CareQuest Institute for Oral Health™

RESEARCH REPORT

An Evaluation of

COVID-19 Impacts on Dental Office Visits

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Authors

Mary Bayham, MPH
Practice Improvement Trainer
CareQuest Institute for Oral Health

Annaliese Cothron, MS
Executive Director, American Institute of Dental Public Health
Senior Advisor, CareQuest Institute for Oral Health

Sean Boynes, DMD, MS
Vice President, Health Improvement
CareQuest Institute for Oral Health

Ilya Okunev, MS
Biostatistician
CareQuest Institute for Oral Health

Jude Bayham, PHD
Assistant Professor, Department of Agriculture and Resource Economics Colorado State University Department of Epidemiology
Assistant Professor, Colorado School of Public Health

Acknowledgments

Christine B. Kavanagh, RD, MSN, PPCNP-BC
Nursing Faculty
Pennsylvania College of Technology

Mark Deutchman, MD
Professor, Department of Family Medicine
Associate Dean for Rural Health
Director, School of Medicine Rural Track Program University of Colorado School of Medicine

David Krol, MD, MPH
Vice President for Health Initiatives Child Health and Development Institute
Medical Director Connecticut Children's Care Network

Background

The spread of COVID-19 and the resulting pandemic has created significant social and economic disruptions in many sectors, including dental care. Efforts to stem the spread of COVID-19 and preserve personal protective equipment resulted in most states restricting dental care to urgent and emergent cases. This closure of dental offices produced a sharp decline in patient visits and revenue for the dental industry.[1,2] When lockdown orders were lifted and dental offices could reopen, surveys completed by dentists revealed increasing office visits by dental patients.[1,3,4] As the pandemic continues, the frequency and mobility of patients accessing oral health care at dental offices is of particular interest. As such, the authors completed an analysis of aggregate patient mobility data evaluating personal smart device positioning and dental office locations to illustrate effects of the early COVID-19 response.

Purpose and Significance

COVID-19 has greatly shifted the U.S. economy, particularly within the health care system. Although dental care is a critical primary care service, it was not generally deemed essential during the initial response to the pandemic. As a result, lockdown policies had dramatic impacts on dental offices and the businesses that rely on dental care visits to increase consumer presence. As a means of investigating the impact of COVID-19 and shelter in place orders on behaviors associated with dental office visitation, we conducted an analysis of dental patient travel and visitation patterns using personal device positioning within a registered dental care site.

Prior to the current analysis, patient mobility patterns of accessing dental care had not been assessed using aggregate mobile device data. Even before COVID-19, geographic barriers to accessing oral health care were an important contributing social risk factor to oral health inequity.[5] Exploring patient mobility patterns and longitudinal trends during shutdown months now that closures have been lifted can help dental offices support patient needs and invest in community influences like strategic health messaging.

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Data and Methods

Understanding patient visitation patterns during the COVID-19 pandemic is especially important to oral health. Dental office closures impacted the time, driving distance, and frequency of patient visits. To evaluate this impact, the DentaQuest Partnership used mobile device location data from SafeGraph to analyze dental patient mobility patterns from January 1, 2020 until September 9, 2020. All data analysis was conducted using the R Statistical Computing language.

SafeGraph is a data company that produces aggregated and anonymized mobile device data. SafeGraph aggregates anonymized mobile device data that can be used to understand movement patterns during the COVID-19 pandemic.[6-8] To preserve anonymity, SafeGraph applies differential privacy techniques to add "noise," or variation, to the large dataset. In essence, meaningless data is added to a deidentified dataset to reduce the opportunity for matching data back to an individual. This is a best practice technique for big data security and privacy.[9] After integrating data with the values, only attributes with at least two devices were considered for the analysis. Location data is collected when location services are permitted in participating personal device applications that are undisclosed to SafeGraph.

This evaluation did not test formulated hypotheses, but instead explored implications of changing trends in dental office visits and mobility patterns around dental office visits using aggregated mobile device data. For this analysis, over 5 million points of interest were examined in the full dataset, of which nearly 100,000 were classified as dental offices. Using this subset of data, three facets of patient mobility patterns stratified by metropolitan and nonmetropolitan areas were examined: 1) visitation to dental offices, 2) distance traveled from home location to the dentist office, and 3) other locations visited on the same day.

