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.

Investigation

Changes in dental care use patterns due to COVID-19 among insured patients in the United States

Sung Eun Choi, MS, PhD; Lisa Simon, MD, DMD; Sanjay Basu, MD, PhD; Jane R. Barrow, MS

ABSTRACT

Background. Demand for dental services has been known to be linked closely to dental insurance and disposable income. Widespread economic uncertainty and health systems changes due to COVID-19 thus may have a significant impact on dental care use.

Methods. Using deidentified dental practice management data from 2019 and 2020, the authors observed variations in dental care use among insured patients since the COVID-19 outbreak (during the period of practice closure and after the reopening) by patient age, procedure type, insurance type, practice size, geographic area, and reopening status. The authors examined whether the rebound in procedure volumes at dental practices can be explained by county-level characteristics using hierarchical regression models.

Results. Although dental care use among privately insured patients fully rebounded by August 2020, use still remained lower than the prepandemic level by 7.54% among the publicly insured population. Demand for teledentistry increased 60-fold during practice closure. Geographic characteristics—such as median household income, percentages of rural or Black populations, and dental care professional shortage designations—were associated significantly with the number of procedures performed at dental practices.

Conclusions. As a result of COVID-19, dental practices experienced substantial decreases in procedure volume, particularly among patients covered by public insurance or residing in underserved areas.

Practical Implications. During economic downturns, state health officials should be encouraged to adopt policies to expand access to oral health care for vulnerable populations via oral health promotion strategies and increasing the supply of dentists or midlevel dental care providers in underserved areas.

Key Words. COVID-19; oral health; access to care; dental utilization; neighborhood effect; health services research.

JADA 2021:152(12):1033-1043
https://doi.org/10.1016/j.adaj.2021.07.002

The COVID-19 pandemic has had a significant impact on the US health care system, resulting in the cancellation and postponement of most elective procedures and outpatient care from March through May 2020.[1] In dentistry, COVID-19 resulted in the closure of dental practices for all care except emergency and urgent services starting in March 2020, limiting access to routine care and preventive services.[2] In May 2020, dental practices began reopening in states where government mandates began to lift, and the Centers for Disease Control and Prevention released reopening guidance for dental practices, emphasizing strong infection control protocols in dental offices and the highest level of personal protective equipment to help protect patients and dental care providers, given elevated risk of experiencing transmission from aerosol-generating procedures in dental settings.[3]

After the reopening in May 2020, outpatient visits rebounded to prepandemic levels in medical practices.[4] Some specialties, such as dermatology, urology, and adult primary care, were seeing more patients than they did at the beginning of the year, before the COVID-19 outbreak. Visits to other

This article has an accompanying online continuing education activity available at: http://jada.ada.org/ce/home.

specialists, including pulmonologists and behavioral health providers, remain substantially lower than prepandemic levels.[4] Although the impact of COVID-19 on medical practices has been well investigated,[4-9] its impact on dental practices and dental care use on a granular level using procedure-level data has not been studied, to our knowledge, other than the surveys of dentists conducted by the American Dental Association's Health Policy Institute and an analysis of private claims data, evaluating overall changes in use.[10,11]

In addition to the marked impact on dental practices resulting from infection control concerns, which increase practice costs and turnaround time between patients, demand for dental services, more than for other types of medical interventions, is closely linked to dental insurance and disposable income.[12,13] Thus, the COVID-19 recession may have a greater impact on dental care use and people's oral health.

In this study, we used dental practice management data to describe the variation in dental care use since the COVID-19 outbreak (during the period of practice closure and after reopening) by patient age, geographic area, procedure type, practice size, and insurance coverage. Moreover, evidence suggests that neighborhood characteristics and geographic location play important roles in patterns of oral health care.[14] Thus, we examined whether the rebound in procedure volumes performed at dental practices after reopening varied by geographic location, such as county, and whether the observed variation is related to practice- and county-level characteristics.

METHODS

Data source and study population

We analyzed dental practice management data from a health care technology company that helps dental practices with care delivery, including billing and payment, to describe changes in dental care use due to the COVID-19 pandemic among insured patients. The aggregated procedure-level data included approximately 26,000 provider organizations representing more than 34,000 dental care providers across all 50 states and the District of Columbia, approximately 17% of dental care providers working in the United States. (More details about the data sample are provided in the Appendix, available online at the end of this article.) In typical years, these provider organizations have approximately 51 million patients who are covered by an array of private and public insurance plans (approximately 68.6% private and 31.4% public). We derived the procedure-level data from practice management software on a weekly basis from January 1 through August 31 in 2019 and 2020 to evaluate changes in dental care use rates since the COVID-19 outbreak compared with prepandemic levels, adjusting for trends and seasonality. Our methods followed the Strengthening the Reporting of Observational Studies in Epidemiology reporting guidelines.

Measures

For our descriptive analysis, the primary outcome was percentage changes in total number of dental procedures compared with the same week in the previous year to reflect seasonality. We studied use by procedure-level variables that may affect the percentage changes in total number of dental procedures, including insurance plan (private, public insurance), patient age (0-2, 3-5, 6-17, 18-64, 65-74, $\geq$ 75 years), practice size (0-5 providers, 6-20 providers, $>$ 20 providers per practice); procedure type (including teledentistry [eTable 1, available online at the end of this article]), and geographic area (hot spot states [the top 9 states in new COVID-19 cases per capita from June through August 2020 were Texas, Florida, Georgia, Arizona, North Carolina, Tennessee, Louisiana, Alabama, and South Carolina],[15] Northeast, and all other states). Because there was within-U.S. heterogeneity in shelter-in-place (SIP) orders (eFigure), we also studied changes in use by the status of reopening (SIP orders ended before and after mid-May).

In our secondary analysis to explore contributing factors to variations in the dental procedure volumes since reopening, we chose dental practice as the unit of analysis. The outcome was total number of procedures performed at dental practices each week from May through August 2019 and 2020. We evaluated variations in the procedure volume by practice-level variables, including mean age of the patients, insurance type (private, public), number of dentists at the practice, SIP order status, and year. Year was coded as 0 and 1, with 0 indicating 2019. Other demographic and socioeconomic variables pertaining to patients who received care at dental practices, such as race or ethnicity, and the type of facility (federally qualified health centers ([FQHC], private practices) that

ABBREVIATION KEY

FQHC: Federally qualified health centers.
SIP: Shelter in place.

Table 1. Characteristics of studied dental practices.

