assess the level of socioeconomic disadvantage within specific geographic areas, often defined by postal codes or ZIP codes.[19,21] Derived from multiple indicators, including income, education, employment, and housing quality, the ADI creates a single numeric score that reflects the overall socioeconomic conditions of a given area. The ADI is divided into deciles at the state level and percentiles at the national level, with a higher decile or percentile representing a higher level of economic disadvantage. Studies that acknowledge neighborhood-level factors, such as ADI, are scarce and frequently confined to smaller patient populations.[18] This study aimed to use the ADI to explore sociodemographic factors that contribute to the timing of presentation for craniosynostosis surgery at a single tertiary care children's hospital.

Takeaways

Question: What sociodemographic factors contribute to the timing of presentation for craniosynostosis surgery?

Findings: A retrospective cohort study of 694 California-based craniosynostosis patients at a tertiary children's hospital was performed from 2006 to 2023. State-specific Area Deprivation Index and distance to the hospital were calculated using ZIP codes. Results showed that patients who had public insurance or resided in more disadvantaged areas presented later for craniosynostosis surgical consultation.

Meaning: Eliminating disparities in these populations is essential to ensure more equitable access to surgical options and improve patient outcomes.

METHODS

This study received institutional review board approval from Children's Hospital Los Angeles (CHLA). A retrospective review was performed of California-based patients with craniosynostosis presenting to CHLA for initial surgical evaluation between 2006 and 2023. All craniosynostosis diagnoses were included. Exclusion criteria included patients who (1) resided outside of California, (2) previously underwent surgical correction at an outside hospital, (3) did not undergo any surgical intervention, or (4) had unavailable/incomplete documentation.

Variables collected included patient demographics, socioeconomic factors, syndromic diagnosis, suture type (sagittal, unicoronal, metopic, lambdoid, multisuture), periprocedural data, postoperative outcomes, and follow-up time. Sociodemographic factors were defined as race/ethnicity (White, Black/African American, Hispanic/Latinx, Asian, other/unreported), primary language (English, non-English language), insurance type (public, private, self-pay), and household five-digit ZIP code.

Neighborhood Characteristics

Each patient's ZIP code was applied to the neighborhood atlas[19] to calculate their ADI California state decile, where 1 represented the least socioeconomically disadvantaged and 10, the most disadvantaged. Median household income (MHI) was gathered from publicly available ZIP code-stratified US Census Bureau reports.[22] The MHI data were adjusted for inflation based on year to permit accurate comparison across time. Patient distance to the hospital was calculated using the haversine formula based on centroids of the patients' and hospital's ZIP code.[23–25] This measure provided information on the geographic accessibility of the hospital for each patient and served as a proxy for travel-related barriers to timely consultation.

Outcomes

Our primary outcome was the age of presentation, defined as patient age at initial surgical consultation with either the Division of Plastic and Maxillofacial Surgery or the Division of Pediatric Neurosurgery at CHLA. At this institution, patients are currently eligible for endoscopic surgery before 4 months of age. Thus, to account for accessibility to all surgical approaches, delayed presentation was defined as an initial consultation after four months of age. Periprocedural outcomes of interest included operative time, length of stay, weight-adjusted estimated blood loss, and transfused packed red blood cells. Postoperative outcomes included complications (seroma formation, wound dehiscence, and postoperative infections), emergency department (ED) visits, and readmissions within 30 days of discharge.

Statistical Analysis

Patients presenting in delayed fashion were compared with patients presenting on time using chi-squared analysis for categorical variables and Wilcoxon signed-rank and Kruskal-Wallis tests for continuous variables between two groups (insurance) and multiple groups (race), respectively. A post hoc Dunn test was used following Kruskal-Wallis analysis to compare the age of presentation, age of surgery, and ADI deciles between racial groups. Pearson correlation coefficient was used to analyze trends in age of presentation and sociodemographic factors. For better visualization of ZIP code-based trends, heat maps were created using Tableau software (Tableau Software Version 2022.2, Seattle, Wash.).

Scatter plots and descriptive statistics were used to identify outliers in continuous variables. The normality of data was determined using histograms and the Shapiro-Wilk test. Multivariate regression models were created to adjust for sex, race, syndromic status, suture type, insurance type, primary language, distance from the hospital, and state-specific ADI decile. Multivariate linear and logistic regressions were conducted to identify factors associated with older age of presentation, older age at surgery, and delayed presentation after 4 months of age, respectively. Statistical significance was established at a P value less than 0.05. All statistical analyses were performed using Stata version 17.0 (Stata Corp, College Station, Tex.).