Visitation to dental offices

Visitation is measured by counting the number of geolocated points recorded from a mobile device that fall within the building perimeter. The rate of visitation was calculated by dividing the number of reported visits by the total number of devices in the sample. This visitation rate effectively controls for the change in the sample size over time and more accurately describes changes in visitation patterns.

Distance traveled to a dental office

Safegraph also reports median distance from home for all visits to a particular dental office over the course of a week. To protect privacy, the distance traveled measure is only reported for a location when there are more than five total visits to the dentist office location in a given week. For this analysis, distance traveled is defined as the "haversine distance" (as the crow flies) between a device's home location (not reported in the data) and the dental office. Weekly trends in distance traveled for all of the nearly 100,000 dental offices across the country were then explored for this analysis. (See Appendix for more details on this measurement.)

Same day locations visited

The SafeGraph data report the popularity (measured by visit frequency) of national brand-name locations visited on the same day as the dental office visit. (See Technical Appendix for details.) An average popularity index of other brands visited across all dental locations were calculated for this analysis. The brands then were ranked in order to compare their popularity in the same month between 2019 and 2020.

Stratifying metropolitan and nonmetropolitan areas

Frequency of dental office visits, distance traveled, and same-day locations were analyzed by metropolitan/nonmetropolitan counties. Counties are classified as metropolitan and nonmetropolitan based on the Centers for Disease Control and Prevention classification scheme.[10] Specifically, we classify a county as metropolitan if the Office of Management and Budget's (OMB) February 2013 delineation is equal to 1 (large central metropolitan) through 4 (small metropolitan). Results then were aggregated to metropolitan versus nonmetropolitan based on the county in which the dental office is located.

Results

Dental Office Visitation Rate

Personal mobile device location was used to measure the impact of the COVID-19 pandemic on dental care utilization over time as shelter-in-place orders were implemented and then repealed. To address daily fluctuations in the data series, data were "smoothed" (e.g., removing noise from the data to identify patterns more clearly) using locally estimated scatterplot smoothing (LOESS).[11] As seen in Figure 1, the aggregated personal device data indicated that the overall dental office visitation rate decreased from an average of 1.25% in April 2019 to less than 0.75% in the same month of 2020. Figure 1 displays the trends in daily dental office visitation in 2019 and 2020. As phased reopening began to occur across the country, visitation rates increased but were not comparable to the 2019 rates. Figure 2 shows a similar trend in metropolitan and nonmetropolitan counties. The mean visitation rate was just under 1.25% in metropolitan counties in 2019 and just over 1% in nonmetropolitan counties in 2019. Current data trends reveal visitation is again declining as some areas of the country experience a resurgence in COVID-19 transmission.

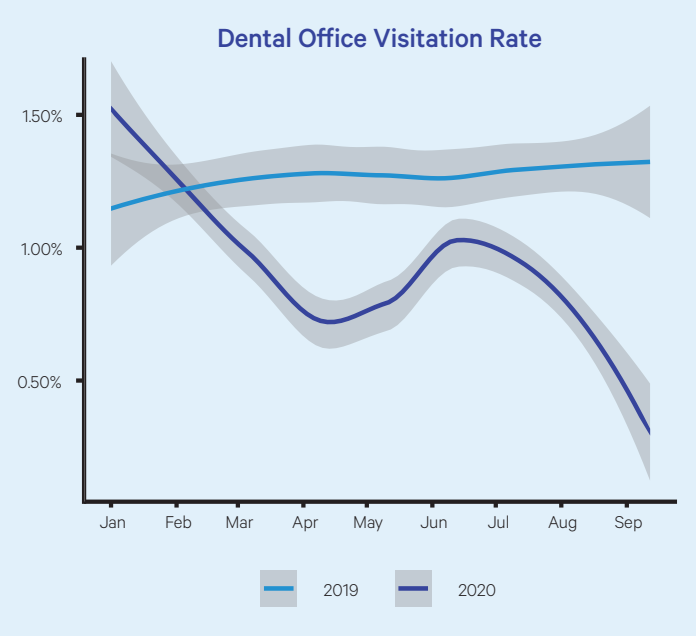

Figure 1. National percentage of smart devices spending time at a dental office. Curves are smoothed time trends and gray bands represent 95% confidence intervals based on day-to-day variation.