CHARACTERISTIC	DATA
Practices, Total No.	26,042
Dentists per Practice, Mean No. (Standard Deviation)	1.33 (1.39)
Practice Size, No. of Providers, %	
0-5	99.1
6-20	0.87
21-100	0.03
Patient Age,*Y, Mean (Standard Deviation)	41.0 (10.8)
Patient Age Groups,* Y, %	
0-2	1.29
3-5	6.04
6-17	27.78
18-64	55.34
65-74	6.42
≥ 75	3.13
Patient Sex, Male,*%	47.8
US Census Region, %	
South	34.39
Midwest	15.40
Northeast	18.23
West	31.97
Dental Care Providers, Total No.	34,333
Counties, No.	1,906
States, No.	50 states and the District of Columbia

* Patient characteristics were obtained from patient information associated with each procedure.

are potentially associated with dental care use were not available in the data.[16] Because dental practice patterns vary by economic factors that can be captured at the county level, we included county-level factors in the analysis. We identified counties on the basis of Federal Information Processing Standard codes and assigned beneficiaries to the county associated with their index claim. County-level variables were constructed using the Area Health Resource File data and changed over time: dental Health Professional Shortage Area (none, partial, whole county based on population to provider ratio, percentage of population below 100% federal poverty guidelines, water fluoridation status, travel time to nearest source of care)[17], median household income, and percentages of Black, Hispanics, unemployed, urban population, population in poverty, and population with less than a high school education.[18] We used variance inflation factors and the Farrar-Glauber test to assess multicollinearity and removed the covariates with the highest variance inflation factors (unemployment, poverty).

Analytical approach

To evaluate changes in dental care use (total number of dental procedures) due to the COVID-19 pandemic, accounting for the overall dental care use difference between 2019 and 2020, we adjusted dental care use in 2020 by the percentage difference in use on the first week of March; this approach allowed us to maintain the first week of March as the baseline for our analysis, a representative week among the practices before the effects of the pandemic were felt. We adjusted for visits on holidays as well. After adjusting for seasonality and trends, we calculated descriptive statistics on a weekly basis as percentage changes in procedure-level dental care use in 2020 compared with 2019 by patient age, geographic area, practice size, procedure type, SIP order status, and insurance plan.

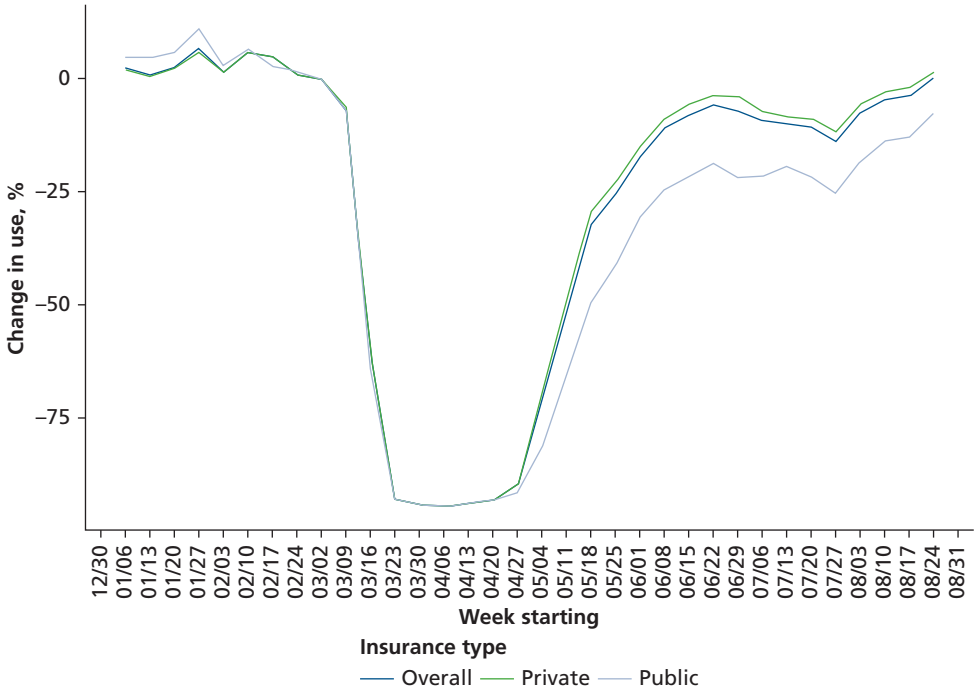


Figure 1. Percentage changes in dental care use by insurance type. Percentage changes calculated as changes in the number of procedures compared with those performed in the same week in 2019.

As a secondary analysis, we estimated hierarchical linear regression models relating the total number of procedures performed at dental practices since reopening in May 2020 with practice-level and county-level covariates (details in the Appendix, available online at the end of this article). A random intercept for practices and counties nested within states as well as a random slope for the year effect at the county and state level permitted variations in the volume of procedures for repeated measures within each practice and for geographic location. The hierarchical model empirically estimated the within-group versus between-group components of variation in procedure volumes, correctly modeling for correlated errors. We rescaled continuous variables to be centered around the means. In a first set of models, we included only practice-level covariates (mean age of patients, number of dentists at practice, insurance type, SIP order status, year, interactions between year and the rest of practice-level covariates). We allowed the intercepts (representing average total number of procedures performed under private insurance at dental practices in 2019) to vary across practices, counties, and states in a nested structure. We assumed year coefficients (representing changes in procedure volumes performed under private insurance in 2020 since the reopening) to vary across counties nested within states. In a second set of hierarchical models, we included county-level covariates and cross-level interactions between year and the county-level covariates. We selected the best-fitting models as those with the smallest Akaike information criterion values.

The variance components associated with the random intercepts and year effects provide an estimate of between-group variation. To determine whether changes in procedure volume differed across practices, counties, and states, we examined the statistical significance of the associated variance components. For example, a statistically significant year variance component at the county level implies the rebound in procedure volume differs significantly across counties. We estimated all models using statistical software (R, Version 3.6.1, Revolution Analytics).

RESULTS

Characteristics of dental practices

Deidentified dental practice management data included 26,042 dental practices nationwide and 34,333 dental care providers in years 2019 and 2020 (Table 1 and Appendix, available online at the end of this article). From January 1 through August 31 in 2019 and 2020, 269 million dental procedures were performed (156 million procedures in 2019 and 113 million procedures in 2020).

