Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
How has the COVID Pandemic Impacted the Clinical Volume and Variety of an Academic Oral and Maxillofacial Surgery Program?

Michael J. Cimba, BA,* Saxon Day, BA,* Matthew J. Rose, BS,* Kevin C. Lee, DDS, MD,† Sung-Kiang Chuang, DMD, MD, DMSc,‡,§,‖ Helen E. Giannakopoulos, DDS, MD,*, and Brian P. Ford, DMD, MD**

Purpose: Attempts to mitigate the coronavirus disease of 2019 (COVID) have disrupted the delivery of non−pandemic care. The purpose of this study was to evaluate the effects of the COVID pandemic on surgical volume and variety at an academic oral and maxillofacial surgery program.

Materials and Methods: A retrospective cohort study was conducted using the surgical logs of the University of Pennsylvania, Department of Oral and Maxillofacial Surgery from January 2012 through January 2021. Each record identified patient demographics and case classifications. The study predictor was timing of care, which was divided into pre-pandemic, peak pandemic, or post-peak pandemic. The primary study outcomes were the monthly procedure count and the procedure categories. The secondary dependent variables were patient age and race. Multivariate and univariate analyses of variance were used to determine whether pandemic effects existed within outcome groups.

Results: The final sample included 64,709 surgical procedures. Before, during, and after the pandemic peak, there were means of 691.0, 209.0, and 789.4 procedures per time period, respectively ($P < .01$). There was significantly more infection (baseline 2.2%, peak 6.0%, post-peak 2.0%, $P < .01$) and trauma (baseline 5.3%, peak 26.7%, post-peak 3.9%, $P < .01$) cases during the pandemic peak. The mean percentage of pediatric patients increased during the peak and post-peak periods (baseline 2.4%, peak 12.9%, post-peak 10.2%, $P < .01$). No differences were observed among the mean percentage of White ($P = .12$), Black ($P = .21$), and Hispanic ($P = .25$) patients treated.

* DMD Candidate, Dental School, University of Pennsylvania School of Dental Medicine, Philadelphia, PA.
† Resident, New York-Presbyterian/Columbia University, Irving Medical Center, New York, NY.
‡ Clinical Professor, Department of Oral and Maxillofacial Surgery, University of Pennsylvania, School of Dental Medicine, Philadelphia, PA.
§ Private Practice, Brockton Oral and Maxillofacial Surgery Inc, Brockton, MA.
‖ Attending, Department of Oral and Maxillofacial Surgery, Good Samaritan Medical Center, Brockton, MA.
¶ Visiting Professor, Department of Oral and Maxillofacial Surgery, Kaohsiung Medical University, School of Dentistry, Kaohsiung, Taiwan.
* Associate Professor and Program Director, Department of Oral and Maxillofacial Surgery, University of Pennsylvania School of Dental Medicine, Philadelphia, PA.
** Associate Professor, Department of Oral and Maxillofacial Surgery, University of Pennsylvania School of Dental Medicine, Philadelphia, PA.

Conflict of Interest Disclosures: None of the authors have any relevant financial relationship(s) with a commercial interest.

Address correspondence and reprint requests to Mr Cimba: Dental School, University of Pennsylvania School of Dental Medicine, 240 S 40th St, Philadelphia, PA; e-mail: 19104.mcimba@upenn.edu
Received May 3, 2021
Accepted June 24, 2021.
© 2021 The American Association of Oral and Maxillofacial Surgeons.
0278-2391
https://doi.org/10.1016/j.joms.2021.06.033
Conclusions: Along with a predictable decline in surgical numbers, a greater proportion of infection and trauma procedures were performed at the pandemic’s peak. Despite these changes, surgery volume normalized and case variety returned to pre-pandemic levels in the post-peak period. Our study suggests that the addition of COVID restrictions did not change the case volume or variety in the months after the initial crisis.