Distance Traveled to A Dental Office

Distance traveled increased in 2020 at the beginning of the year before the COVID-19 pandemic began. However, distance traveled declined as visitation declined in April (Figure 3), demonstrating a change in behavior with device locations during dental site travel. The increase in average miles traveled in 2020 relates to an increase observed from January through March, after which a decrease in average miles traveled occurred as shelter-in-place orders were implemented to limit dental care access. A closer analysis of distance traveled revealed that California data had a significant impact on increasing the average miles traveled in 2020 (see Figure 6 in Appendix). Although the authors are not able to investigate this trend further within the scope of the current analysis, it may warrant additional research.

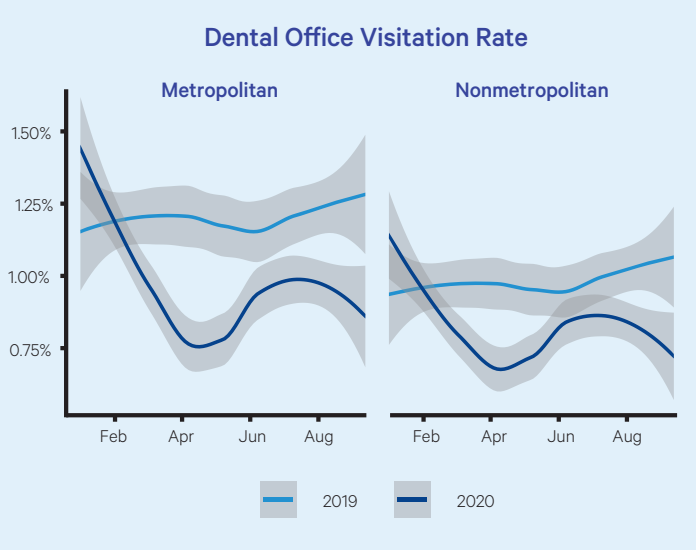

Figure 2. Average county-level percentage of smart devices spending time at dental office. Curves are smoothed time trends and gray bands represent 95% confidence intervals based on day-to-day

Transportation challenges create differences in access to care that generate social and health care disparities. As seen in Figure 4, individuals from nonmetropolitan areas travel more miles on average to a dental office (10 miles) than those in metropolitan areas, regardless of time period (6.9 miles). When evaluating the most up-to-date information on miles traveled with cost per gallon of gasoline ($2.19)12 and average national miles per gallon performance (24.9 miles),13 the estimated cost of gasoline per person is approximately 31% more for nonmetropolitan populations than for metropolitan populations during the timeframe examined (March–July 2020). In nonmetropolitan areas, average distance traveled tends to increase in the summer months. However, average distance traveled during the pandemic fell below the average for 2019 and remained lower throughout summer 2020. Given the significant impact transportation can have on access to care,5 future exploration may be warranted to investigate the year-to-year changes in miles traveled.

Same Day Locations Visited

Using SafeGraph data and publicly-registered address locations, visits to other locations on the same day as visits to a dental office can be investigated (Figure 5). Visit locations were compared by month in 2019 and 2020 to illustrate the impact of COVID-19 on daily routines. Changes were observed that coincide with shelter-in-place orders and the transition in most states from comprehensive dental care availability to urgent care only. While Walmart and McDonalds ranked consistently as the top same-day destinations, home improvement stores (Lowe's and The Home Depot) and gas stations also saw increased visits in 2020. Same-day visits to pharmacies and some casual restaurants declined in 2020 relative to the same month in 2019. Overall, big box retail stores and fast food locations were the most commonly visited same-day sites when a dental office visit occurred, a trend that remained unchanged from 2019 to 2020.