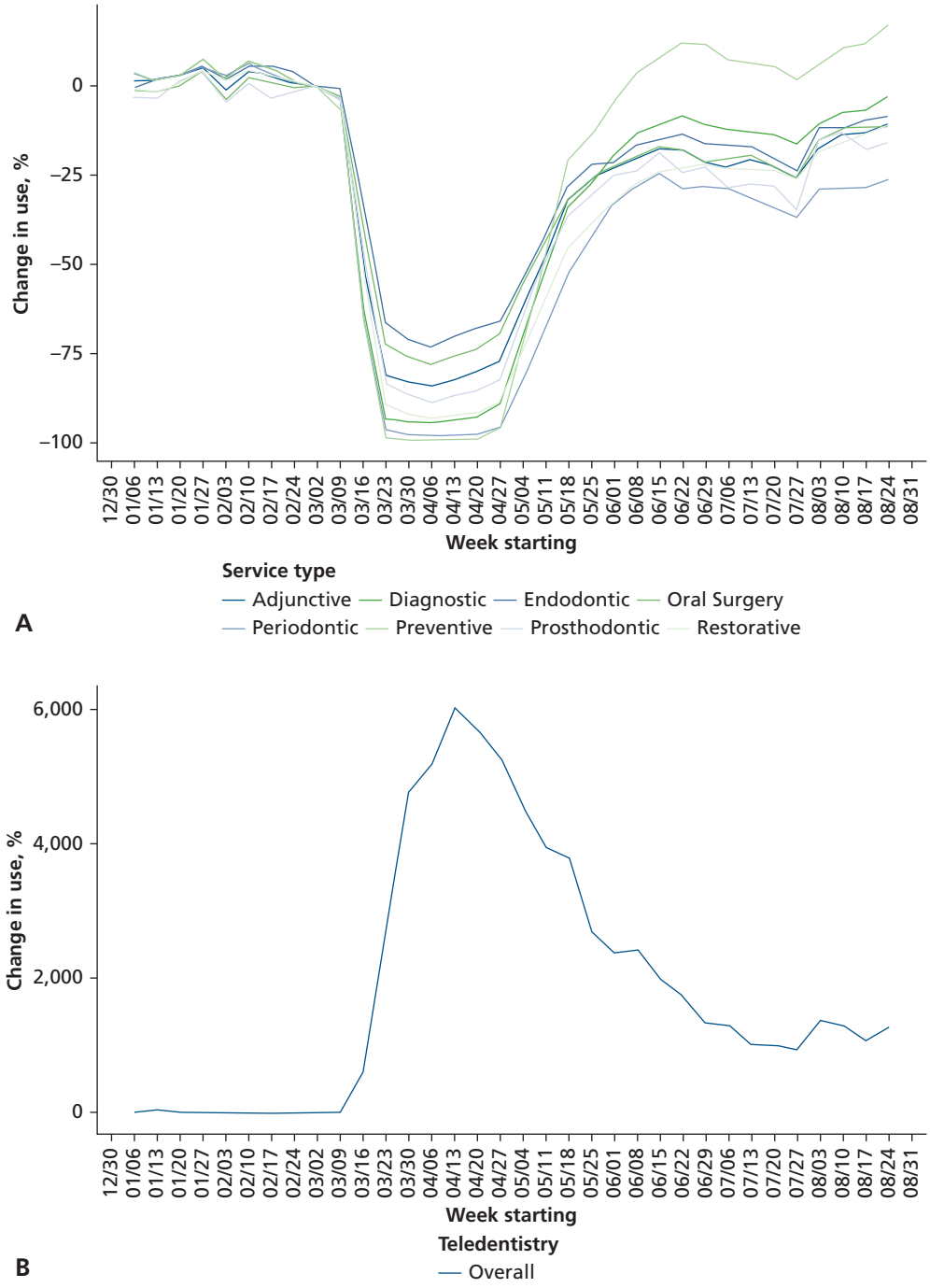


Figure 2. Percentage changes calculated as changes in the number of procedures as compared to those performed in the same week in 2019. All procedure types excluding teledentistry (**A**), and teledentistry procedures (**B**).

Our sample included 1,906 counties with at least 1 dental practice in the 50 states and the District of Columbia.

Changes in dental care use due to COVID-19

Starting in the week of March 9, 2020, dental care use started to decrease and reached the nadir during the week of April 6; a 94.5% decrease in use was seen compared with the previous year (Figure 1). After the reopening, dental care use began to rebound at a faster rate among the privately insured population than the publicly insured population. Use of dental services by privately insured patients fully rebounded during August, slightly exceeding prepandemic levels; however, among publicly insured patients, dental care use remained lower than the prepandemic level by 7.54% during the last week of August.