RESULTS

Patient Population

Of the 824 patients who presented for surgical consultation, 694 met the inclusion criteria. Suture types included 297 (42.9%) sagittal, 127 (18.4%) unicoronal, 133 (19.2%) metopic, 25 (3.6%) lambdoid, and 110 (15.9%) multisuture (Fig. 1). The median age at initial surgical consultation was 4.5 months [interquartile range (IQR): 2.6–7.6 months]. There were 388 (55.9%) patients who presented to the clinic after 4 months of age. The median age at surgery was 8.0 months (IQR: 5.6–10.4 months). Most patients (97.3%) underwent open calvarial vault remodeling, whereas 19 (2.7%) underwent endoscopic repair. English was identified as the primary language for 403 (59.3%) families. Based on the ZIP code of residence, the MHI ranged from $30,556 to $212,115. The median state-specific decile of ADI score was 5.4 (IQR: 4.0–7.1).

Race and Ethnicity

Patients' racial/ethnic backgrounds included 287 (41.2%) identified as Hispanic/Latinx, 163 (23.6%) as White, 26 (3.7%) as Asian, 14 (2.0%) as Black/African American, and 204 (29.5%) as other/unreported. Across racial groups, significant differences were seen in age at presentation and surgical intervention (Table 1 and Figure 2). White patients presented earlier for initial evaluation (3.8 months, IQR: 2.2–7.1) than both Black/African American patients (5.8 months, IQR: 2.8–10.7; $P = 0.037$) and Hispanic/Latinx patients (4.7 months, IQR: 2.6–7.8; $P = 0.002$). Hispanic/Latinx patients resided in more disadvantaged neighborhoods (ADI 6.4, IQR: 5.2–7.4) compared with White patients (ADI 4.3, IQR: 2.6–5.7; $P < 0.001$) and Asian patients (ADI 4.1, IQR: 2.1–5.0; $P < 0.001$). Similarly, Black/African American patients came from more disadvantaged areas with higher median ADI scores than Asian patients (5.4 [IQR: 3.2–7.2] versus 4.1 [IQR: 2.1–5.0]; $P = 0.016$). Black/African American patients trended toward having lower ADI scores than White patients, but findings were not statistically significant (Fig. 3). A comprehensive racial breakdown of additional sociodemographic and neighborhood factors is displayed in Table 1.

Insurance Type

In the study cohort, 405 (58.4%) patients had public and 289 (41.6%) had private insurance. Public insurance was more commonly utilized than private insurance by Black/African American (3.0% versus 0.7%; $P = 0.036$) and Hispanic/Latinx patients (58.0% versus 18.1%; $P < 0.001$). In contrast, public insurance was less commonly utilized by White (11.4% versus 40.3%; $P < 0.001$), Asian (1.5% versus 6.9%; $P < 0.001$), and other/unreported race patients (26.2% versus 34.0%; $P = 0.025$). Compared with private insurance, patients with public insurance had a significantly lower MHI ($66,494 [IQR: $53,659–78,356] versus $97,368 [IQR: $79,630–$113,017]; $P < 0.001$), lived in a more disadvantaged area (ADI: 6.4 [IQR:5.1–7.3] versus 4.3 [IQR: 2.8–5.7]; $P < 0.001$) and had less travel distance to the hospital (23.6 kilometers [IQR: 16.0–46.6] versus 33.9 km [IQR: 17.9–68.0]; $P < 0.001$). Notably, patients