© 2021 The American Association of Oral and Maxillofacial Surgeons.
J Oral Maxillofac Surg 79:2482–2486, 2021

The novel coronavirus disease of 2019 (COVID) has contributed to multiple shifts in healthcare utilization. On March 18, 2020, the Centers for Medicare and Medicaid Services (CMS) made recommendations to postpone elective medical, surgical, and dental procedures in order to mitigate the spread of COVID and preserve scarce healthcare resources. Following these expert guidelines, Pennsylvania quickly issued an executive order to restrict all procedures that were non–emergent. This statewide pause lasted until April 27, 2020 when non–emergent and elective surgeries were permitted to resume. Many other states likewise implemented similar preventive guidelines during this period, and every major hospital system had to adapt to new pandemic policies.

Despite the liberalization of constraints at the end of April 2020, by mid-June, global decreases in the number of hospitalized non–COVID patients were still commonplace. Not only were there changes in healthcare utilization at the pandemic’s peak, but there also appear to be sustained changes in the aftermath of the initial COVID crisis. This investigation sought to determine how the COVID pandemic impacted the practice patterns at a major urban academic oral and maxillofacial surgery program. The purpose of this study was to evaluate the effects of the pandemic on the volume and types of surgical cases performed. To achieve this aim, we compared both peak and post-peak periods to a pre-pandemic baseline. We hypothesized the surgical volume and case variety would be significantly different across all 3 time points.

Materials and Methods

This retrospective cohort study was composed of oral-maxillofacial surgical encounters at the University of Pennsylvania from January 2012 through January 2021. We classified this study as an open, dynamic cohort study because this is not a traditional cohort study that follows a single sample of patients over time with repeated measures. Emergency department treatments were not included in the final study sample. From each surgical encounter, the following information was recorded: date of service, patient age, self-reported race, International Classification of Diseases (ICD) diagnosis code, and Current Procedural Terminology (CPT) code. In order to assess the effect of the COVID pandemic, 3 time points (pre-pandemic, peak pandemic, and post-peak pandemic) were delineated. Pre-pandemic was defined as any time before March 2020. Peak pandemic was defined as the months of March 2020, April 2020, and May 2020. Post-peak pandemic was defined as any time after the pandemic peak and included dates from June 2020 through January 2021. Patient age was classified as pediatric (<18 years), younger adult (18 to 65 years), and older adult (65 years and older). Patients identifying with multiple ethnicities were classified as “other”. Using billing codes, each surgery was classified as either cancer/reconstruction, benign pathology, craniofacial, orthognathic, temporomandibular joint, cosmetic, dentoalveolar, sedation, odontogenic infection, or facial trauma. Surgical encounters that were ambiguous or that could not be grouped into 1 of the aforementioned categories were excluded from the analysis. Multiple procedures that were performed and coded for during the same visit were each considered separately. For example, a dentoalveolar surgery performed under sedation was counted both as a dentoalveolar case and a sedation case in this study.

The predictor variable was the timing of surgery relative to the pandemic. The primary study outcomes were the monthly procedure count and distribution of procedure categories. Procedural variety was defined as having a significantly different distribution of cases across clinical categories. The secondary study outcomes were the patient characteristics of age and race. For the primary outcome of monthly case counts, an analysis of variance (ANOVA) was performed to determine whether the mean number of cases were significantly different across all time periods. For all of the remaining multilevel study outcomes, multivariate analyses of variance (MANOVAs) were conducted to determine whether timing of surgery had a significant association with each outcome group. Significance in each MANOVA test, as determined using Wilks’s lambda statistics, was followed by post hoc ANOVAs to determine which specific factors within each outcome category experienced pandemic changes. All
statistical analyses were performed with SAS, version 9.4 (SAS Institute, Cary, NC). This study was granted exemption by the University of Pennsylvania Institutional Review Board.

Results

A total of 64,709 surgical procedures were included in the final sample. The descriptive statistics of the samples are presented in Table 1. There were statistically significant differences in the mean monthly case volume before, during, and after the COVID pandemic peak (F(2,109) = 8.96, P < .01) (Table 2). Before the pandemic, an average of 691.0 cases (SD: 212.9) were performed per month. During the peak of the pandemic, the case volume declined to 209.0 cases (SD: 163.8) per month. After the peak, the case volume increased above pre-pandemic levels to 789.4 cases (SD: 120.2) per month.