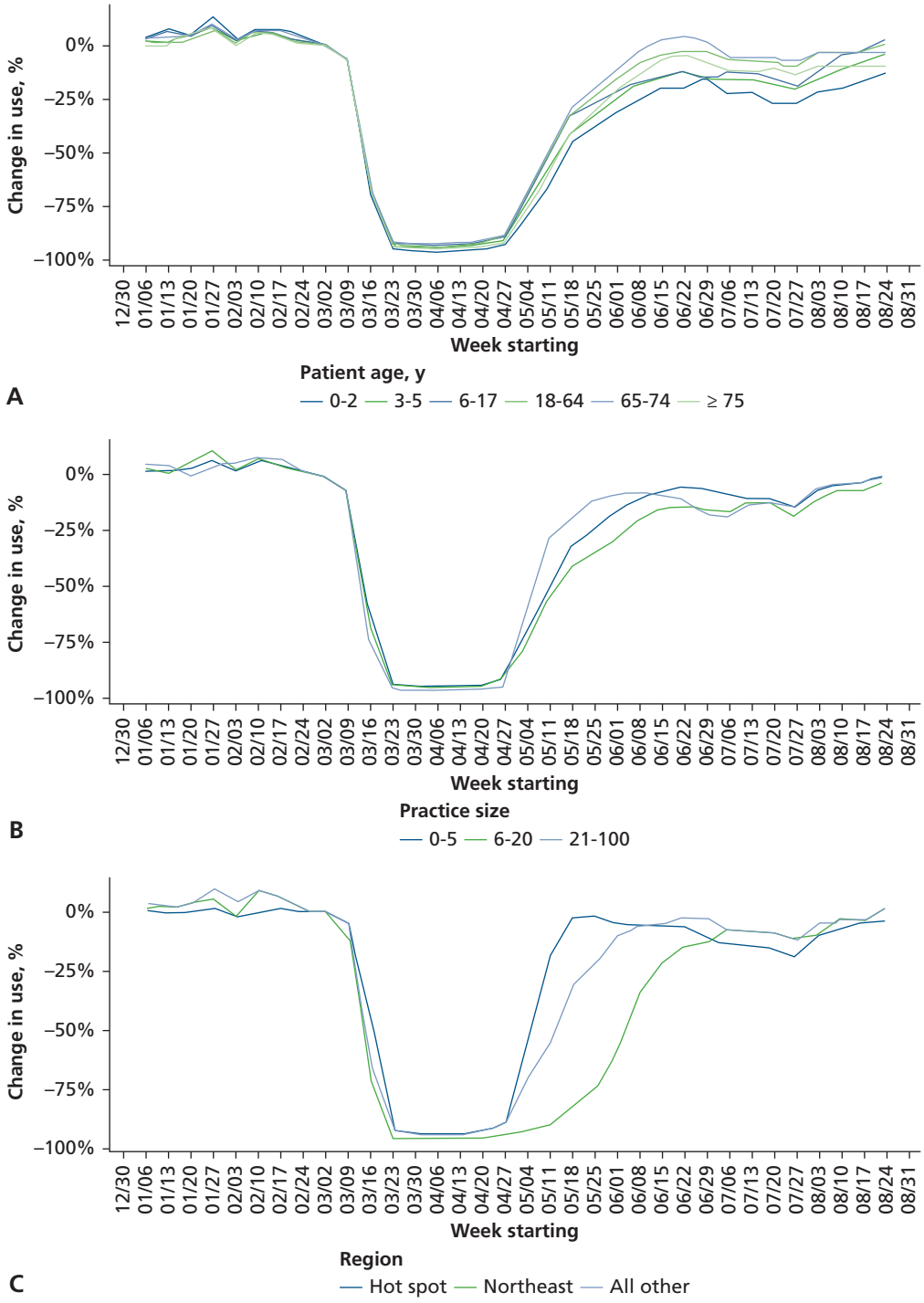


Figure 3. Percentage changes in use by age (**A**), practice size (**B**), region (**C**), and shelter-in-place (**D**) order status. Percentage changes calculated as changes in the number of procedures compared with those performed in the same week in 2019. The regions were hot spot (9 states in terms of new cases per capita from June-August 2020: Texas, Florida, Georgia, Arizona, North Carolina, Tennessee, Louisiana, Alabama, and South Carolina [Source: Centers for Disease Control and Prevention[15]]); Northeast; and all other states. The following states, along with the District of Colombia, ended SIP orders after mid-May: Arizona, California, Delaware, Florida, Hawaii, Illinois, Indiana, Louisiana, Maryland, Maine, Michigan, Minnesota, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Ohio, Oregon, Pennsylvania, Vermont, Virginia, Washington, Wisconsin.

During the SIP period of March and April 2020, dental care use rates were lowest for preventive, periodontic, and diagnostic services, resulting in more than 94% decreases in use, whereas use of endodontic services and oral surgery (including tooth extraction) were relatively higher (Figure 2). After the reopening, preventive services were in the greatest demand, exceeding prepandemic levels

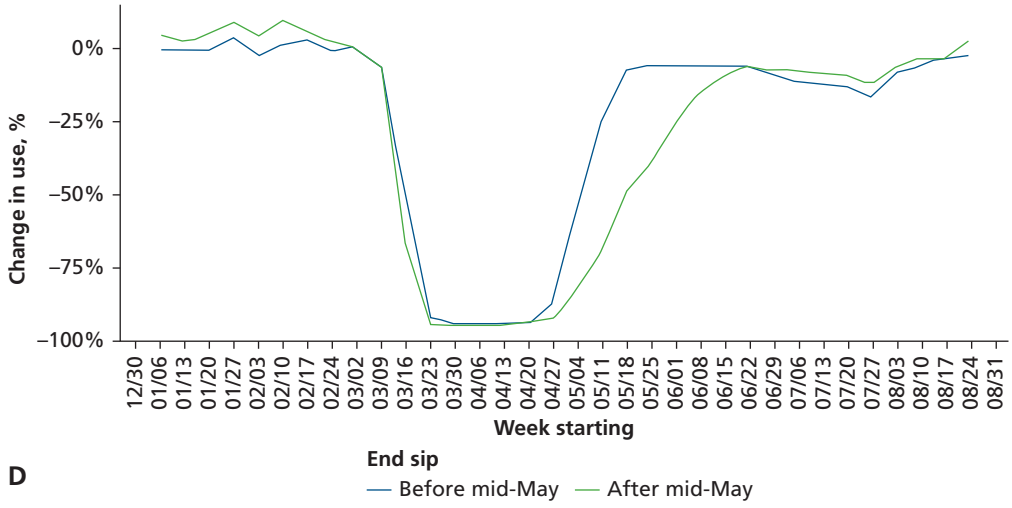


Figure 3. (Continued)

in June 2020, followed by diagnostic services. Use of teledentistry, a relatively new practice on the rise for dentists mostly providing dental consultation and treatment planning, substantially increased during the SIP period; it increased up to 60 times the prepandemic level in April 2020. Although teledentistry use decreased after the reopening, the use rate remained 12.7 times higher in the last week of August 2020 than the same period in 2019.

Changes in dental care use differed by multiple factors at individual, practice, and regional levels (Figure 3). After the reopening, children and seniors ($\geq$ 75 years) started receiving oral health care at substantially lower rates than other age groups; dental care use among patients aged 0 through 2 years and 75 years and older remained 10% lower than the prepandemic levels during the last week of August. Large group dental practices (21-100 providers) gained patient volumes at a faster rate than mid- and small-sized dental practices after practices reopened in May, and patient volumes fully rebounded by the last week of August for large and small group practices. At the regional level, in hot spot states (top 9 states in new cases per capita from June-August 2020), patient volume rebounded at the fastest rate in May and decreased slightly in July.

After the reopening of most outdoor activities in the United States in May 2020, the average number of procedures performed under private insurance at a dental practice was 26.91 (95% CI, −31.80 to −22.02) lower per week than the average performed in 2019, which is approximately a 19.8% relative reduction from 2019, adjusting for other practice-level covariates (Table 2). Results from models with a single practice-level covariate and year terms are shown in eTable 2, available online at the end of this article. The number of procedures performed under public insurance was reduced even further: 37.26 fewer procedures weekly per practice, which is a 52.9% relative reduction from 2019, adjusting for other practice-level covariates. The average number of procedures performed by a single dental care provider was lower in 2020 than in 2019: 1.73 (95% CI, −2.06 to −1.39) fewer procedures performed per provider per week. Changes in procedure volume differed across practices, counties, and states with statistically significant variance components with *P* values less than .05.

We found county-level covariates to be associated significantly with the number of procedures performed at dental practices. County-level median household income, percentage of population in an urban area, and whole-county dental professional shortage designations were associated with the number of procedures performed at dental practices even before the outbreak of the pandemic. After the pandemic, counties with higher percentages of Blacks and partial-county dental professional shortage designations experienced further decreases in the volume of procedures (Table 2). We observed more between-practice variation than between-county or between-state variation.