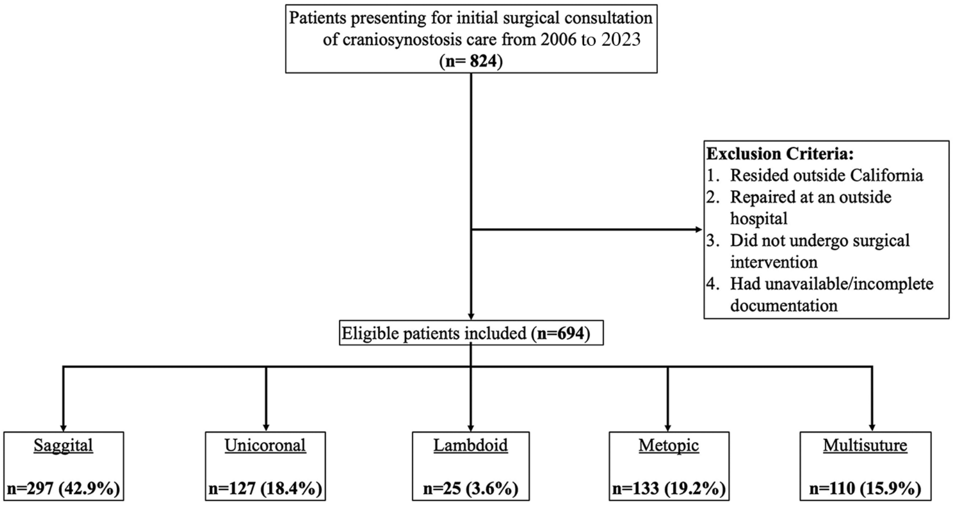

Fig. 1. Flowchart of study population.

Table 1. Population Demographics by Race

	Total n = 694	White n = 163	Asian n = 26	Black/African American n = 14	Hispanic n = 287	Other/Unreported n = 204	*P*
Age at presentation (mo), median [IQR]	4.5 [2.6–7.6]	3.8 [2.2–6.1]	4.6 [2.8–10.3]	5.8 [2.8–10.7]	4.7 [2.6–7.8]	4.8 [2.8–8.0]	**0.012***
Age at surgery (mo), median [IQR]	8.0 [5.6–10.4]	7.1 [4.4–8.8]	7.8 [5.4–11.5]	10.5 [5.8–12.0]	8.9 [6.7–11.1]	7.9 [5.7–10.2]	**<0.001***
Sex							
Male	454 (65.4%)	113 (69.3%)	17 (65.4%)	11 (78.6%)	175 (61.0%)	138 (67.6%)	0.275
Female	240 (34.6%)	50 (30.7%)	9 (34.6%)	3 (21.4%)	112 (39.0%)	66 (32.4%)	0.275
Suture type							
Sagittal	297 (42.9%)	89 (54.9%)	8 (30.8%)	6 (42.9%)	98 (34.1%)	96 (47.3%)	**<0.001***
Metopic	133 (19.2%)	33 (20.4%)	4 (15.4%)	1 (7.1%)	56 (19.5%)	39 (19.2%)	0.792
Unicoronal	127 (18.4%)	18 (11.1%)	7 (26.9%)	2 (14.3%)	64 (22.3%)	36 (17.7%)	**0.035***
Multisuture	110 (15.9%)	18 (11.1%)	4 (15.4%)	4 (28.6%)	58 (20.2%)	26 (12.8%)	**0.039***
Lambdoid	25 (3.6%)	4 (2.5%)	3 (11.5%)	1 (7.1%)	11 (3.8%)	6 (3.0%)	0.189
Craniofacial syndrome	60 (8.6%)	14 (8.6%)	2 (7.7%)	1 (7.1%)	34 (11.8%)	9 (4.4%)	0.077
Socioeconomic Factors							
Public insurance	405 (58.4%)	46 (28.4%)	6 (23.1%)	12 (85.7%)	235 (81.9%)	106 (52.0%)	**<0.001***
Distance from the hospital (km), median [IQR]	27.8 [16.7–55.5]	36.2 [16.0–70.1]	23.0 [18.4–31.1]	27.8 [16.1–60.9]	23.8 [15.7–48.3]	29.9 [17.8–55.2]	0.065
Median household income, median [IQR]	$76,341 [$60,546–$98,181]	$98,125 [$74,949–$116,443]	$102,060 [$71,735–$116,443]	$77,532 [$60,493–$101,623]	$67,756 [$54,572–$78,630]	$80,062 [$64,820–$100,523]	**<0.001***
ADI state decile, median [IQR]	5.4 [4.0–7.1]	4.3 [2.6–5.7]	4.1 [2.1–5.0]	5.4 [3.2–7.2]	6.4 [5.2–7.4]	5.1 [3.9–6.8]	**<0.001***

*Indicates statistical significance at *P* value less than 0.05.

with public insurance presented at an older age than those with private insurance (5.1 months [IQR: 2.9–8.1] versus 3.7 months [IQR: 2.3–6.1]; $P < 0.001$).