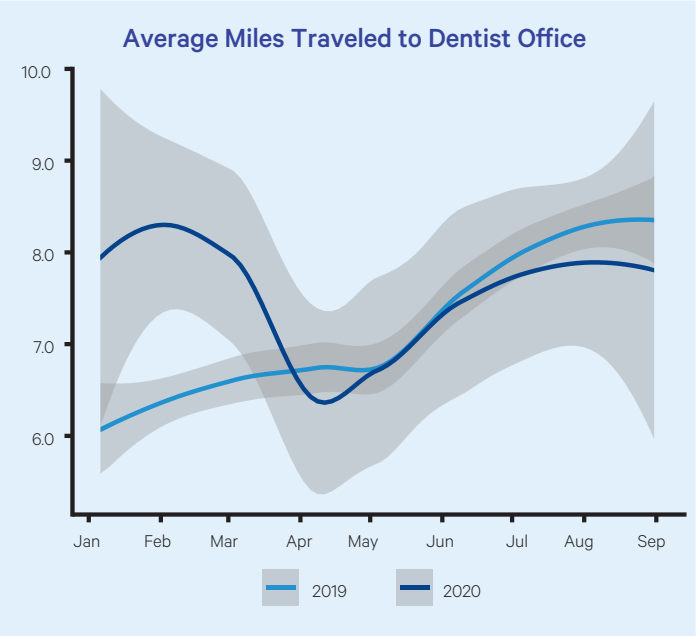

Figure 3. National average distance (miles) from home to dental office.

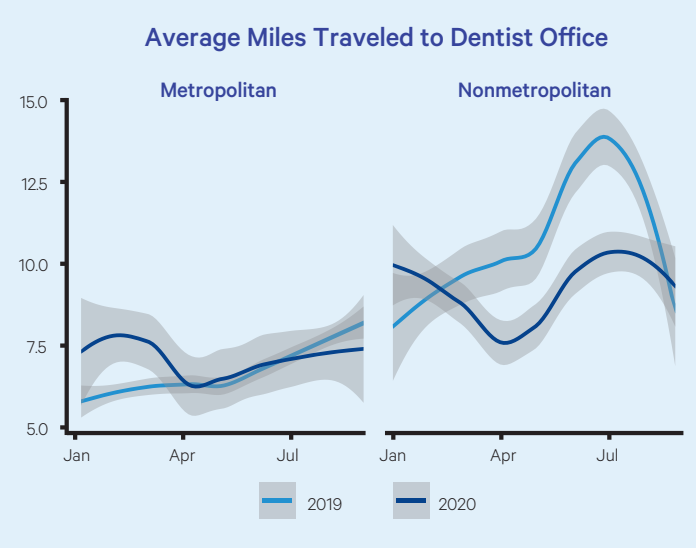

Figure 4. Average miles traveled to dentist offices comparing metropolitan to nonmetropolitan areas.