DISCUSSION

Demand for dental services, more than for other types of medical interventions, is closely linked to dental insurance and disposable income.[12,13] The current practice model of dentistry serves insured

Table 2. Linear mixed effects regression estimates, May-August 2019 and 2020.

VARIABLE	WITHOUT COUNTY-LEVEL CHARACTERISTICS* (95% CI)	WITH COUNTRY-LEVEL CHARACTERISTICS* (95% CI)
Practice-Level Covariates		
Intercept	156.63 (149.15 to 164.11)	195.17 (170.52 to 219.83)
Mean age of patients, y	−1.68 (−1.72 to −1.63)	−1.69 (−1.73 to −1.64)
Public insurance	−95.38 (−96.84 to −93.92)	−96.13 (−97.61 to −94.67)
Number of dentists	43.45 (42.18 to 44.69)	43.41 (42.13 to 44.67)
Year	−26.91 (−31.80 to −22.02)	−4.62 (−18.28 to 9.04)
Interactions with year 2020		
Mean age of patients, y	0.47 (0.42 to 0.52)	0.47 (0.42 to 0.52)
Public insurance	−10.35 (−12.36 to −8.39)	−10.53 (−12.54 to −8.52)
Number of dentists	−1.73 (−2.06 to −1.39)	−1.71 (−2.06 to −1.37)
Late reopen	−10.09 (−16.85 to −3.33)	−10.71 (−17.35 to −4.07)
County-Level Covariates		
% Black	NA†	−0.20 (−0.51 to 0.10)
% Hispanic	NA	−0.20 (−0.59 to 0.18)
% Urban	NA	0.53 (0.33 to 0.73)
% < High school education	NA	−0.58 (−1.52 to 0.38)
Median (standard deviation) household income (in thousands), $	NA	0.50 (0.78 to 0.21)
Dental professional shortage (partial county)	NA	−5.39 (−14.66 to 3.89)
Dental professional shortage (whole county)	NA	−9.89 (−19.17 to −0.61)
Interactions with year 2020		
% Black	NA	−0.31 (−0.51 to −0.10)
% Hispanic	NA	−0.13 (−0.38 to 0.12)
% Urban	NA	0.04 (−0.07 to 0.15)
% < high school education	NA	−0.32 (−0.86 to 0.21)
Median (standard deviation) household income (in thousands), $	NA	−0.12 (−0.33 to 0.09)
Dental professional shortage (partial county)	NA	−8.36 (−15.89 to −0.83)
Dental professional shortage (whole county)	NA	−3.46 (−13.38 to 6.45)
Variance	Practice variance: 0.477 County variance: 0.043 State variance: 0.005	Practice variance: 0.477 County variance: 0.042 State variance: 0.005
R^2,‡ %	57.6	57.7

* Entries are point estimates with 95% CIs. Point estimates are changes in the weekly number of procedures performed at dental practices per 1-unit changes in the covariates. For interaction terms, estimates represent relative changes in 2020 compared with the reference group in 2020. For example, the point estimate of the interaction term between public insurance and year 2020, −10.35 (95% CI, −12.36 to −8.39), can be interpreted as 10.35 fewer procedures performed under public insurance compared with procedures performed under private insurance in 2020 and, thus, 37.47 less procedures (adding estimates for the year, −26.91 [95% CI, −31.80 to −22.02], and interaction term between year and public insurance, −10.35 [95% CI, −12.36 to −8.39]) under public insurance in 2020 versus 2019. † NA: Not applicable. ‡ Percentage of variance explained by the entire model.

patients or patients who have the disposable income to pay for services out of pocket.[19] In addition, dental insurance in the United States is largely an indemnity plan with coverage for prevention but not treatment, so even patients with insurance often cover a meaningful portion of the cost. Because the practice model is strikingly different from the overall medical system, it is important to understand the impact of the COVID-19 pandemic on dental care use to consider potential solutions to maintain dental practices and, furthermore, the oral health of the population, especially among vulnerable groups. Using nationwide dental practice management data, our study found that

although dental care use among privately insured people fully rebounded by August 2020, it remained lower than the prepandemic level among the publicly insured population. Geographic characteristics, such as county-level median household income, percentages of rural or Black populations, or dental care professional shortage designation, also were associated significantly with the number of procedures performed at dental practices.

The results of our study show that dental care use among the publicly insured population remained lower than the prepandemic level, and patients in counties with partial dental professional shortage designations and a higher proportion of Blacks experienced lower dental care use than the prepandemic level. Oral health care presents the highest level of financial barriers compared with other health care services, particularly for people who are publicly insured or uninsured or in underserved areas.[20] Considering the disproportionate burden of the pandemic on low-skill workers, the COVID-19 pandemic is likely to raise inequality,[21,22] and without coverage to reduce the cost of dental services or increasing the supply of dentists or midlevel dental care providers in underserved areas, receiving oral health care will be a greater burden for the population affected by COVID-19, exacerbating already profound oral health care disparities in the United States.[23]

With the ongoing COVID-19 crisis, reducing face-to-face consultations can reduce the risk of experiencing infection, and teledentistry may present a potential solution for future practice. We observed that the demand for teledentistry increased 60-fold during the closure of dental practices, and even after the reopening, the demand still remains approximately 10 times higher than the prepandemic levels. This is significantly higher than telemedicine, which settled to only approximately 7% higher than the prepandemic level.[4] Given the procedural nature of dentistry, the role of telehealth has not been developed fully within dentistry. Before the COVID-19 pandemic, only California provided Medicaid reimbursement for teledentistry billing codes, which still required in-person evaluation and data collection from dental hygienists.[24] The 6 teledentistry billing codes approved by most insurers at the start of the COVID-19 pandemic were intended to facilitate remote triage of dental emergencies with diagnostic services, rather than substituting for needed procedural care.[25] Emergency changes to the Health Insurance Portability and Accountability Act by the US Department of Health and Human Services Office of Civil Rights in the early days of the pandemic also supported adoption, as it allowed providers to use less-secure platforms, including telephone and video chatting software, to conduct visits.[26] Although it remains to be seen whether teledentistry will become a permanent fixture in routine dental practice, assessing the rapidly evolving use of teledentistry and supports needed at the state and national policy level will be critical to enhancing the use of teledentistry and overcoming barriers to oral health care.