Predictors of Delayed Presentation

ADI state decile positively (more disadvantaged) correlated with age of presentation (r 0.152 [95% confidence interval (CI): 0.078–0.224]; $P < 0.001$, Fig. 4). No correlation was seen between distance from the hospital and age of presentation (r 0.024 [95% CI: −0.051 to 0.098]; $P = 0.536$). By linear regression, public insurance (β 1.687 [95% CI: 1.379–1.995]; $P < 0.001$), and higher ADI decile (β 0.207 [95% CI: 0.136–0.279]; $P < 0.001$) independently contributed to an older age of presentation (Table 2). When using 4 months as a cutoff for age of presentation for initial evaluation, public insurance (odds ratio 1.903 [95% CI: 1.270–2.852]; $P = 0.002$) was associated with late presentation (Table 3). By linear regression, Black/African American race (β 2.628 [95% CI: 1.481-3.774]; $P < 0.001$), Hispanic/Latinx race (β 0.542 [95% CI: −0.185 to 0.899]; $P = 0.003$), and higher ADI decile (β 0.089 [95% CI: 0.019–0.159]; $P = 0.012$) were associated with an older age at surgical intervention. (**See table, Supplemental Digital Content 1,** shows a multivariate linear regression of patient factors associated with older age at surgical intervention for craniosynostosis. **http://links.lww.com/PRSGO/D449**.)

Perioperative Outcomes

Amongst all patients, the mean operative time was 222.3 ± 77.7 min. The mean weight-adjusted estimated blood loss was 29.5 ± 17.6 mL per kg. Of those requiring transfusion, the mean weight-adjusted volume was 36.7 ± 18.5 mL per kg. The median length of stay was 4 days (IQR: 3–4). Postoperative complications included 22 (3.2%) superficial wound infections, six (0.9%) seromas, and three (0.4%) wound dehiscences. Overall, 37 (5.3%) patients presented to the ED within 30 days of discharge with the highest rates seen in Black/African American patients (14.3%) followed by Asian (7.7%) and Hispanic/Latinx patients (5.9%). The most common indications for returning to the ED included fever (n = 9), vomiting (n = 7), and surgical site swelling (n = 6). Thirty-day readmission rate was 1.2%, where Hispanic/Latinx patients had the highest rate of readmission (n = 5/287, 1.7%). Across racial cohorts, there were no significant differences in 30-day ED visits ($P = 0.130$) or 30-day readmission rates ($P = 0.093$).

DISCUSSION

Timely surgical intervention in craniosynostosis is crucial to mitigate the consequences of premature suture fusion and avert potential complications, such as elevated ICP and developmental delays. This study identified sociodemographic disparities at the neighborhood and individual level that contribute to disparities in timely surgical consultation for craniosynostosis care. Results demonstrated that patients with public insurance and those residing in areas of greater economic disadvantage

