

# Effects of Sociodemographic and Child Opportunity Index on Pediatric Plastic and Oral and Maxillofacial Surgical Volume Trends in the COVID-19 Pandemic

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**Background:** The coronavirus disease 2019 (COVID-19) pandemic caused disruptions to pediatric surgical care. Although surgical capacity has returned to the prepandemic state, barriers to surgical access may still exist for children who are medically underserved. We assessed pediatric plastic and oral and maxillofacial surgical volumes by sociodemographic characteristics before and during the COVID-19 pandemic.

**Methods:** A 72-month retrospective cohort analysis of 10,681 pediatric plastic and oral and maxillofacial procedures between 2016 and 2021 was conducted. Multivariable logistic regression and interrupted time series analyses were used to analyze surgical volume trends by sociodemographic groups and Child Opportunity Index (COI).

**Results:** Compared with prepandemic, patients undergoing procedures were more likely to be older than 18 years ( $P < 0.001$ ) and Hispanic/Latino (adjusted odds ratio 1.38; 95% confidence interval, 1.14–1.68;  $P < 0.01$ ). Surgical volume trends among patients from the lowest COI levels were lower than where they were estimated to have been if the pandemic did not occur ( $P = 0.040$ ). Patients who spoke a primary language other than English or Spanish ( $P = 0.02$ ) and patients with the lowest COI levels ( $P = 0.04$ ) continued to have unrecovered surgical volumes.

**Conclusions:** There were differences in the sociodemographic case-mix of patients undergoing plastic and oral and maxillofacial surgical procedures before and during the pandemic, and surgical volumes did not recover at the same rate for all patients. Further research can determine why certain sociodemographic groups and patients with low COI levels had decreased surgical access compared with prepandemic trends, and develop interventions focused on equitable pediatric surgical access. (*Plast Reconstr Surg Glob Open* 2024; 12:e5707; doi: [10.1097/GOX.0000000000005707](https://doi.org/10.1097/GOX.0000000000005707); Published online 5 April 2024.)

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## INTRODUCTION

In the early stages of the novel coronavirus disease 2019 (COVID-19) pandemic, the postponement of non-emergent surgical procedures was one of the strategies implemented by many hospitals and health systems to reduce COVID-19 exposure and transmission, and to lessen the burden on overwhelmed healthcare systems.<sup>1,2</sup> As a result, there were disruptions to pediatric plastic and oral and maxillofacial surgical care nationwide.<sup>3,4</sup> Several studies suggest that this downstream effect of COVID-19 may have maintained or exacerbated disparities related to equitable access and delivery of needed pediatric surgical care early in the pandemic.<sup>5–7</sup>

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Although many hospitals have since returned to full surgical volume capacity, the possible effects of the deferment of nonemergent surgical procedures on equitable access for underserved and/or underrepresented patient populations to pediatric plastic and oral and maxillofacial surgical care is not well understood. Delayed presentation and overall decreased access to care are known disparities<sup>8–11</sup> that may have been exacerbated by this disruption experienced early in the pandemic. It has yet to be analyzed whether certain sociodemographic groups may have been disproportionately affected by the pause in pediatric plastic and oral and maxillofacial surgery during COVID-19, and if so, whether surgical volumes recovered for those groups.

Our study aimed to examine the effects of sociodemographic factors and the Child Opportunity Index (COI) on pediatric plastic and oral and maxillofacial surgical volume trends across a prepandemic and pandemic time frame. We hypothesized that after the return to full surgical volume capacity the pediatric plastic and oral and maxillofacial surgical volumes would vary by sociodemographic and zip code-level factors as measured by the COI. The COI is a composite measure of multiple child-level indicators related to healthy childhood development. This study sought to understand and provide important insight into which populations of children experienced and/or continue to experience, persistent barriers to equitable pediatric and oral and maxillofacial surgical access following the onset of COVID-19.

## METHODS

### Study Design

We conducted a single-center retrospective cohort study at a pediatric quaternary care medical center in the northeastern United States to examine trends in surgical volumes among patients undergoing plastic and oral and maxillofacial surgery procedures before the onset of COVID-19 (January 1, 2016–March 14, 2020) and during COVID-19 (March 15, 2020–December 31, 2021). The study was reviewed and approved by the hospital's institutional review board and did not require funding.