The pandemic was associated with significant differences in the distributions of procedure types (F(10,210) = 5.99, Wilks’ lambda = 0.61, P < .01), patient age (F(6,214) = 10.86, Wilks’ lambda = 0.59, P < .01), and patient race (F(10,210) = 3.13, Wilks’ lambda = 0.76, P < .01). In the post-hoc analysis (Table 3), the mean percentage of pediatric patients sustained an increase during the peak and post-peak periods (P < .01). There were no significant differences in the proportion of older adults over 65 years that were treated (P = .34). With respect to race, no differences were observed among the mean percentage of White (P = .12), Black (P = .21), and Hispanic (P = .25) patients. During the pandemic months, there were higher rates of Asian (P < .01) and lower rates of other/multiracial (P < .01) patients. For procedure categories, the mean proportions of cancer/pathology/reconstruction (P = .73) and craniofacial/orthognathic/TMJ/cosmetic (P = .06) cases were maintained at pre-pandemic levels during the entire study period. There were significantly more infection (P < .01) and trauma (P < .01) cases during the pandemic peak; however, this surge appeared to normalize to baseline in the ensuing months after the peak. Similarly, the share of dentoalveolar (P < .01) cases decreased during the height of the pandemic, but returned to pre-pandemic levels afterward.

Table 1. SUMMARY STATISTICS OF THE FINAL STUDY SAMPLE.

| Procedure category       | N (%)          |
|--------------------------|----------------|
| Sample size              | 64,709 (100%)  |
| Age                      |                |
| 0 to 17y                 | 2,179 (3.4%)   |
| 18 to 64y                | 50,157 (77.6%) |
| 65y and older            | 12,373 (19.1%) |
| Race                     |                |
| White                    | 32,763 (54.6%) |
| Black                    | 21,044 (35.1%) |
| Asian                    | 2,271 (3.8%)   |
| Hispanic                 | 1,408 (2.5%)   |
| American Indian          | 37 (0.1%)      |
| Other/Multiracial        | 2,447 (4.1%)   |

Discussion

The study sought to determine how the COVID pandemic affected case volume and variety at an academic oral and maxillofacial surgery program, and we found that the pandemic was associated with statistically significant changes in these outcomes. On closer examination of the data, there was a clinically relevant increase in the share of infection and trauma cases treated by the Penn oral and maxillofacial surgery service during the pandemic peak. This likely stemmed from the statewide restrictions on elective procedures at that time. Once the restrictions were lifted, the number and variety of surgical cases were restored to pre-pandemic levels. Mandatory social distancing and pre-operative COVID testing did not appear to lead to a protracted pandemic effect on our institution’s clinical practice. The normalization of the post-peak period also argues against the presence of a second wave phenomenon at our institution. Furthermore, this finding is reassuring as it suggests that oral and maxillofacial surgery training programs can adapt to new guidelines and preserve the resident surgical experience.

The surgical volume did not appear to return to a normal steady state until July 2020. This brief period of delay may have had multiple contributions including both limited availability of hospital beds and COVID testing, a public fear of contagion, or a general decreased ability to afford elective services secondary to financial strain from the pandemic. Fear of contagion refers to public hesitancy to obtain medical care due to the prevalence of COVID in the healthcare setting. It is important to note that this concern of transmission does solely impact high-risk specialties with...
aerosol generating procedures. There have been reports across multiple specialties confirming the role of fear in causing public reluctance to seek out medical attention.\textsuperscript{5} To combat this sentiment, health systems have issued communications reinforcing the importance of seeking healthcare during the post-pandemic period.\textsuperscript{6} Fortunately, any fear of contagion phenomenon or other barrier to care did not appear to have a sustained post-peak effect on surgical volume in our oral and maxillofacial surgery practice.

