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Use of SafeGraph visitation patterns for the identification of essential services during COVID-19

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Abstract. Mobility was severely impacted during the COVID-19 pandemic due to travel restrictions, curfews, and closed locations, such as businesses, schools, administrative offices, and other points of interest (POIs). This study uses SafeGraph visitation data to identify which POI categories experienced a significant drop in visitation counts and distance travelled from home between March/April 2019 (pre-pandemic) and March/April 2020 (during the pandemic) in Florida and California. The analysis identified a small set of POI categories for which visitation counts and travel distance did not change significantly. They can be characterized as essential services which are needed for a community's everyday operations. This study provides insight into the effect of COVID-19 on people's travel behavior to different types of trip destinations during the pandemic.

Keywords. SafeGraph, COVID-19, mobility pattern.

1 Introduction

Location data from mobile phone networks and social media applications such as Twitter have been widely used to assess the change in mobility patterns around natural disasters, such as hurricanes, wildfires, earthquakes, and floods (Crooks et al., 2013; Yabe et al., 2022), and during pandemics (Yabe et al., 2020). Geo-tagged media data are also used to investigate the relationship between mobility patterns and the spread of diseases (Ramadona et al., 2019). Mobility studies help to better understand travel behavior and facilitate effective urban and transportation planning (Anagnostopoulou et al., 2020), especially during emergency situations (Yin et al., 2020).

Visitation patterns of POIs were gravely affected by COVID-19 mitigation interventions such as stay at home orders and lockdowns, which were mandated to reduce the spread of the pandemic. For example, mobility reduction identified from Google and Apple mobility data during the first wave of COVID-19 was found to decrease the infection rate occurring two to five weeks after the onset of mobility reduction for selected European countries and U.S. states (Cot et al., 2021).

SafeGraph is another proprietary data product that provides information about POI visitation patterns based on mobile phone data. It has been used to analyze the impact of various events on mobility patterns. For example, it revealed short-term perturbations in the number of visits to universities, gas stations, and grocery stores around Hurricane Irma (September 2017) in Florida (Juhász and Hochmair, 2020). SafeGraph data has also been used to determine anomalies in POI visitation counts on selected POI categories (e.g., elementary and secondary schools, restaurants, malls) during the pandemic in Minnesota, which revealed different recovery speeds in reaching pre-pandemic levels for different POI categories (Sharma et al., 2022). Another study used SafeGraph and subway turnstile data to analyze the effect of lockdowns and other restrictions on the spread of COVID-19 across five U.S. cities, finding that a ten percentage point decrease in mobility leads to a fall between 19% and 34% in COVID-19 cases per capita (Glaeser et al., 2022). Our study expands previous work by analyzing the change both in POI visitation numbers and distance travelled from home to POIs of many categories. It applies the analysis to all SafeGraph top categories with at least 50 POIs in Florida or California, respectively.

The main hypothesis of the presented study is that nonessential POIs experience a significant drop in visitation counts and access distance within the first seven weeks of the onset of the pandemic compared to the same seven weeks a year before (pre-pandemic), whereas no such changes will be observed for essential services. Essential services are critical services which are necessary to maintain the health, safety, and well-being of a

population, particularly in times of crises or emergency situations (U.S. Department of Homeland Security, 2021).

Change in travel behavior will be assessed based on two attribute values in the SafeGraph dataset that are provided for each POI, namely visit counts and median distance from home. While domestic travel decreased by 52% in 2020 compared to 2019 in the U.S. (International Trade Administration, 2021), we posit that the POIs whose visit counts and distance from home did not significantly decrease in any of the seven weeks following the approximate onset of COVID-19 in 2020 (March 15) compared to 2019 are essential services whereas those that were significantly less in any of the corresponding weeks in 2020 are nonessential. To the best of our knowledge, this is the first study to systematically analyze all POI categories from SafeGraph regarding COVID-19 lockdown impact on mobility. Previous work assessed the effect of COVID-19 on visitor flows from aggregated SafeGraph data at three geographic scales: census tract, county, and state (Kang et al., 2020) or explored the COVID-19 effect on travel distance and number of visitors only on selected POI categories (Sharma et al., 2022).

A practical implication of this research is that it demonstrates the use of data mining of observed SafeGraph travel patterns to determine the compliance of different POI categories with COVID-19 mitigation protocols.

The two periods compared in this analysis are March 15 to April 30, 2019 (pre-pandemic) and March 15 to April 30, 2020 (during pandemic), respectively. The analysis is conducted on weekly data over these seven-week study periods. The research hypothesis will be approached through the following three related objectives:

1. Determine POI categories for which the median distance from home does not significantly drop between 2019 and 2020 in any of the seven weeks.
2. Determine POI categories for which the median visitation number does not significantly drop between 2019 and 2020 in any of the seven weeks.
3. Combine results from objective 1 and 2 to identify essential services and compare them to governmental defined essential services.