### Data Sources and Study Population

This study included all completed plastic and oral and maxillofacial surgical procedures conducted between January 2016 and December 2021, identified by electronic health records within the hospital's department of plastic and oral surgery (11,565). These procedures were merged with supplemental clinical and socioeconomic data extracted from the Pediatric Health Information System (PHIS), an administrative pediatric database that contains comprehensive demographic, clinical, and financial information on each patient's procedure from 49 tertiary care pediatric hospitals across the United States, maintained by the Children's Hospital Association.<sup>8</sup> Ninety-four percent of internal electronic health record procedures were successfully merged with PHIS supplemental data (10,861). Because an exposure of interest was the zip code-based

## Takeaways

**Question:** Did pediatric plastic and oral surgical volumes recover at the same rate for all patients following the onset of coronavirus disease 2019?

**Findings:** A cohort of plastic and oral surgical cases were retrospectively analyzed to identify surgical volume trends by patient sociodemographic groups and Child Opportunity Index (COI) levels. Compared with prepandemic, patients who spoke a language other than English or Spanish and patients in the lowest COI levels had unrecovered surgical volumes.

**Meaning:** Disparities in surgical volumes existed for patients from certain sociodemographic groups and for patients in the lowest COI levels, indicating a need for interventions focused on promoting equitable pediatric surgical care access.

COI, procedures with missing zip codes were excluded (180). The final study cohort consisted of 10,681 surgical procedures, involving 9174 distinct patients.

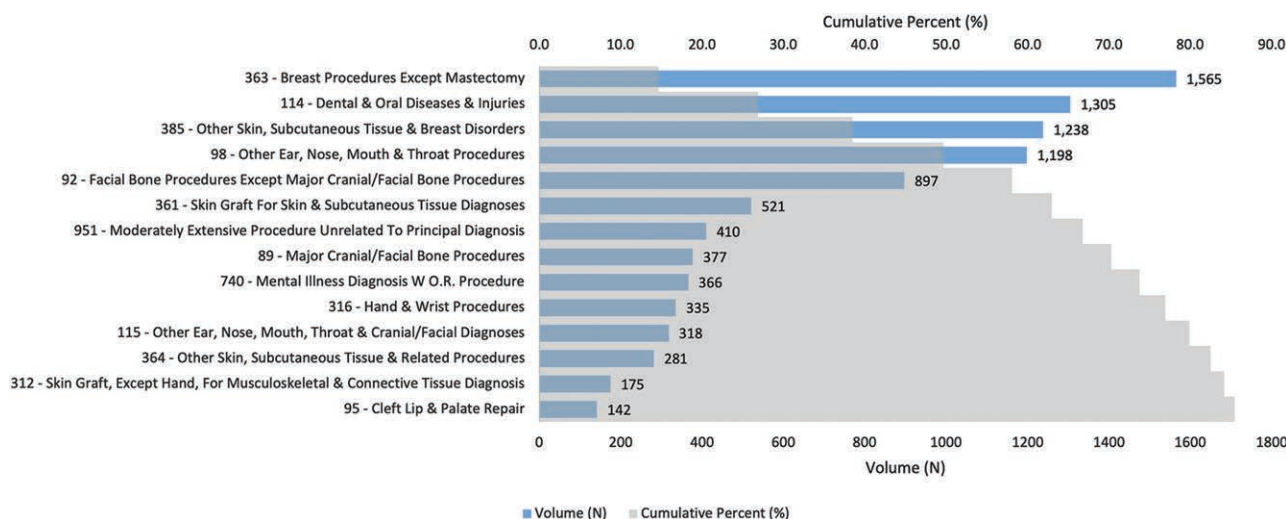
### Measures

Procedures from January 1, 2016, and March 14, 2020, were considered prepandemic procedures for the univariate and multivariable analyses. Procedures occurring between March 15, 2020, and December 31, 2021, were considered part of the COVID-19 pandemic time frame.

Interrupted time series (ITS) analyses were assessed bimonthly due to sample size constraints. Because of this, March/April 2020 was considered the onset of the pandemic time frame for all ITS models.