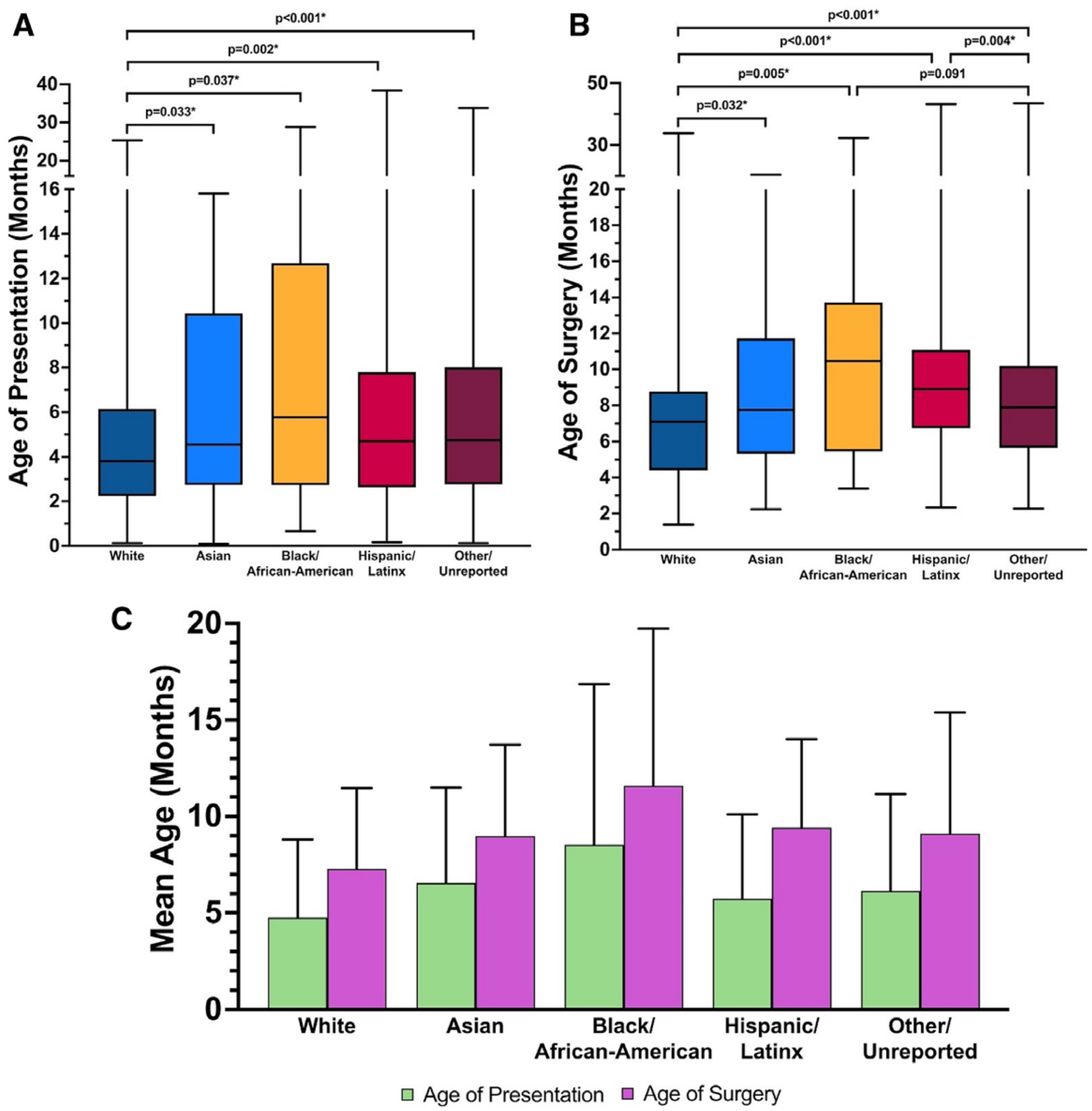

Fig. 2. Median age at presentation and surgery by race. Box plots showing the median age at presentation (A) and age at surgery (B) by race. Bar graph showing mean age by race (C).

presented later to the craniosynostosis clinic and had delayed surgical intervention.

We found a correlation between worse ADI and later initial age at surgical consultation, which is consistent with several studies in the craniosynostosis literature suggesting economically disadvantaged patients struggle to access care. Akbari et al reported that Black and socioeconomically disadvantaged patients with higher ADI deciles experienced a higher rate of delay in referrals. These patients were also disproportionately impacted by a state health insurance policy that prohibited coverage of helmet therapy following endoscopic repair of sagittal synostosis.[18] Furthermore, Varagur et al reported that patients with craniosynostosis and higher ADI deciles had worse speech/language outcomes.[26] Notably in our cohort, ADI did not correlate with distance to the hospital suggesting that the financial resources of a population more significantly impact access to care than geographic location. In other words, with financial resources, you can travel from further away without issue. In the absence of resources, even a shorter travel distance may be difficult to achieve. These findings suggest ADI is a valuable tool in assessing which populations are truly disadvantaged in receiving craniosynostosis care. Understanding how ADI affects access to services is the first step toward implementing interventions that adequately support patients in under-resourced areas.