To illustrate a typical change of travel pattern for nonessential services during the COVID-19 pandemic, Figure 1 compares the median number of weekly visits to colleges and museums in Florida (a) and California (b) for March and April 2019 and 2020. There was a clear drop in visits in the third week in March 2020 to Florida colleges (45.1%) and museums (32.4%) and to California colleges (37.7%) and museums (42.4%) when pandemic control measures were put in place, whereas no such drop could be observed in 2019.

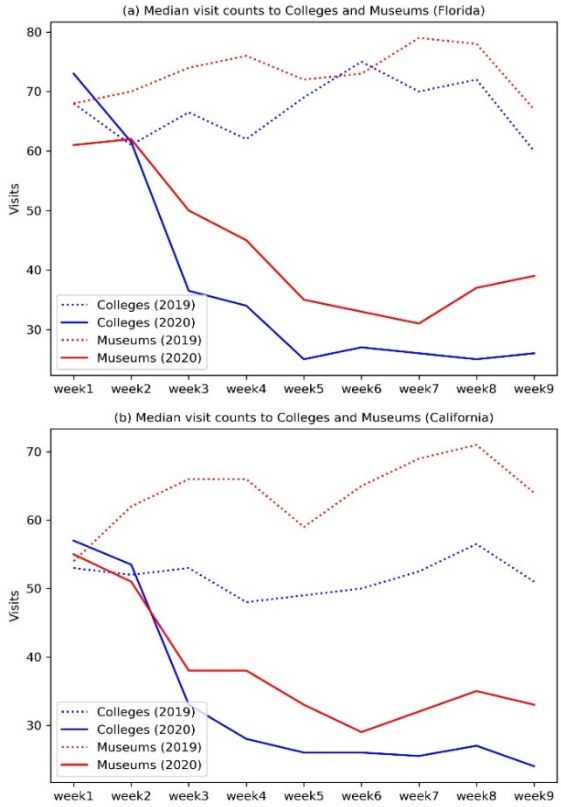

Figure 1. Weekly median visit counts to colleges and museums in Florida (a) and California (b) in March and April 2019 and 2020.

Similar charts reflect the change in median distance to colleges and museums in March and April 2019 and 2020 for Florida (Figure 2a) and California (Figure 2b). The biggest drop in median distance from home was recorded in week 5 for both colleges and museums, with a drop of 20.2% (colleges) and 29.3% (museums) in Florida and 16.5% (colleges) and 39.9% (museums) in California,

respectively.

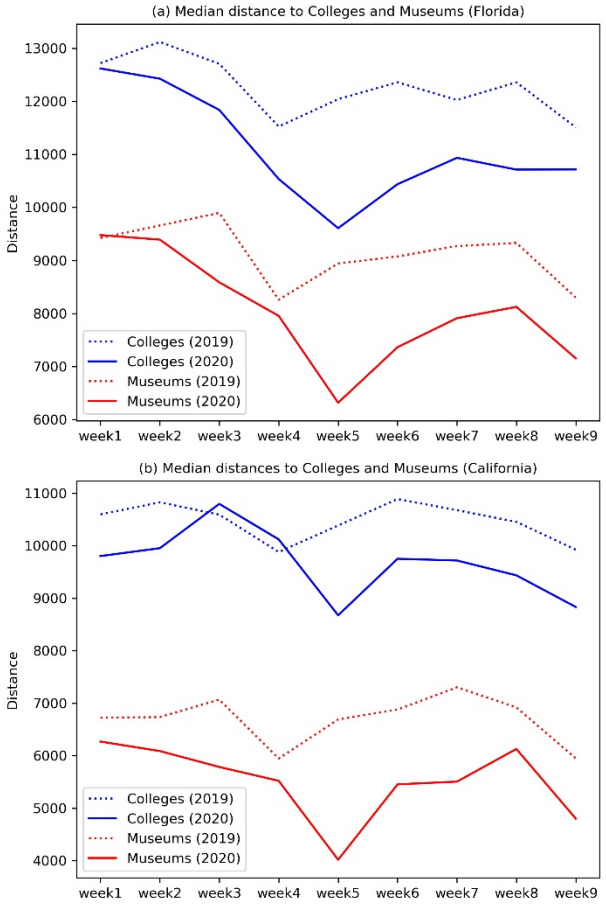

Figure 2 Weekly median distance (in m) from home to colleges and museums in Florida (a) and California (b) in March and April 2019 and 2020.

2 Study setup

2.1 Study areas

Florida and California were chosen as study areas because of their large numbers of POIs which facilitates statistical analysis in almost all SafeGraph top categories. The use of two study areas also allows for comparison of analysis results and evaluating their consistency. Stay at home orders for Florida and California became effective on April 3, 2020, and March 19, 2020, respectively (Mervosh et al., 2020).