Patient demographics included race and ethnicity, age at admission, sex, primary language, and need for an interpreter at the time of a procedure. Race and ethnicity were self-reported and aggregated into a single variable consisting of seven categories: (1) Asian non-Hispanic/Latino; (2) Black non-Hispanic/Latino, (3) Hispanic/Latino, (4) multiracial non-Hispanic/Latino, (5) White non-Hispanic/Latino, (6) another race non-Hispanic/Latino, and (7) unknown. Due to the small volume of patients who self-identified as American Indian or Alaskan Native, Native Hawaiian, or Pacific Islander, and patients who self-identified as another race, these groups were aggregated into the other race category. Primary language was grouped into the following three categories: (1) English, (2) Spanish, and (3) another language.

Health-related social needs were assessed using the geographic-based COI 2.0.<sup>9,10</sup> The COI is a composite metric that measures the resources and conditions of where a child lives (based on their zip code) by assimilating 29 child-relevant measures within three domains. The three domains are (1) education, (2) health and environment, and (3) social and economic. By ranking census tracts on domain and overall average z-scores, five quintiles of child opportunity levels are created ranging from "very low COI" to "very high COI." Due to sample size constraints, "very low" and "low" COI levels were aggregated into a single category.



**Fig. 1.** A graph showing most frequent All Patient-Refined Diagnosis-Related Groups related to plastic surgery encounters.

Clinical variables included (1) intensive care unit utilization; (2) priority of admission, categorized as elective, emergency, or urgent; (3) type of procedure, categorized as ambulatory or inpatient/observation; (4) presence of complex chronic conditions (CCC); and (5) All Patient-Refined Diagnosis-Related Groups. Complex chronic conditions were measured using the Pediatric CCC version 2 (v2) classification system. The CCC v2 is a multidimensional system that defines CCCs utilizing the International Classification of Diseases Ninth Revision (ICD-9) and International Classification of Diseases Tenth Revision (ICD-10) codes.<sup>11</sup> The All Patient-Refined Diagnosis-Related Group is an inpatient classification system co-developed by the National Association of Children’s Hospitals and Related Institutions and 3M that classifies individual non-Medicare patient hospitalizations into clinically relevant subgroups based on reason for hospital admission, severity of illness, and risk of mortality.<sup>12</sup>

**Statistical Methods**

Descriptive analyses were used to present patient demographics, health-related social needs (as measured by the COI), and clinical-level characteristics related to plastic and oral and maxillofacial surgery procedures during the pre-pandemic and pandemic time frames. Categorical variables were summarized as frequencies and percentages. Differences in patient demographics (age group, race and ethnicity, and primary language), COI, and clinical characteristics (payer, presence of a CCC, and medical or surgical indicator) across the pre-pandemic and pandemic time frames were assessed using chi-square tests. A multivariable mixed-effects logistic regression model was used to identify race and ethnicity, language, and COI-related disparities that may have occurred pre-pandemic and during the pandemic, controlling for patient age, insurance, CCC, and medical/surgical indicators. The mixed-effects model took into account the random effects of patient-level clustering. Effect estimates were presented using adjusted odds ratios (aORs) and 95% confidence intervals (CIs).

ITS regression models were used to examine bimonthly trends in surgical volumes across race and ethnicity, primary language, and COI groups to identify disparities in surgical volumes during the pre-pandemic and pandemic time frames. Counterfactual trends, defined as the expected trends that would have occurred if the pandemic had not taken place, were included in all models. Statistical analyses were conducted using Statistical Analysis Software, version 9.4 (SAS Institute, Cary, N.C.) with a two-sided P value of less than 0.05 considered statistically significant.

**RESULTS**

The study cohort comprised 10,681 surgical procedures, involving 9174 distinct patients, from 2016 through 2021; 71% (7585) of procedures were performed before the onset of COVID-19 in March 2020 and 29% (3096) during the COVID-19 period. (See table, Supplemental Digital Content 1, which displays plastic and oral surgery encounters from 2016 to 2021, <http://links.lww.com/PRSGO/D129>.) The most frequent principal diagnoses included (1) hypertrophy of breast (14.1%; 1504), (2) impacted teeth (8%; 857); and (3) transsexualism (3.3%; 356). The highest volume principal procedures included (1) excision of bilateral breast with an open approach (13.9%; 1479), (2) excision of face skin with an external approach (5.7%; 608), and (3) resection of lower tooth with a multiple or open approach (5.3%; 566). Additional top 10 by volume principal diagnoses and procedures are presented in Figure 1.