Reduced demands in oral health care among publicly insured patients may have a larger impact on practices at FQHCs where patients are disproportionately low-income, publicly insured, or uninsured.[27] FQHC dental programs already are operating on limited margins, and owing to COVID-19, dental staff members have been diverted for COVID-19—related tasks, such as frontline COVID-19 testing[28]; these COVID-19 response efforts combined with reduced demand for dental services may threaten practice viability, reducing further an already insufficient number of dental care providers at FQHCs. Moreover, solo practices and practices run by peri-retirement dentists may experience a greater challenge maintaining viability of their practices. In our study, we observed that larger group practices recovered more quickly than smaller practices, and, thus, this may result in increased consolidation in dentistry. Barriers to personal protection equipment compliance among health care personnel included a lack of time, physical discomfort, and unavailability of equipment[29]; these barriers, as well as being considered a higher-risk group for COVID-19 infection as a result of age, may be more pronounced among practices run by peri-retirement dentists, potentially impacting practice productivity.

Our analysis has several limitations. Because we used a convenience sample of dental practice management data of outpatient patients who are privately or publicly insured, the changes in oral health care use patterns we observed may not be generalizable to all dental practices nationally or regionally or extended beyond August 2020. The observed changes in use patterns do not capture access behaviors among uninsured patients and do not include changes in dental-related emergency department visits. Owing to a lack of data regarding the type of facility, our analysis represents overall practice patterns across the facilities. Investigating changes in procedure volume by the facility type (for example, comparison of rebound in oral health care in FQHCs versus private

practices) would be an area for future research. Like with any observational study, there may be unmeasured variables that confound the association between covariates and changes in dental care use, such as patient characteristics (the demographics and socioeconomic status among the patients each practice served) as well as provider characteristics (age, sex, and race of providers in each practice), that could not be included in the model owing to lack of data availability at the patient or provider level. Lastly, because county-level covariates constructed with the Area Health Resource File represent a county average, they may not describe fully the particular geographic area where dental practices are located, and interpretation of associations with dental care use cannot be made at the practice or individual level.

CONCLUSIONS

As a result of COVID-19, dental practices experienced a substantial reduction in patient volume, and dental care use among publicly insured population and patients residing in underserved localities remained lower than the prepandemic level. Disparities in rates of rebounds in procedure volume existed by insurance type and county-level characteristics: dental care professional shortage and race or ethnicity. During economic downturns, state health officials should be encouraged to adopt policies to expand access to oral health care for the vulnerable populations via oral health promotion strategies and increasing the supply of dentists or midlevel dental care providers in underserved areas. ■

SUPPLEMENTAL DATA

Supplemental data related to this article can be found at: https://doi.org/10.1016/j.adaj.2021.07.002.

Dr. Choi is an instructor, Department of Oral Health Policy and Epidemiology, Harvard School of Dental Medicine,188 Longwood Ave REB 204, Boston, MA 02115, email sung_choi@hsdm.harvard.edu. Address correspondence to Dr. Choi.

Dr. Simon is a fellow, Office of Global and Community Health, Harvard School of Dental Medicine, Boston, MA, and a clinical fellow in medicine, Harvard Medical School, Boston, MA.

Dr. Basu is the director of research, Center for Primary Care, Harvard Medical School, Boston, MA.

Ms. Barrow is an associate dean, Office of Global and Community Health, Harvard School of Dental Medicine, Boston, MA.

Disclosures. None of the authors reported any disclosures.

Research reported in this article was supported by the Harvard School of Dental Medicine Initiative to Integrate Oral Health and Medicine. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Harvard School of Dental Medicine.

1. Cutler DM, Nikpay S, Huckman RS. The business of medicine in the era of COVID-19. *JAMA*. 2020;323(20):2003-2004.
2. American Dental Association. ADA interim guidance for minimizing risk of COVID-19 transmission. Accessed May 18, 2020. https://snlg.iss.it/wp-content/uploads/2020/04/ADA_COVID_Int_Guidance_Treat_Pts.pdf
3. Centers for Disease Control and Prevention. Guidance for dental settings. Accessed October 27, 2020. https://www.cdc.gov/coronavirus/2019-ncov/hcp/dental-settings.html
4. Mehrotra A, Chernew M, Linetsky D, Hatch H, Cutler D, Schneider EC. The impact of the COVID-19 pandemic on outpatient care: visits return to prepandemic levels, but not for all providers and patients. The Commonwealth Fund. Accessed February 11, 2021. https://www.commonwealthfund.org/publications/2020/oct/impact-covid-19-pandemic-outpatient-care-visits-return-prepandemic-levels
5. Basu S, Phillips RS, Phillips R, Peterson LE, Landon BE. Primary care practice finances in the United States amid the COVID-19 pandemic. *Health Aff (Millwood)*. 2020;39(9):1605-1614.
6. Berkowitz SA, Basu S. Unmet social needs and worse mental health after expiration of COVID-19 federal pandemic unemployment compensation. *Health Aff (Millwood)*. 2021;40(3):426-434.
7. Berkowitz SA, Basu S. Unemployment insurance, health-related social needs, health care access, and mental health during the COVID-19 pandemic. *JAMA Intern Med*. 2021;181(5):699-702.
8. Skyrud K, Telle K, Magnusson K. Impacts of COVID-19 on long-term health and health care use. medRxiv. June 15, 2021. Preprint. Withdrawal status: active. https://doi.org/10.1101/2021.02.16.21251807
9. Birkmeyer JD, Barnato A, Birkmeyer N, Bessler R, Skinner J. The impact of the COVID-19 pandemic on hospital admissions in the United States. *Health Aff (Millwood)*. 2020;39(11):2010-2017.
10. COVID-19 Economic impact of COVID-19 on dental practices: results for private practice dentists. Accessed April 25, 2021. https://www.ada.org/en/science-research/health-policy-institute/covid-19-dentists-economic-impact/private-practice?&utm_source=adaupdate&utm_medium=email&utm_content=cv-hpi-view-latest-results&utm_campaign=covid-19
11. FAIR Health. Dental services and the impact of COVID-19: an analysis of private claims. Accessed April 1, 2021. https://mma.prnewswire.com/media/1274933/Dental_Services_and_the_Impact_of_COVID_19___An_Analysis_of_Private_Claims___A_FAIR_Health_Brief.pdf?p=pdf
12. Sikka V, Savin G. The impact of the financial crisis on the U.S. dental industry. Accessed November 5, 2020. https://www.dentaleconomics.com/money/article/16390429/the-impact-of-the-financial-crisis-on-the-us-dental-industry
13. Burgette JM, Weyant RJ, Ettinger AK, Miller E, Ray KN. What is the association between income loss during the COVID-19 pandemic and children's dental care? *JADA*. 2021;152(5):369-376.
14. Guarnizo-Herreno CC, Wehby GL. Explaining racial/ethnic disparities in children's dental health: a decomposition analysis. *Am J Public Health*. 2012;102(5):859-866.
15. Centers for Disease Control and Prevention. COVID-19 case surveillance public use data. Accessed November 5, 2020. https://data.cdc.gov/Case-Surveillance/COVID-19-Case-Surveillance-Public-Use-Data/vbim-akqf
16. Flores G, Lin H. Trends in racial/ethnic disparities in medical and oral health, access to care, and use of services in US children: has anything changed over the years? *Int J Equity Health*. 2013;12:10.
17. Health Resources and Services Administration. Scoring shortage designation. Accessed August 17, 2020. https://bhw.hrsa.gov/shortage-designation/hpsa-criteria
18. Health Resources and Services Administration. Area Health Resources Files (AHRF). Accessed July 17, 2019. https://data.hrsa.gov/topics/health-workforce/ahrf
19. Mertz E, O'Neil E. The growing challenge of providing oral health care services to all Americans. *Health Aff (Millwood)*. 2002;21(5):65-77.
20. Vujicic M, Buchmueller T, Klein R. Dental care presents the highest level of financial barriers, compared to other types of health care services. *Health Aff (Millwood)*. 2016;35(12):2176-2182.