In the United States, simply having medical insurance does not guarantee access to comprehensive care. In particular, Medicaid consumers have been reported to encounter more challenges in accessing care than private insurance holders.[12,27–29] These reported challenges are consistent with our study, which found that patients with public insurance resided in more disadvantaged areas and had a higher

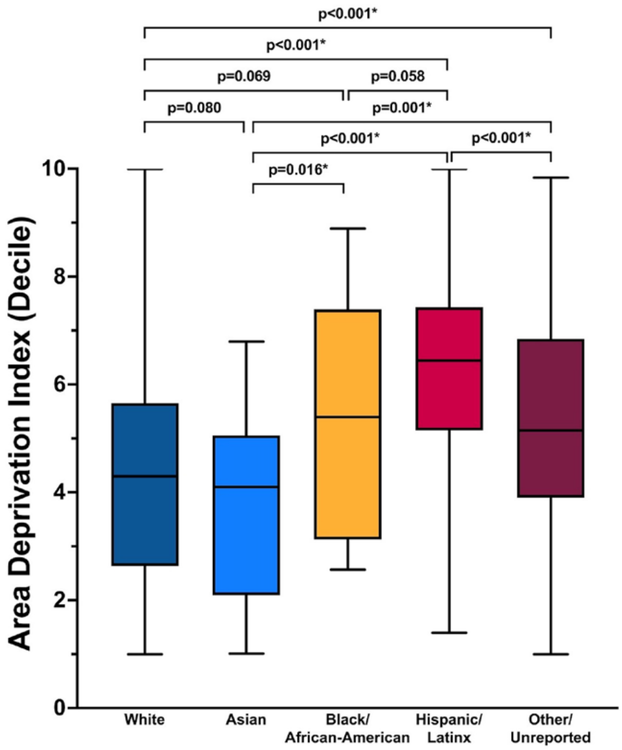

Fig. 3. Box plots showing the median ADI by race.

likelihood of delayed consultation. Existing literature suggests that delays in presentation are linked to difficulties in scheduling healthcare appointments under Medicaid, particularly for specialized care providers. In the case of craniosynostosis, initial evaluation of patients by community-based providers may also delay diagnosis and referral due to lack of extensive knowledge about the condition. Given the challenges with access, improving disparities in craniosynostosis care requires the implementation of strategies that target patients from disadvantaged neighborhoods or with public insurance. Interventions should address barriers to care faced by public insurance holders, which may include late clinic hours and increased appointment availability.[12,30,31] Implementing telehealth coverage in pediatric clinics has also proven effective in improving access to quality care.[32]

In addition to insurance-related barriers, living further away from the hospital has been reported to contribute to an older age of presentation for craniosynostosis.[33] Paradoxically in our study, financially vulnerable populations presented to our institution at a later age despite their close proximity, suggesting that financial means have a more significant influence on healthcare access than geography. Similarly, affluence and financial resources seen in patients with private insurance may give patients the ability to travel longer distances for healthcare. In other words, proximity to a craniofacial center may not fully reduce the negative impact of low socioeconomic status. The results necessitate the need for increased understanding of geographic barriers to care and outreach to vulnerable populations.

When controlling for insurance status, Black/African American and Hispanic/Latinx patients underwent surgery at a later age. These populations resided in more disadvantaged areas based on higher ADI scores. An explanation for the difference in presentation amongst racial groups may be due to cultural differences, including