Univariate analysis indicated that during the pandemic patients were more likely to be older than 18 years at surgery (31.4% versus 21.9% pre-pandemic;  $P < 0.001$ ), more likely to identify as Hispanic (9% versus 6.8% pre-pandemic;  $P < 0.001$ ), and less likely to speak a language other than English or Spanish (2.8% versus 4.4% pre-pandemic;  $P < 0.001$ ). Procedures involving patients with a CCC were less common during the pandemic period (14.9% versus 17.2% pre-pandemic;  $P = 0.004$ ; data not shown).

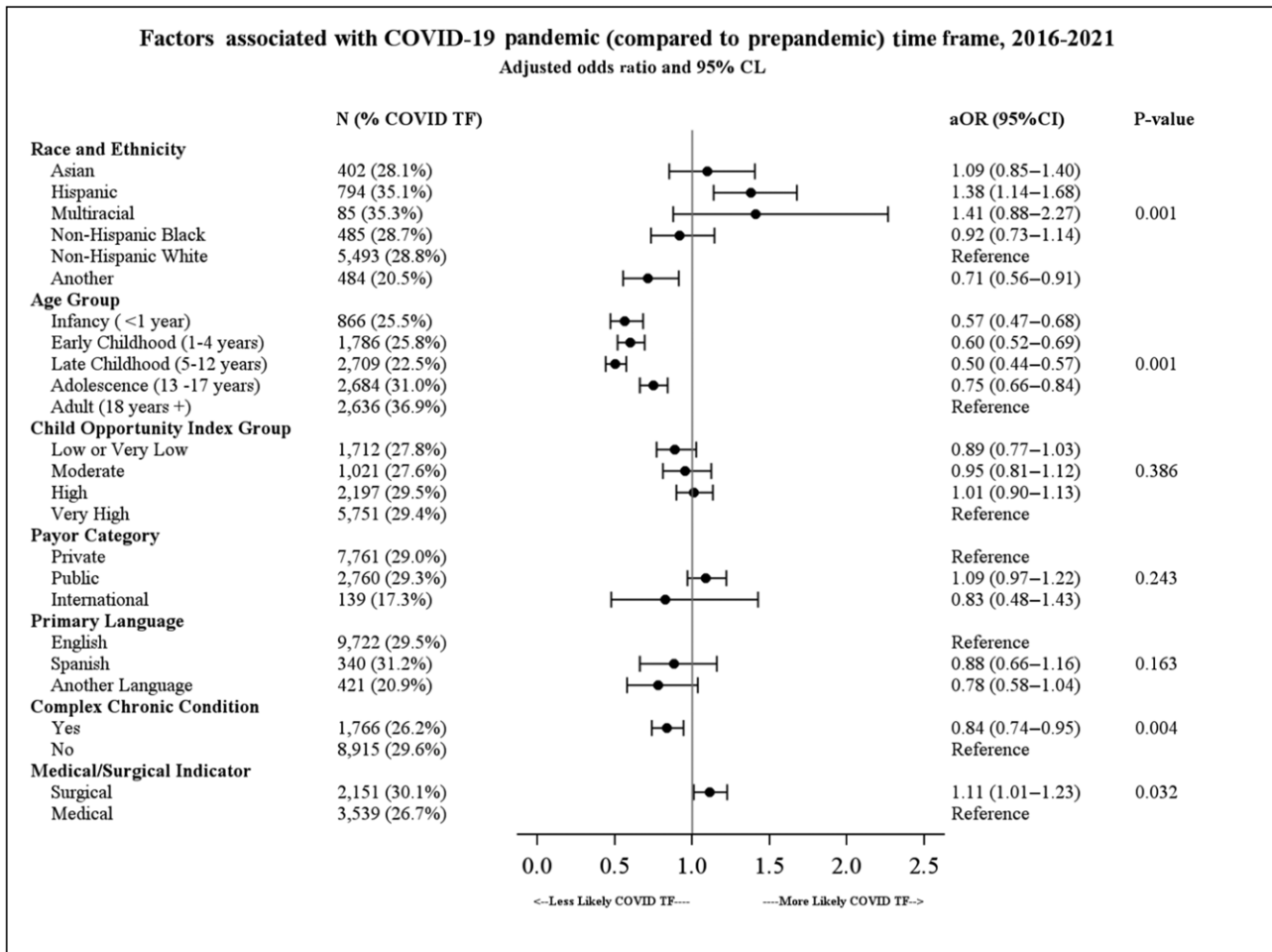
Multivariable logistic regression analysis indicated that patients seen during the pandemic time frame were older ( $\geq 18$  years at surgery), less likely to be a patient of another race/ethnicity (aOR 0.71; 95% CI, 0.56–0.91), and more likely to be Hispanic/Latino (aOR 1.38; 95% CI, 1.14–1.68) compared with White/non-Hispanic patients. Although not statistically significant, patients living in the lowest levels of the COI were less likely to undergo procedures during the pandemic time frame compared with children living in the highest COI (aOR 0.89; 95% CI, 0.77–1.03). Procedures involving patients with a CCC were less likely to occur during the pandemic time frame (aOR 0.84; 95% CI, 0.74–0.95; Fig. 2). Area under the receiver operating characteristic curve of the model was 0.70 (95% CI, 0.69–0.71).