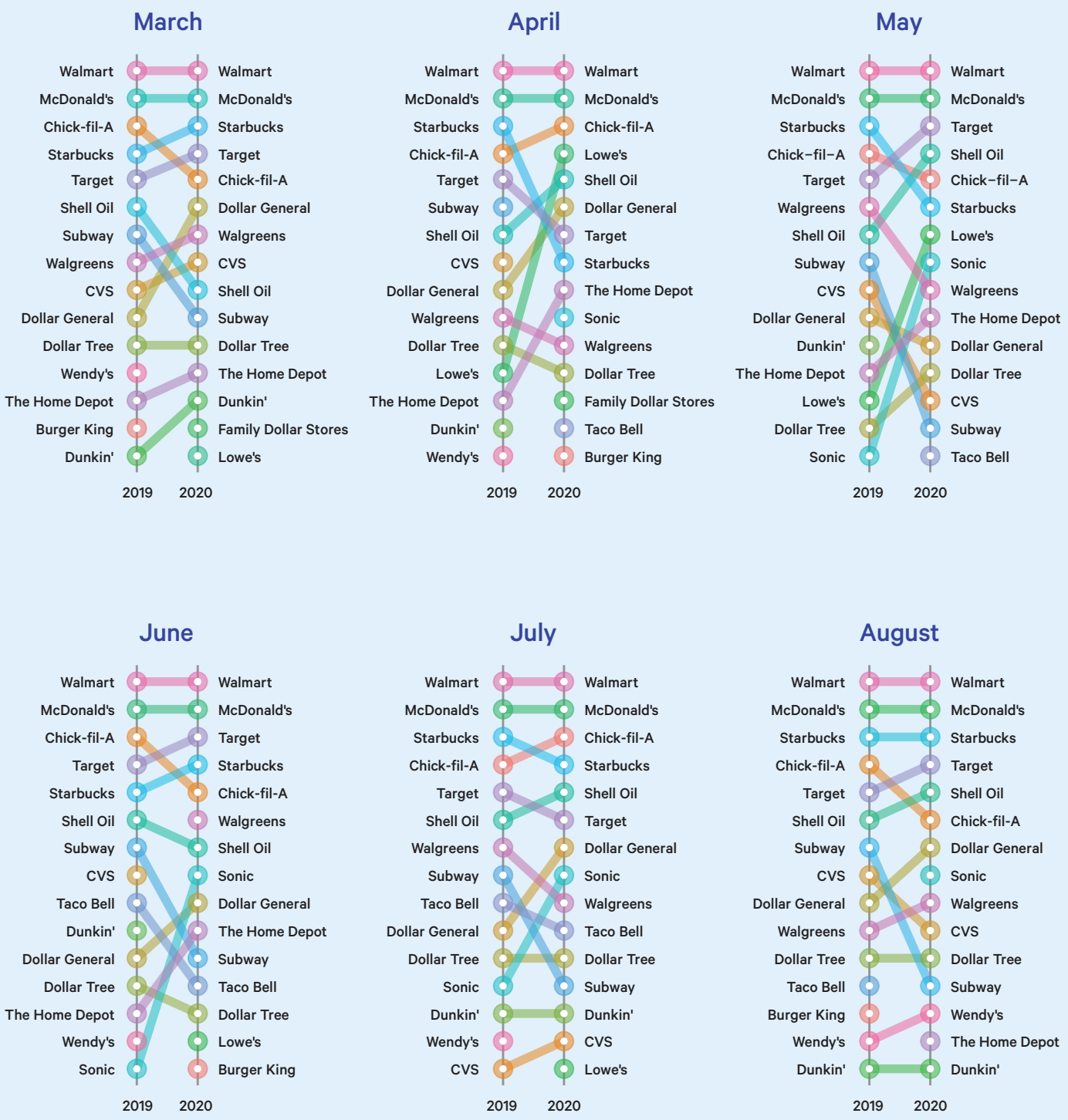

Figure 5. Comparison of top 15 locations visited on the same day as a dental office visit from 2019 to 2020 by month. The line between 2019 and 2020 indicates the change in rank. The absence of a line indicates that the location was not in the top 15 either in 2019 or 2020.

Discussion of Findings

COVID-19 and Dental Care Sites

While research studies identifying contributors to COVID-19 health outcomes are still being conducted, recent findings suggest that access to routine oral health care may reduce the severity of COVID-19 if contracted. The connection between unbalanced oral biofilm and infections, chronic disease, and poor health outcomes has long been established. Building upon this association, findings published in the British Dental Journal indicate a potential link between SARS-CoV-2 and oral cavity bacterial load.[14] The respiratory pathology of COVID-19 creates a higher risk of aspirating oral secretions into the lungs and developing infection. Improved oral hygiene may reduce these complications both during the course of the disease and in recovery. As the COVID-19 pandemic continues, accessible and convenient oral health care may become critical in reducing negative health outcomes and complicating risk factors.

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Dental care sites have experienced profound impacts from the COVID-19 pandemic. Many states closed all but emergent dental care from March 2020 through May 2020, eliminating many forms of in-person preventive oral health care. While long-term repercussions still are unknown, 93% of dentists surveyed recently said they anticipated long-term changes in dentistry, including the method of care provision, approaches to infection control, and reassuring patients that care at a dental office will not raise their risk of contracting COVID-19.[4] The short- and long-term impact of closures on patient oral health outcomes remains to be seen.

Implications of Methodology

Anonymous mobile device data offers a powerful new tool to evaluate impacts to industries by understanding traffic patterns associated with particular locations. In this study, we focus on the implications of the COVID-19 pandemic and access to oral health care. However, the data can be used to evaluate market potential for strategizing dental office locations, impacts of medical or insurance policy on behavior, and the consequence of other economic shocks. Longitudinally, these data can be evaluated for changes in utilization trends or the impact of environmental changes (e.g., policy, systemic influences, etc.) on patient behavior in a variety of health fields. Data applications have the potential to highlight influences on dentistry, medicine, and public health to inform innovative solutions.