21. Inequality and the COVID-19 crisis. University of Chicago Booth. Accessed June 21, 2020. http://www.igmchicago.org/surveys/inequality-and-the-covid-19-crisis/

22. The impact of coronavirus on households in major U.S. cities. NPR. Accessed April 3, 2021. https://media.npr.org/assets/img/2020/09/08/cities-report-090920-final.pdf

23. Choi SE, Simon L, Riedy CA, Barrow JR. Modeling the impact of COVID-19 on dental insurance coverage and utilization. *J Dent Res*. 2021;100(1):50-57.

24. Hernandez D. California to launch Medicaid-funded teledentistry. Kaiser Family Foundation. Accessed November 25, 2020. https://khn.org/news/california-to-launch-medicaid-funded-teledentistry/

25. American Dental Association. COVID-19 coding and billing interim guidance: virtual visits. Accessed November 25, 2020. http://www.7dds.org/uploads/files//ADA%20COVID%20Coding%20and%20Billing%20Guidance%2004.03.20.pdf

26. U.S. Department of Health and Human Services. OCR announces notification of enforcement discretion for telehealth remote communications during the COVID-19 nationwide public health emergency. Accessed November 25, 2020. https://www.hhs.gov/about/news/2020/03/17/ocr-announces-notification-of-enforcement-discretion-for-telehealth-remote-communications-during-the-covid-19.html

27. Brian Z, Weintraub JA. Oral health and COVID-19: increasing the need for prevention and access. *Prev Chronic Dis*. 2020;17:E82.

28. National Network for Oral Health Access. Engaging dental staff in COVID19 response efforts. Accessed November 25, 2020. http://www.nnoha.org/nnoha-content/uploads/2020/04/NNOHA-STAR-Center-Engaging-Dental-Providers-Webinar-4-15-20-FINAL.pdf

29. *Preventing Transmission of Pandemic Influenza and Other Viral Respiratory Diseases: Personal Protective Equipment for Healthcare Personnel: Update 2010*. Institute of Medicine; 2011.

APPENDIX. DATA SAMPLE AND DESCRIPTION OF REGRESSION MODEL.

In this study, we used dental practice management data from a national health management services company that helps dental practices with efficient care delivery, including billing and payments, and analyzed the data to describe changes in dental utilization due to the COVID-19 pandemic. The data includes 26,042 provider organizations representing 34,333 dental providers, approximately 17% of providers working in the United States. Our sample included 1,906 counties with at least 1 dental practice in the 50 states and the District of Columbia.

The billing data aggregated at the procedure level by dental providers and practice were derived from practice management software on a weekly basis from January 1 through August 31 in 2019 and 2020 and used for the analysis.

To examine whether rebound in the procedure volumes at dental practices varies by geographic location, such as counties, and whether the observed variation is related to practice-level and county-level characteristics, we estimated a hierarchical regression model that quantifies the change in the number of dental procedures performed at dental practices per week from May through August in 2019 and 2020. We defined *utilization* as the number of procedures performed at dental practice k that is located in county j and state i.

First model (practice-level covariates only):

$$\begin{aligned}\text{Utilization}_{ijk} &= \beta_{0ijk} + \beta_{1ijk}\text{MeanAge}_{ijk} + \beta_{2ijk}\text{Public}_{ijk} + \beta_{3ijk}\text{Year}_{ijk} + \beta 4_{ijk}\text{Num\_Dentist}_{ijk} \\ &\quad + (\text{Interactions with Year}) + \varepsilon_{ijk}\end{aligned}$$

Second model (practice-level and county-level covariates):

$$\begin{aligned}\text{Utilization}_{ijk} &= \beta_{0ijk} + \beta_{1ijk}\text{MeanAge}_{ijk} + \beta_{2ijk}\text{Public}_{ijk} + \beta_{3ijk}\text{Year}_{ijk} + \beta_{4ijk}\text{Num\_Dentist}_{ijk} \\ &\quad + (\text{Interactions with Year}) + \beta_{8ijk}\text{Prop\_AfricanAmerican} + \beta_{9ijk}\text{Prop\_Hispanic} \\ &\quad + \beta_{10ijk}\text{MedianHouseholdIncome} + \beta_{11ijk}\text{Prop\_Urban} \\ &\quad + \beta_{12ijk}\text{Prop\_LessthanHighSchoolEdu} + \beta_{13ijk}\text{Dentist\_shortage} + \varepsilon_{ijk}\end{aligned}$$

With a random intercept for practice and county nested within states as well as a random slope for the year effect at county level nested within states.