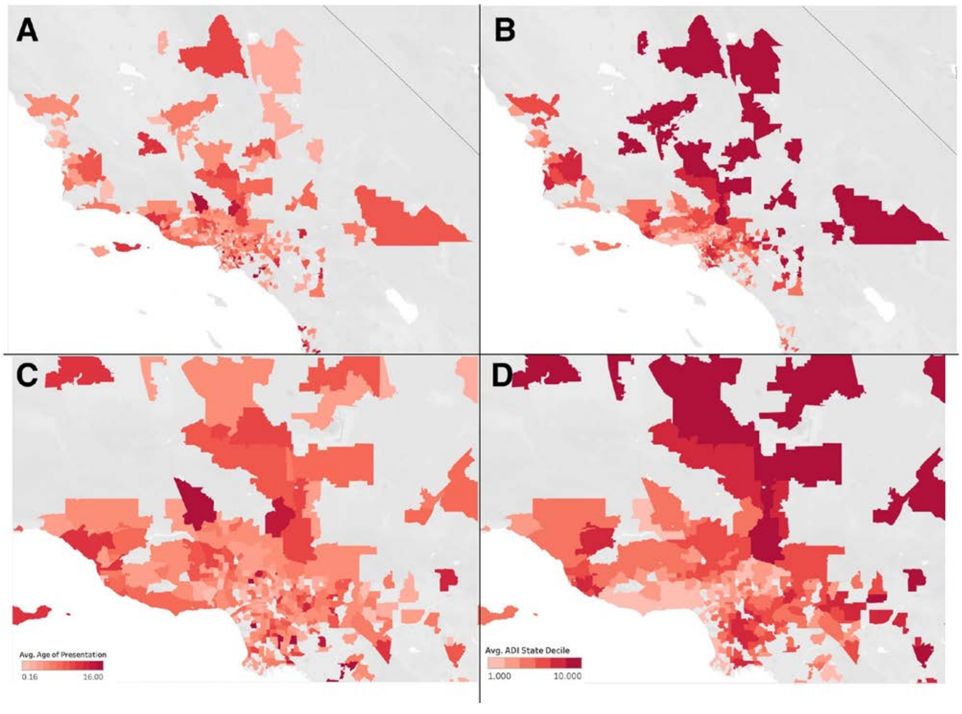

Fig. 4. Distribution of age of presentation and ADI by ZIP code. Heat map showing (A) age of presentation based on ZIP code, (B) ADI based on ZIP code, (C) age of presentation based on ZIP code, zoomed in, and (D) ADI based on ZIP code, zoomed in.

Table 2. Multivariate Linear Regression of Patient Factors Associated with Older Age of Initial Surgical Consultation for Craniosynostosis

	β Coefficient	95% CI	*P*
Male sex	−0.352	[−0.665 to −0.040]	**0.027***
Race			
White		Reference	
Asian	1.642	[−0.269 to 3.552]	0.092
Black/African American	0.134	[−2.036 to 2.304]	0.903
Hispanic/Latinx	−0.331	[−1.365 to 0.703]	0.530
Other/unreported	0.714	[−0.357 to 1.070]	**<0.001***
Diagnosed syndrome	0.375	[−0.364 to 1.014]	0.249
Suture type			
Sagittal		Reference	
Unicoronal	2.539	[2.121–2.957]	**<0.001***
Metopic	1.808	[1.443–2.174]	**<0.001***
Lambdoid	1.880	[1.194–2.567]	**<0.001***
Multisuture	−0.372	[−0.870 to 0.126]	0.142
Public insurance	1.687	[1.379–1.995]	**<0.001***
English speaking	0.059	[−0.244 to 0.363]	0.702
Distance from the hospital (km)	0.040	[−0.007 to 0.087]	0.093
State-specific ADI decile	0.207	[0.136–0.279]	**<0.001***

Multivariate linear regression analyses were performed adjusting for sex, race, syndromic status, suture type, insurance type, primary language, distance from the hospital, and state-specific ADI decile. Variables with omitted values were either not included in the table or represented by a dash (R^2: 0.688; $P < 0.001$).
The square root of distance from the hospital was used to transform the variable and improve the model.
*Indicates statistical significance at a *P* value less than 0.05.

Table 3. Multivariate Logistic Regression of Patient Factors Associated with Presenting for Initial Surgical Consultation for Craniosynostosis after 4 Months of Age

	Odds Ratio	95% CI	*P*
Male sex	0.569	[0.388–0.834]	**0.004***
Race			
White		Reference	
Asian	2.098	[0.804–5.472]	0.130
Black/African American	1.317	[0.368–4.711]	0.672
Hispanic/Latinx	1.068	[0.647–1.764]	0.796
Other/unreported	1.244	[0.778–1.990]	0.362
Diagnosed syndrome	0.975	[0.468–2.032]	0.946
Suture type			
Sagittal		Reference	
Unicoronal	3.101	[1.820–5.282]	**<0.001***
Metopic	2.008	[1.287–3.134]	**0.002***
Lambdoid	2.333	[0.911–5.974]	0.077
Multisuture	0.497	[0.271–0.914]	**0.024***
Public insurance	2.364	[1.379–1.995]	**<0.001***
English speaking	1.460	[−0.990 to 2.154]	0.056
Distance from the hospital (km)	0.990	[−0.931 to 1.053]	0.750
State-specific ADI decile	1.084	[0.985–1.194]	0.100

Multivariate logistic regression analyses were performed adjusting for sex, race, syndromic status, suture type, insurance type, primary language, distance from the hospital, MHI, and state-specific ADI decile. Variables with omitted values were either not included in the table or represented by a dash. (Pseudo R^2: 0.102; $P <$ 0.001). The squareroot of distance from the hospital was used to transform the variable and improve the model.
*Indicates statistical significance at a *P* value less than 0.05.