Results of the ITS showed that overall surgical volumes were increasing with an average of 289 procedures bimonthly before the pandemic (95% CI, 250–323). Overall surgical volumes dropped by an estimated 31 procedures bimonthly during the pandemic time frame and were lower than the counterfactual trends ( $P = 0.003$ ) by the end of the study period.

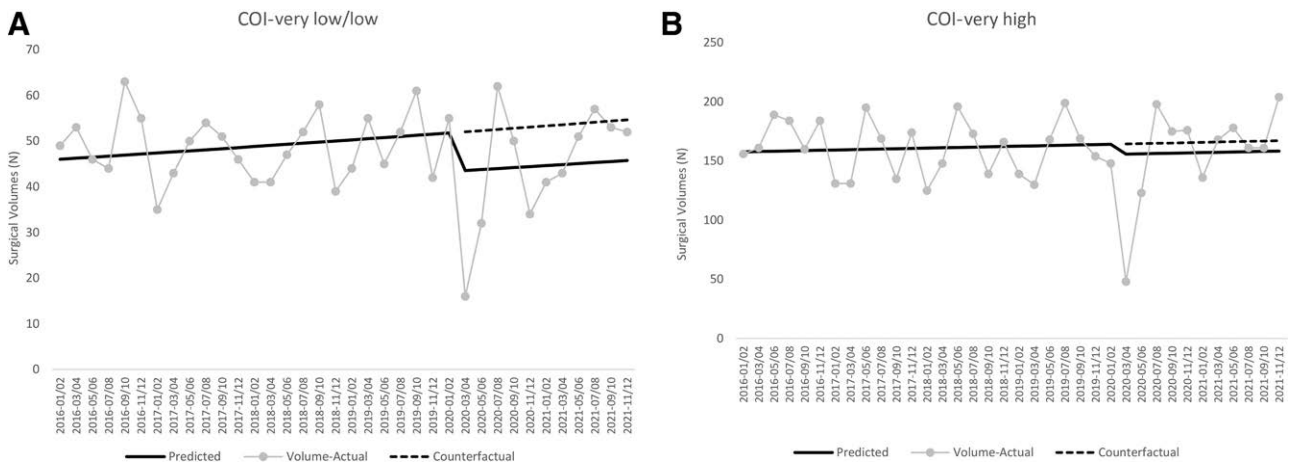
Focusing on patient groups of interest, surgical volume trends among patients with the lowest COI levels were significantly lower than where they were estimated to have been if the pandemic did not occur according to the counterfactual model ( $P = 0.040$ ; Fig. 3). Although volume trends during the pandemic time frame among White non-Hispanic/Latino patients no longer differed from the counterfactual trends, surgical volumes had not yet recovered for patients of another race/ethnicity ( $P = 0.029$ ). Although not statistically significant, most likely due to sample size, Hispanic/Latino patients had pandemic trends higher than their counterfactual estimated volumes (Fig. 4). Patients who spoke a primary language other than English or Spanish continued to have unrecovered surgical volumes by the end of the study time frame ( $P = 0.015$ ; Fig. 5).