eTable 1. Procedure type and CDT codes.*

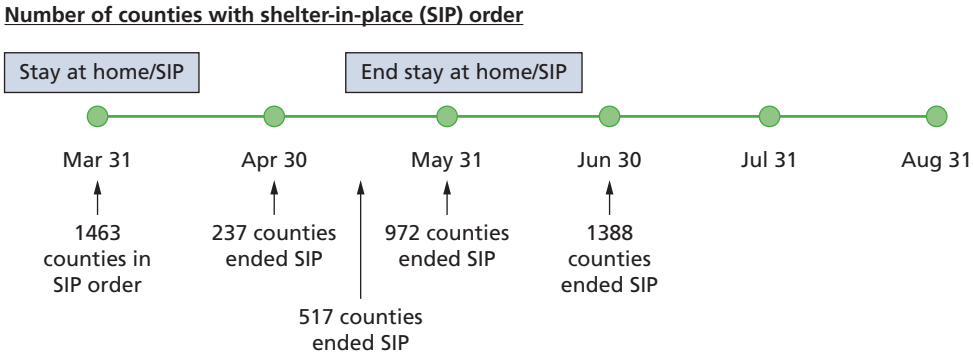
PROCEDURE TYPE	CDT PROCEDURE CODE
Diagnostic	D0100-D0999
Preventive	D1100-D1999
Restorative	D2000-D2999
Endodontic	D3000-D3999
Periodontic	D4000-D4999
Prosthodontic	D5000-D5999, D6200-D6999
Implant	D6000-D6199
Oral Surgery	D7000-D7999
Orthodontic	D8000-D8999
Adjunctive General†	D9000-D9999

* Dental procedures types were defined by the Code on Dental Procedures and Nomenclature (CDT Code)[e1,e2] as shown in this table. † Teledentistry procedures were identified as claims with procedure codes D9995 and D9996 and were excluded from the above-defined adjunctive general category.

eTable 2. Comparison of regression estimates.*

VARIABLE	FULLY ADJUSTED MIXED EFFECT MODEL (95% CI)	FULLY ADJUSTED LINEAR MODEL WITH CLUSTERED STANDARD ERRORS (95% CI)	MEAN AGE X YEAR MIXED EFFECTS MODEL (95% CI)	PUBLIC INSURANCE X YEAR MIXED EFFECT MODEL (95% CI)	NO. OF DENTISTS X YEAR MIXED EFFECT MODEL (95% CI)	REOPEN STATUS X YEAR MIXED EFFECT MODEL (95% CI)
Practice-Level Covariates						
Mean age of patients	−1.68 (−1.72 to −1.63)	−1.62 (−2.02 to −1.23)	−1.10 (−1.14 to −1.06)	NA†	NA	NA
Public insurance	−95.38 (−96.84 to −93.92)	−88.42 (−98.18 to −78.65)	NA	−100.20 (−102.80 to −89.93)	NA	NA
Number of dentists	43.45 (42.18 to 44.69)	41.12 (28.69 to 53.55)	NA	NA	39.38 (38.25 to 40.51)	NA
Year	−26.91 (−31.80 to −22.02)	−29.45 (−50.27 to −8.64)	−40.16 (−44.37 to −35.74)	−19.33 (−17.46 to −10.44)	−15.81 (−17.58 to −10.59)	−13.05 (−16.55 to −9.32)
Interactions With Year 2020						
Mean age of patients	0.47 (0.42 to 0.52)	0.59 (0.36 to 0.83)	0.57 (0.42 to 0.52)	NA	NA	NA
Public insurance	−10.35 (−12.36 to −8.39)	−13.50 (−20.57 to −6.42)	NA	−11.99 (−15.31 to −8.66)	NA	NA
Number of dentists	−1.73 (−2.06 to −1.39)	−2.31 (−4.27 to −0.36)	NA	NA	−2.95 (−3.33 to −2.05)	NA
Late reopen	−10.09 (−16.85 to −3.33)	−11.22 (−14.76 to −7.68)	NA	NA	NA	−11.00 (−17.47 to −4.53)
R^2,‡ %	57.7	NA	54.3	53.8	50.4	49.1

* Results from models with year and single practice-level covariate were compared with estimates from a fully adjusted model. † NA: Not applicable. ‡ Percentage of variance explained by the entire model.



DATE	STATES THAT ENDED SIP ORDER
4/27/20	AK, CO, MS, MT
5/4/20	AL, AK, CO, GA, ID, KS, MS, MO, MT, SC, TN
5/11/20	AL, AK, CO, GA, ID, KS, MS, MO, MT, NV, RI, SC, TN, WV
5/18/20	AL, AK, AZ, CO, FL, GA, ID, IN, KS, LA, MD, MA, MN, MS, MO, MT, NV, RI, SC, TN, VT, WV, WI
5/25/20	AL, AK, AZ, CO, FL, GA, ID, IN, KS, LA, MD, MA, MN, MS, MO, MT, NV, NC, OH, RI, SC, TN, VT, WV, WI
6/1/20	AL, AK, AZ, CO, DE, DC, FL, GA, HI, ID, IL, IN, KS, LA, ME, MD, MA, MI, MN, MS, MO, MT, NV, NC, OH, RI, SC, TN, VT, VA, WA, WV, WI
6/8/20	AL, AK, AZ, CO, DE, DC, FL, GA, HI, ID, IL, IN, KS, LA, ME, MD, MA, MI, MN, MS, MO, MT, NV, NC, OH, PA, RI, SC, TN, VT, VA, WA, WV, WI
6/15/20	AL, AK, AZ, CO, DE, DC, FL, GA, HI, ID, IL, IN, KS, LA, ME, MD, MA, MI, MN, MS, MO, MT, NV, NJ, NC, OH, PA, RI, SC, TN, VT, VA, WA, WV, WI
6/22/20	AL, AK, AZ, CO, DE, DC, FL, GA, HI, ID, IL, IN, KS, LA, ME, MD, MA, MI, MN, MS, MO, MT, NV, NH, NJ, NC, OH, OR, PA, RI, SC, TN, VT, VA, WA, WV, WI
6/29/20	AL, AK, AZ, CO, DE, DC, FL, GA, HI, ID, IL, IN, KS, LA, ME, MD, MA, MI, MN, MS, MO, MT, NV, NH, NJ, NY, NC, OH, OR, PA, RI, SC, TN, VT, VA, WA, WV, WI

eFigure. SIP orders across the states. Only SIP orders containing language that ordered people to stay at home were considered. The following states, along with the District of Colombia, that ended SIP orders after mid-May (week starting May 18) were considered as late reopen: AZ, CA, DE, FL, HI, IL, IN, LA, ME, MD, MA, MI, MN, NH,NJ, NM, NY, NC, OH, OR, PA, VT, VA, WA, WI.

e1. American Dental Association. Code on Dental Procedures and Nomenclature (CDT Code). Accessed Mar 20, 2019. https://www.ada.org/en/publications/cdt

e2. Agency for Healthcare Research and Quality. Medical expenditure panel survey. Accessed March 20, 2019. https://meps.ahrq.gov/data_stats/download_data_files.jsp

e3. Centers for Disease Control and Prevention. COVID-19 case surveillance public use data. Accessed November 5, 2020. https://data.cdc.gov/Case-Surveillance/COVID-19-Case-Surveillance-Public-Use-Data/vbim-akqf