sentiments of distrust in the medical system that result in delays in seeking care. Boulware et al examined differences in trust in physicians, hospitals, and health insurance plans among various racial groups. They found that Black/African American respondents were the least likely to trust their physicians.[34] Numerous instances of unequal treatment, medical harm, and worse medical care—stemming from discrimination and systemic racism within the healthcare system—contribute to the sentiment of distrust in the healthcare system experienced by marginalized groups. Such systematic inequalities have resulted in suboptimal health outcomes and lower care quality for these groups.[35] Historical unethical medical experiments have also exacerbated distrust among these groups, fostering feelings of deceit and exploitation.[36–39] Recent literature has highlighted that these racial disparities exist in pediatric healthcare utilization and treatment with a pronounced impact on the Black/African American population in the United States.[40–42] Pilot programs in cleft care have demonstrated that implementing a cleft navigator nurse to facilitate contact between families and the cleft team have eliminated racial disparities in timing of presentation.[43] Similar programs can be adapted to craniosynostosis clinics to achieve similar results.

Primary healthcare providers play a vital role in addressing the gaps in craniosynostosis care and can significantly reduce the time taken to initiate treatment. Early recognition of craniosynostosis by skilled providers expedites the patient's journey to specialized care, enhancing overall health outcomes. However, many healthcare professionals may not consistently screen for craniosynostosis during routine checkups, often due to insufficient understanding of the condition's urgency. Additionally, misdiagnosis of craniosynostosis as nonsurgical positional plagiocephaly may lead to excessive referrals for helmet therapy rather than surgical evaluation. Incorporating additional education on positional plagiocephaly versus craniosynostosis into pediatric training may help mitigate these delays. Another factor potentially contributing to disparities is the reluctance of many pediatricians to take on many Medicaid patients due to poor reimbursement rates.[13,44] Furthermore, healthcare providers in underserved communities often face overwhelming workloads with limited resources, increasing the likelihood of missed diagnoses.[45] Given that public insurance is associated with significant delays in presentation, impaired access to well-child visits may exacerbate and perpetuate inequalities, leading to further delays in the treatment of marginalized communities. Enhanced understanding and prompt detection of craniosynostosis may be achievable with focused training and informative programs for community-based providers to facilitate higher quality care among historically disenfranchised groups.

The use of artificial intelligence in primary care settings may also facilitate earlier detection.[46] Artificial intelligence algorithms may potentially analyze cranial imaging or clinical photographs for features indicative of craniosynostosis, allowing for earlier referral to specialists. Standardized screening protocols for cranial asymmetry in infants can assist healthcare providers in distinguishing between benign positional molding and craniosynostosis.[47,48]

Several limitations exist in this study. Race was often reported as "other" or not reported at all by patients, likely due to poor documentation or families' reluctance to identify with a single hospital-based ethnicity option, particularly given the large multiethnic population in southern California. Moreover, there was a disproportionately lower number of Black/African American patients compared with the racial prevalence in the regional population.[49] This discrepancy may be due to a lower incidence of craniosynostosis in Black/African American patients compared with other ethnic groups.[50] Alternatively, this lower incidence may result from late or absent presentation of Black/African American patients to clinic for diagnosis.[50] Further, as a single institutional study at a California tertiary children's hospital, geographic and institutional biases may exist, with Black/African American families more likely to seek care at other area hospitals. Given nuances in geographic and population variability, future studies should continue to investigate sociodemographic disparities in craniosynostosis care in different settings. Despite these limitations, this study presents a large retrospective cohort study investigating demographic disparities within craniosynostosis management.

CONCLUSIONS

This study contributes to the growing body of literature highlighting the significant influence of sociodemographic factors on the timing of craniosynostosis presentation. Patients with public insurance or residing in more disadvantaged areas are more likely to present later for initial surgical consultation. Identifying neighborhood-level factors, particularly the ADI, may better predict access to care than geographic region or financial status alone. These results address the broader societal and systemic obstacles that often result in delayed care. By addressing the broader societal and systemic obstacles, proactive initiatives can ensure timely and equitable care for all pediatric patients, regardless of their sociodemographic background.

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DISCLOSURE

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