### DISCUSSION

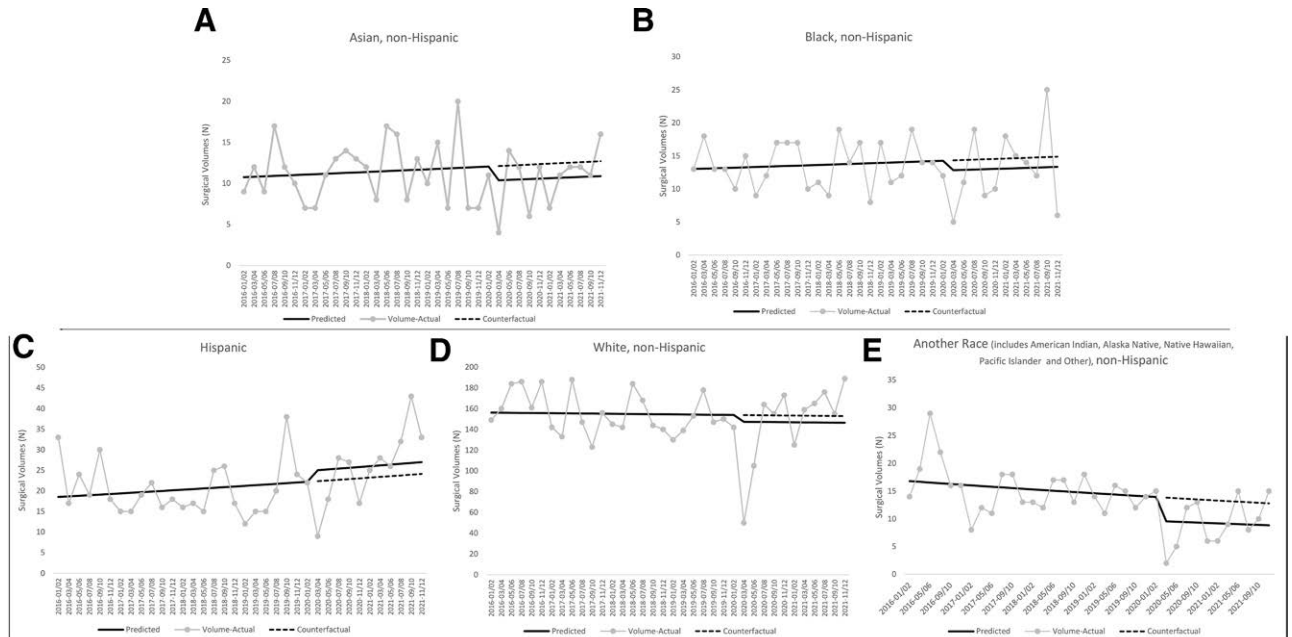
Our study showed that compared with the prepandemic period, patients undergoing procedures post-March 2020 were more likely to be over the age of 18



**Fig. 2.** A graph showing sociodemographic factors associated with the COVID-19 time frame. Adjusting for all covariates presented. Takes into account individual-level random effects. TF, time frame.



**Fig. 3.** Time series analysis by COI: A, A graph showing the time series analysis of trends in plastic surgical volumes across pre-pandemic and pandemic time frames by COI-very low/low. Note: baseline trend  $P = 0.199$ ; COVID-19 shift  $P = 0.040$ . B, A graph showing the time series analysis of trends in plastic surgical volumes across pre-pandemic and pandemic time frames by COI-very high. Note: Baseline trend  $P = 0.432$ ; COVID-19 shift  $P = 0.257$ .