Dental Office Visitation Rates

As the COVID-19 pandemic progressed in the U.S., elective procedures were cancelled or postponed as a public health strategy to reduce disease transmission. This negatively affected dental office operations and access to needed dental care.[15,16] The analysis of personal device data found a national overall reduction of dental office visits from March to June when comparing 2020 to 2019. This reduction corresponds to previous analyses of self-reported data from dentists in the U.S. In a survey of American Dental Association members completed during the week of April 6, 84.3% of over 6,000 respondents reported that patient volume was less than 5% compared to the same week a year ago.[16] Subsequent updates of dentist members through May demonstrated incremental improvements in patient volume, although overall patient volume was significantly less than the previous year.[17] The present analysis also supports the results of a recently published prospective survey of safety-net oral health providers.[4] Approximately 4,000 dentists reported significant decreases in patient volume, with an average decline of 51%. Nearly half (41%) of all providers responded that it will take 6 months or longer for business to return to pre-COVID-19 volumes, and 16% were unsure of when they can expect to return to pre-COVID-19 volumes. This indicates a severe impact on the financial operations of dental offices due to COVID-19 closures.

Distance Traveled to a Dental Office

Little data is available examining the distance patients typically travel to a dental office for care. The few published studies that reported miles or distance traveled to dental care found responses ranging from 1.5 to 24.2 miles on average.[18-20] Most published data focused on distance traveled within underserved or Medicaid populations. The current analysis, which does not differentiate by coverage or payment type associated with an individual, found an average distance traveled of 6.3 miles in the first quarter of 2019 and approximately 8 miles during the same period in 2020, demonstrating an increase in overall travel during the COVID-19 pandemic response. Transportation challenges only exacerbate social and health care disparities, particularly in marginalized communities. Cost associated with increased travel, coupled with job loss and a plummeting economy, pose an additional hardship. Some research indicates approximately 25% of travelers involved in trips for medical or dental care agreed that road conditions, high traffic volume, or the price of gasoline present significant challenges to overcome.[21] Similarly, outreach programs that offer gasoline payment cards or vouchers report higher rates of utilization and the opportunity to decrease unnecessary emergency department visits.[22-24] While transportation is an established barrier to equitable oral health care, other costs associated with dental care visits such as child care, lost wages, and public transportation fees can intensify poor health outcomes.

The increased adoption of teledentistry during the stay-at-home orders could have decreased the miles traveled since individuals were able to access oral health care from home.

Differences between average miles traveled in metropolitan and nonmetropolitan locations confirmed in this analysis echoed similar transportation and travel distance issues previously reported.[24-26] Both metropolitan and nonmetropolitan regions saw a decrease in average miles that coincided with government orders decreasing dental care access. An analysis of the National Household Travel Survey provided similar results, with rural residents traveling more miles than urban residents (17.5 versus 8.3 miles); the investigators determined that rural trips were 31.4% longer than those made in urban environments (27.2 versus 20.7 minutes),[21] demonstrating a heavier travel burden for rural populations. The increased adoption of teledentistry during the stay-at-home orders could have decreased the miles traveled since individuals were able to access oral health care from home. Further investigation from qualitative research may prove beneficial to understanding the true impact.

Same-Day Locations Visited

People often visit dental offices as part of a planned trip with multiple stops since appointments are made in advance. The overwhelming majority of locations are related to food purchases either with fast food service, snack, or grocery items. The awareness that individuals are likely to complete grocery shopping and purchase fast food on the same day as health care appointments is not unknown since many big-box retailers and grocers are placing health care teams within various locations to improve the shopper experience.[27,28]

Nutritional Counseling

Given the prevalence of food location visits in the dataset, there appears to be considerable opportunity for dental care teams to prioritize nutritional counseling during dental care visits. In a survey of American Academy of Pediatric Dentistry and American Academy of Pediatrics members, 89% of the joint organization members somewhat and strongly agreed that diet and nutritional counseling is a crucial aspect to dental care delivery.[29]

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A systematic review of adult oral rehabilitation and health dietary advice described support for nutritional counseling with oral disease management, although limitations in the availability of studies and a call for more research was noted by the investigators.[30] Reports from nutrition and oral health pilot projects reinforce that relationships between dentistry and nutritional health professionals result in better outcomes related to obesity and oral health.[31-36] Despite these connections, purposeful nutritional counseling that focuses on reducing intake of sugar-sweetened beverages along with healthier nutritional habits is not commonly employed in the dental care setting. In order to improve the occurrence and understanding of dietary coaching, the American Dental Association is planning to update CDT codes for billing reimbursement in 2021.[37] Further emphasizing the importance of this, new objectives from Healthy People 2030 include measures directed at reducing unhealthy sugar consumption. Implications from this study support the direct inclusion of dental health care professionals in the nutritional counseling process.