Given the mandatory pause on elective surgeries, there was a predictable increase in the share of infection and trauma cases treated during the peak of the COVID crisis. We suspect that there were also other driving factors that contributed to an increased number of infection and trauma cases during that time. Of note, our sample only included emergency department encounters that were treated in the operating room. Because outpatient dental services were inaccessible at the time, patients with odontogenic infections had limited care options. Furthermore, because most patients were avoiding local emergency departments that were overwhelmed with COVID, it is probable that certain mild infections that otherwise could be treated in-office may have transformed into more severe airway threatening conditions that required operating room drainage. Trauma accounted for over a quarter of surgical cases during the peak months of the pandemic. Pennsylvania issued a stay-at-home order for Philadelphia county from March 23 until May 8, 2020.\textsuperscript{7} With the stay-at-home order, certain areas found that there was a dramatic decline in the total incidence of traumatic injuries.\textsuperscript{8} According to Abdallah et al, there was a regional decrease in the overall volume of trauma at the University of Pennsylvania.\textsuperscript{5} This was largely driven by parallel decreases in the number of unintentional injury mechanisms such as motor vehicle collisions.\textsuperscript{5} Interestingly, in the same sample, there was a paradoxical increase in the number of intentional interpersonal injuries.\textsuperscript{5} The rise in domestic violence with the stay-at-home order has been documented elsewhere. Firearm violence in Philadelphia saw an increase with social distancing and home sheltering.\textsuperscript{9} Nationally, the number of domestic assault cases grew by at least 5% during this time.\textsuperscript{10}

\begin{table}[h]
\centering
\caption{ONE-WAY ANOVA COMPARING MEAN MONTHLY SURGICAL VOLUME BY TIME PERIOD.}
\begin{tabular}{|l|c|c|c|c|}
\hline
 & Baseline & COVID peak & COVID post-peak & \textit{P} value \\
\hline
Procedures per month\textsuperscript{†} & 691.0 (212.9) & 209.0 (163.8) & 789.4 (129.2) & \textless .01\textsuperscript{*} \\
\hline
\end{tabular}
\textsuperscript{* \textit{P} \textless .05, \textsuperscript{†} mean (SD)}
\end{table}

\textit{Cimba et al.} How Has the Covid Pandemic Impacted. J Oral Maxillofac Surg 2021.

\begin{table}[h]
\centering
\caption{POST-HOC ANOVAS COMPARING THE MEAN MONTHLY PERCENTAGE OF EACH OUTCOME BY TIME PERIOD.}
\begin{tabular}{|l|c|c|c|c|}
\hline
 & Baseline & COVID peak & COVID post-peak & \textit{P} value \\
\hline
Age category & & & & \\
Pediatric & 2.4\% & 12.9\% & 10.2\% & \textless .01\textsuperscript{*} \\
Young adult & 78.2\% & 73.5\% & 70.7\% & \textless .01\textsuperscript{*} \\
Older adult & 19.5\% & 13.6\% & 19.1\% & .34 \\
\hline
Race & & & & \\
White & 58.0\% & 46.7\% & 59.2\% & .12 \\
Black & 31.5\% & 39.9\% & 29.5\% & .21 \\
Asian & 3.9\% & 8.9\% & 5.4\% & \textless .01\textsuperscript{*} \\
Hispanic & 2.2\% & 5.7\% & 2.8\% & .25 \\
Other/Multiracial & 4.4\% & 0.8\% & 3.1\% & \textless .01\textsuperscript{*} \\
\hline
Procedure category & & & & \\
Cancer/Pathology/Reconstruction & 8.2\% & 9.0\% & 8.8\% & .73 \\
Craniofacial/Orthognathic/TMJ.Cosmetic & 5.4\% & 5.6\% & 7.1\% & .06 \\
Dentoalveolar/Sedation & 78.8\% & 52.7\% & 78.2\% & \textless .01\textsuperscript{*} \\
Infection & 2.2\% & 6.0\% & 2.0\% & \textless .01\textsuperscript{*} \\
Trauma & 5.3\% & 26.7\% & 3.9\% & \textless .01\textsuperscript{*} \\
\hline
\end{tabular}
\textsuperscript{* \textit{P} \textless .05}
\end{table}

\textit{Cimba et al.} How Has the Covid Pandemic Impacted. J Oral Maxillofac Surg 2021.
Interestingly, our study found that the proportion of pediatric patients increased significantly during the peak and post-peak periods. Many school systems adopted distance learning for the 2020 academic year. The lack of in person instruction may have allowed teenage patients the flexibility to pursue oral-maxillofacial surgery treatments such as third molar removal and orthognathic surgery. Although there was some statistically significant variance in patient race, we did not identify any obvious clinically significant differences. Past studies have reported that the Black population is less likely to present for medical care during the pandemic when compared with the White population. It has been hypothesized that this disparity may be secondary to the socioeconomic and geographic challenges that affect much of the Black population. Almost half of surveyed Black participants self-reported economic hardships during the pandemic, whereas during the same timeframe, only 21% of their White counterparts provided a similar response. In our sample, there were more Black patients treated during the peak months even though the mean percentage was not significantly different across time periods. This finding, although counter to prior reports, is reassuring.