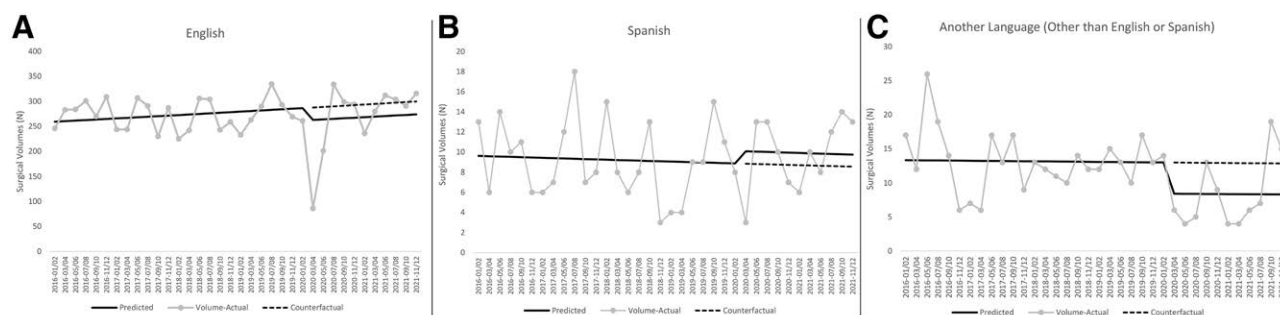


**Fig. 4.** Time series analysis by race and ethnicity: A, A graph showing the time series analysis of trends in plastic surgical volumes across pre-pandemic and pandemic time frames for Asian, non-Hispanic patients. Note: Baseline trend  $P = 0.548$ ; COVID-19 shift  $P = 0.387$ . B, A graph showing the time series analysis of trends in plastic surgical volumes across pre-pandemic and pandemic time frames for Black, non-Hispanic patients. Note: Baseline trend  $P = 0.598$ ; COVID-19 shift  $P = 0.502$ . C, A graph showing the time series analysis of trends in plastic surgical volumes across pre-pandemic and pandemic time frames for Hispanic patients. Note: Baseline trend  $P = 0.199$ ; COVID-19 shift  $P = 0.377$ . D, A graph showing the time series analysis of trends in plastic surgical volumes across pre-pandemic and pandemic time frames for White, non-Hispanic patients. Note: Baseline trend  $P = 0.774$ ; COVID-19 shift  $P = 0.377$ . E, A graph showing the time series analysis of trends in plastic surgical volumes across pre-pandemic and pandemic time frames for patients of another race and non-Hispanic. Note: Baseline trend  $P = 0.260$ ; COVID-19 shift  $P = 0.029$ .

and Hispanic/Latino, and the likelihood of undergoing procedures post-March 2020 decreased for patients in the lowest COI levels compared with those in the highest COI levels. Patients who spoke a primary language other than English or Spanish and patients in the lowest COI levels had unrecovered surgical volumes as of December 2021.

Additionally, Hispanic/Latino patients had increasing surgical volume trends higher than their counterfactual estimated volumes as of December 2021.

The observed finding that surgical volumes decreased among children from the lowest COI levels compared with children from the highest COI levels are consistent



**Fig. 5.** Time series analysis by primary language: A, A graph showing the time series analysis of trends in plastic surgical volumes across pre-pandemic and pandemic time frames for English-speaking patients. Note: Baseline trend  $P = 0.010$ ; COVID-19 shift  $P = 0.013$ . B, A graph showing the time series analysis of trends in plastic surgical volumes across pre-pandemic and pandemic time frames for Spanish-speaking patients. Note: Baseline trend  $P = 0.701$ ; COVID-19 shift  $P = 0.506$ . C, A graph showing the time series analysis of trends in plastic surgical volumes across pre-pandemic and pandemic time frames for patients who speak another language other than English or Spanish. Note: Baseline trend  $P = 0.887$ ; COVID-19 shift  $P = 0.015$ .

with current literature demonstrating the influence of health-related social needs on healthcare access. Two studies assessing pediatric acute care utilization and elective surgical access during the early stages of the pandemic found that patients from the lowest COI level had the highest reduction in care compared with patients from higher COI levels.<sup>13,14</sup> In contrast, another study found that families who were of a race other than White, spoke a language other than English, were publicly insured, and were from low COI levels had the highest hesitancy to seek care during COVID-19.<sup>15</sup> Current research depicts COI as an indicator for reduced care, aligning with the findings of this study that highlights COI as a possible predictor for reduced pediatric surgical care access.

Additional findings of this study indicate that patients who spoke a primary language other than English or Spanish continued to have unrecovered surgical volumes. It has been demonstrated that pediatric patients with limited-English proficiency may experience decreased access to surgical care and use of healthcare services.<sup>16,17</sup> Other studies have found that children who spoke languages other than English and Spanish experienced prolonged hospital stays and limited access to interpreters,<sup>18</sup> and patients who spoke languages other than English demonstrated a decreased understanding of diagnosis and treatment plans.<sup>19</sup> These factors may explain our finding and highlight the need for improved language services to mitigate further disparities in access and outcomes.