Health Messaging Opportunities

This study methodology can be applied in community and public health messaging efforts. Mass media campaigns have been effective in promoting positive behavior change and attitudes addressing public health issues like heart disease, physical activity, and alcohol and drug use.[38-41] Evidence from local-level health messaging campaigns support the community network impact of public health promotion.[42] Local health departments have the opportunity to use information derived from patient visits to community businesses to develop public-private partnerships that leverage health messaging strategies. The impact of health communication strategies can be amplified if paired with mobile health promotion approaches, like group texting or health portal applications.[43]

Understanding patient travel patterns by using their mobile device data creates additional opportunities to capitalize on communication methods for public health interventions.

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Dental offices should be included in these communication networks for referral or reinforcement of oral health promotion. Understanding how people move around their cities and communities in relation to their health providers creates unique opportunities to shape how we communicate about health to include oral health.

Conclusion and Recommendations

Recommendations:

1. COVID-19 has had a significant impact on dental care operations. Dental care teams and organizations must consider how to alter care and business models to address a decrease in utilization and the increased need for technology-based dental encounters.

2. Dental clinicians should embrace new opportunities for improving whole-person health with the introduction of billing and reimbursement codes for nutritional counseling and sugar reduction. Using new information about the types of restaurants visited during the same day of dental treatment, dental health care professionals can help patients make healthier choices through shared care planning.

3. Health messaging strategists and health outreach specialists can maximize visibility of oral health campaigns by targeting locations most frequented in proximity to dental office sites.

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Technical Appendix

About SafeGraph

Information on how participants may opt out is available at https://www.safegraph.com/privacy-policy.

SafeGraph uses many sources of data to determine information about their points of interest. We focus on those points of interest with a North American Industry Classification System (NAICS) code equal to 621210.

Glossary of Terminology

- **SafeGraph:** Aggregator of smart device location data.
- **Ping:** A geolocated signal generated by the GPS of the device.
- **Noise (statistical):** Uninformative variation in the data.
- **Data Smoothing**: A data presentation technique to display the trends in the data rather than variation from unknown sources.

Description of Data

The code for the analysis is available at https://github.com/jbayham/covid_dentaquest.

Points of Interest

SafeGraph maintains and updates a database of points of interest. Points of interest are geographic boundaries around a location visited by devices in the SafeGraph sample. Safegraph puts considerable effort into identifying building footprints, which is critical for measuring visits to a business.[1] For instance, a measure of visitation to a store on a busy street with foot traffic would want to include only those people who entered the store and not just those walking by the front door.

Visitation Rate

SafeGraph reports visits to the points of interest in their database. Machine learning algorithms are used to detect pings that are likely erroneous (e.g., pings that bounce back and forth across a street). The panel of devices active in the dataset changes over time as individuals modify their location settings, acquire new phones, and dispose of old phones. Consequently, evaluating the trends in visitation could be influenced by the number of devices in the sample rather than a true change in visitation. SafeGraph reports the change in their device panel over time, which averages approximately 5% of the U.S. population. Instead of analyzing the number of visits over time, we calculate a visitation rate defined as the number of visits divided by the number of devices in the panel at a given point in time in the relevant geography. Safegraph reports the total number of devices in the national sample each day. For national analyses, we calculate the visitation rate to dental offices as the number of visits divided by the total number of devices in the national sample. For analyses of metropolitan areas, we use the number of devices with home locations recorded in the particular counties in which the dental office is located. We then sum the visits and divide them by the sum of devices in all metropolitan or nonmetropolitan areas. A device's home location is determined based on the common nighttime (6 p.m.–7 a.m.) location over the previous six weeks. If someone visits a dental office while traveling, the distance measure will be large. While the majority of visits should come from people who live in the area, travelers may inflate our measure of distance.