There are a variety of strengths and weaknesses to our study that warrant acknowledgement. Because of annual variation in surgical volume, it would be poor sampling to simply use 1- or 2-years of surgical logs to serve as a pre-pandemic baseline. We pooled 8-years of surgical procedures in order to obtain an accurate depiction of our pre-pandemic operative experience. Although we identified certain trends over time, this study was largely observational and descriptive. Therefore, we could only speculate the underlying causes and were unable to prove that external factors, such as dental neglect or domestic violence, contributed to our results. Finally, this was a single-institution experience and, therefore, our findings may not be generalizable to other dissimilar programs.

In conclusion, our study found that although the surgical case logs were skewed toward infection and trauma cases during the pandemic’s peak, both the case volume and variety normalized in the post-peak period. With widespread vaccination, lower transmission rates, and liberalization of COVID restriction, we assume that normalcy will continue to be maintained in our academic oral and maxillofacial surgery practice. Lessons learned during the COVID pandemic will increase preparedness and guide the management of future public health crises.

References

1. Stuart B. How the COVID-19 pandemic has affected provision of elective services: the challenges ahead. https://www.health-affairs.org/do/10.1377/hblog20201006.265687/full/. Accessed March 20, 2021.
2. Ambulatory Surgery Center Association and ASCA Foundation. State guidance on elective surgeries. https://www.ascassocia-tion.org/asca/resourcecenter/latestnewsresourcedocument/covid-19/covid-state. Accessed March 21, 2021.
3. American College of Surgeons. COVID-19: executive orders by state on dental, medical, and surgical procedures. https://www.facs.org/covid-19/legislative-regulatory/executive-orders. Accessed March 21, 2021.
4. McGuireWoods. State governors’ “stay-at-home” and prohibition on elective procedure orders. https://www.mcguire-woods.com/client-resources/Alerts/2020/10/state-governors-stay-at-home-prohibition-elective-procedures-orders. Accessed March 21, 2021.
5. Abdallah HO, Zhao C, Kaufman E, et al. Increased firearm injury during the COVID-19 pandemic: a hidden urban burden. J Am Coll Surg 232:152-159, 2021
6. Lowenstein CJ. Coronavirus and cardiovascular disease: don’t ignore heart symptoms. https://www.hopkinsmedicine.org/health/conditions-and-diseases/coronavirus/dont-ignore-heart-symptoms. Accessed March 24, 2021.
7. Wolf GT. Gov. wolf, sec. of health take actions on stay-at-home orders, issue yellow phase orders. https://www.governor.pa.gov/newsroom/gov-wolf-sec-of-health-take-actions-on-stay-at-home-orders-issue-yellow-phase-orders/. Accessed March 24, 2021.
8. Leichtle SW, Rodas EB, Procter L, Bennett J, Schrader R, Abou-tanos MB: The influence of a statewide “Stay-at-Home” order on trauma volume and patterns at a level 1 trauma center in the united states. Injury 51:2437, 2020
9. Beard JH, Jacoby SF, Maher Z, et al. Changes in shooting incidence in philadelphia, pennsylvania, between march and november 2020. JAMA 325:1327, 2021
10. Hsu LC, Henke A: COVID-19, staying at home, and domestic violence. Rev Econ Househ 1:1-11, 2020
11. Czeisler M, Marynak K, Clarke K, et al. Delay or avoidance of medical care because of COVID-19-related concerns - United States, june 2020. MMWR Morb Mortal Wkly Rep 69:1250, 2020
12. Rozenfeld Y, Beam J, Maier H, et al. A model of disparities: risk factors associated with COVID-19 infection. Int J Equity Health 19:126, 2020