One unexpected finding in our study was that Hispanic/Latino patients had an increase in plastic and oral and maxillofacial surgical volumes following the return to performing surgical procedures during the COVID-19 time period. Although it is unknown why this patient population had an increase in surgical volumes, it is possible that recent quality improvement initiatives implemented at our pediatric academic medical center, especially initiatives that were aimed at improving patient self-reported race and ethnicity, have led to higher rates of data capture. It is also possible that there were community-level changes that improved access for Hispanic/Latino patients, or community-held beliefs about the threat or

perceived risk of COVID-19 infection, that led to a higher likelihood of receiving health services. Further research is needed to extrapolate the reason(s) for this unexpected finding.

After reviewing the current literature, this study is the first to analyze the effects of COVID-19 and the subsequent disruption to nonemergent surgical care on pediatric plastic and oral and maxillofacial surgical volumes by patient sociodemographics and the COI. One study looking at trends in demographic characteristics of pediatric patients undergoing procedures for craniosynostosis before and during the pandemic found that patients who were Black/African American and/or Hispanic/Latino had an older age at initial presentation and time of surgery compared with patients who were White, Asian, and/or non-Hispanic.<sup>20</sup> This disparity in access to care remained unchanged between the two time frames. Although these findings are not directly translatable to the results of the current study, they support our study's findings that disparities in access to pediatric plastic and oral and maxillofacial surgical care either remained constant or, in some cases, increased during the COVID-19 pandemic.

The findings from this study have important clinical implications, as patient populations that faced barriers before the pandemic may be particularly susceptible to disparate health outcomes following the onset of COVID-19, a time when health disparities were often exacerbated. Our findings suggest that pediatric plastic and oral and maxillofacial surgical volumes may not have fully recovered for all patient populations equitably. Hospitals and healthcare organizations providing pediatric plastic and oral and maxillofacial surgical care could benefit from screening their surgical volumes and, if disparities are discovered, implementing interventions to improve equitable surgical care access. Furthermore, the screening of surgical patients to better understand the barriers to equitable surgical care access and the implementation of interventions to address these barriers would align well with The Joint Commission's new 2023 health equity requirements to understand the barriers that impact their patients' equitable access to healthcare.<sup>21,22</sup>

The complex interactions of social, economic, health, environmental, and educational barriers that are known contributors to inequitable healthcare access for children are measurable by the COI. As such, using the COI, a validated index that provides a robust depiction of vulnerability and healthy childhood development, is a strength of this study. The COI is also an important index for applying a health equity framework to clinical research, as it elevates positive opportunities for healthy child development rather than focusing on negative and deficit neighborhood conditions.<sup>23</sup> Subsequently, the use of the COI can inform targeted and innovative interventions to address barriers to equitable healthcare access for pediatric populations. Another strength of this study is the utilization of the PHIS database; the PHIS database combines data from the hospital's medical record system and billing system to create a robust integrated database that undergoes rigorous quality control methods.

A limitation of this study is that the results may not be generalizable to all pediatric surgical subspecialties. Similarly, the generalizability of this study may be limited due to the patient cohort being contained to a single center. Further research could benefit from analyzing surgical volume trends across different subspecialties and analyzing more heterogeneous patient cohorts. As this study is observational, it is not possible to determine causality for this study's findings regarding changes in surgical volume trends. Future prospective studies could elucidate why these trends occurred and what interventions may be useful in ensuring equitable access to plastic and oral and maxillofacial surgical care for all pediatric patients.

In summary, this study's findings suggest that pediatric plastic and oral and maxillofacial surgical volumes did not recover at the same rate for all sociodemographic groups across a pre-pandemic and pandemic time period. Although surgical volumes recovered for most patients, patients from historically underserved and/or underrepresented groups may remain at risk for decreased access to pediatric plastic and oral and maxillofacial surgical care. Future research is needed to assess why patients from low COI neighborhoods and certain sociodemographic groups have decreased surgical care access compared with pre-pandemic trends. Future studies could elucidate barriers to surgical care access and propose novel interventions for dismantling barriers to equitable care. This will aid in achieving more equitable plastic and oral and maxillofacial surgical care access for pediatric populations.

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#### DISCLOSURES

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