Note for interpretation of Figures 1 and 2: The average of the estimates is 1.31% in the 2019 national, 1.22% in 2019 metropolitan, and 0.99% in 2019 nonmetropolitan. However, the confidence intervals span 1.25% in the national and metropolitan figures, which should be most comparable because most of the population resides in metropolitan areas. The discrepancy is caused by a slightly different normalization. As documented in the manuscript, the visits are based on a sample of devices representing roughly 5% of the population. SafeGraph reports two measures the authors used to normalize the data. The first is a national count of devices reported by day; this is the denominator in the rate of the national figure. The second is a count of devices residing in a census block group reported at the weekly level. We aggregated this up to the county level and used the weekly county number of devices as the denominator to construct visitation by county. Then, we adjusted and classified this county-level data to reflect CDC's designation of metropolitan and nonmetropolitan communities. While these two normalization methods are comparable and yield very similar trends, the point estimates at any given point may differ because of daily fluctuations in device counts or people traveling outside of their county of residence.

Same Day Visits

SafeGraph reports a measure of popularity of other locations (called brands) visited on the same day as a particular point of interest (POI). We focus on dental offices and evaluate the other locations visited on the same day as the dental office visit. SafeGraph defines related_same_day_brand as:

> Other brands that the visitors to this POI visited on the same day as the visit to this POI where customer overlap differs by at least 5% from the SafeGraph national average. The mapping has the brand as the key. The value shown for each brand is a percentage representing the median of the following calculation for each day in the month: (same-day visitors to both the brand and the POI/total daily visitors to the POI) — (daily visitors to the brand/all visitors in SafeGraph panel). This column will only contain values if there are at least 5 visitors to the POI.

We reweight the related_same_day_brand variable reported by SafeGraph by multiplying the reported value by (1/100*raw_visitor_counts) to place more weight on locations that receive more visits. We then sum this measure across the brands and divide it by the number of dental offices in the sample by date. This normalization provides a national measure of popularity of brands (locations) visited on the same day as dental offices.

We then rank the brands in descending order and plot the top 15 in each month in 2019 and 2020.

Data Limitations

While the mobile device data provide high spatial and temporal resolution of visitation to dentist offices during the COVID-19 pandemic, limitations exist within the data. On average, the data cover approximately 5% of the U.S. population. The data lack any identifying or demographic information, and therefore the representativeness of the data across all geographic areas is largely unknown. However, comparison with Census data suggests that the data are not systematically biased (https://www.safegraph.com/blog/what-about-bias-in-the-safegraph-dataset). The dental office visits are based on the detection of a location ping occurring inside of a digital building perimeter. Location accuracy is not perfect, and pings can be misattributed in shared buildings. SafeGraph has implemented many controls to minimize the misattribution rate.

Additional Figures

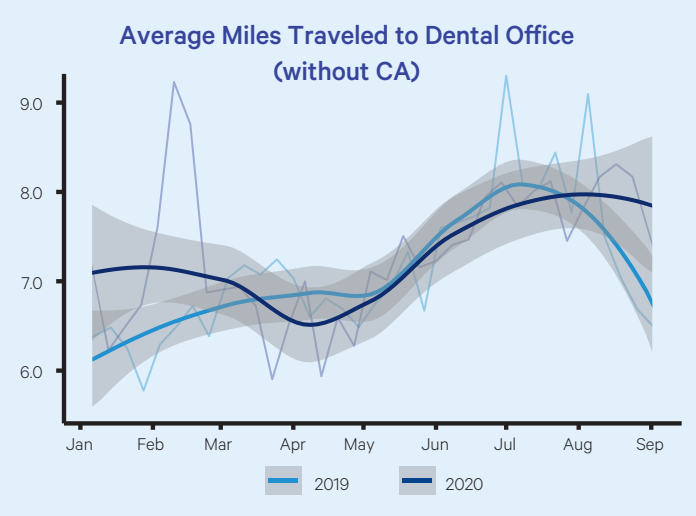

Figure 6. National average distance (miles) from home to dental office, excluding California.

CareQuest

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