2.2 Data collection

SafeGraph comprises four types of data sets, which are Places (POI attributes such as name, location, and hours of operation), Geometry (polygons for buildings associated with the POI), Spend (POI specific consumer spending patterns) and Patterns (foot traffic volume to POIs). The entire dataset contains over 41 million POIs in over 220 countries. POIs are categorized based on the North American Industry Classification System (NAICS). SafeGraph weekly visitation patterns datasets were acquired through the Dewey data platform (Dewey, 2023) for March and April of 2019 and 2020 for Florida and California. To warrant a sufficiently large sample size for statistical analysis, only POIs from NAICS categories, referred to as "top category" on SafeGraph which contain at least 50 POIs in Florida and California were retained for further analysis. In Florida 148 top categories met this requirement, whereas in and California 153 categories did.

2.3 Analysis method

Statistical analyses were conducted to assess change in weekly visit counts and distance between home and POI between the 2019 and 2020 seven-week study periods. That is, weekly POI visit counts of individual POIs were extracted for each POI category for the seven study weeks in 2019 and 2020. Next, a series of one-sided Mann-Whitney tests determined if visit counts between corresponding weeks in 2019 and 2020 experienced a significant drop, which was repeated for each category. A similar approach was applied for home-to-POI distances. Based on test results, POI categories were grouped into those that showed no significant drop in visits and distance in all the seven weeks and thus retained stable visitation patterns (representing essential services) and those that did show a statistical drop in all seven weeks (nonessential services). POIs in-between (those with a statistical drop in some of the weeks) were not analyzed further.

2.4 Data availability

The datasets used for this research are proprietary and can therefore not be shared.

3 Analysis of results

Mann-Whitney tests revealed a significant drop in distances and visit counts for all POI categories in Florida and California ($p < 0.05$ one-tailed, no corrections for multiple testing applied) in at least one week, except for 15 out of 148 POI categories in Florida and 18 out of 153 categories for California, for which no significant drop could be observed across the seven weeks (Table 1).

According to the directives from Florida and California governments the following are defined as essential services (Florida Department of Health, 2020; State of California, 2022): Healthcare, Emergency services, Food and Agriculture, Energy, Water and wastewater management, Transportation and logistics, Communications and Information Technology, Financial

services, Government and public services, Construction and manufacturing, and Defense.

In Table 1, the first column lists SafeGraph top categories, whereas the second column shows government defined essential categories that best matched SafeGraph categories to the left. Keywords and descriptions from government defined essential services were used to find their equivalent to the SafeGraph essential categories. Several SafeGraph top categories could be matched to the same essential category, since SafeGraph top categories are more refined than the governmental ones. Presence of a check mark shows that the criteria for a POI category to be classified as essential services, based on statistical test results for visitation counts or distances, were met. The SafeGraph based analysis was able to confirm all governmental defined essential service categories except for Healthcare and Emergency services and Communications and Information Technology. This suggests that visits or distances to Healthcare and Emergency services POIs dropped significantly in at least part of the study period. This could be attributed to the avoidance of urgent or routine medical care due to COVID-19 concerns in 2020 (Czeisler, 2020) and aversion towards long distance travel in order to exposure to COVID-19. Our statistical analysis would classify POIs under the Communications and Information Technology industries only then as essential if considering six weeks within the seven-week study period. That is, there was one week in which the 2020 visit counts and median distances were significantly lower in 2020 than in 2019.

Some SafeGraph top categories were identified as essential in only one of the two study areas, such as steel product manufacturing (only in California) and support activities for water transportation (only in Florida), which shows that response to COVID-19 mobility restrictions was somewhat different in both states.

The shift to online services for certain businesses (e.g., governmental offices) may have led to an observed drop in POI visits and distances as well and thus classify them as nonessential services, although their nature of service may be essential. However, we assume that most essential services would be less affected by such a shift due to their type of service which often requires real-world activities (e.g., transportation, construction) that cannot be completed online.

Table 1: Identification of essential services based on visitation and distance analysis from SafeGraph data before and during the pandemic.

SafeGraph category name	Government defined essential services	Florida		California	
		Visits	Distance	Visits	Distance
Accounting, tax preparation, bookkeeping, and payroll services	Financial services	✓	✓	✓	✓
Building finishing contractors	Construction and manufacturing	-	-	✓	✓
Freight transportation arrangement	Transportation and logistics	-	-	✓	✓
Grocery and related product merchant wholesalers	Food and agriculture	✓	✓	✓	✓
Insurance and employee benefit funds	Financial services	-	-	✓	✓
Investigation and security services	Defense	✓	✓	-	-
Metal and mineral (except petroleum) merchant wholesalers	Construction and manufacturing	-	-	✓	✓
Miscellaneous nondurable goods merchant wholesalers	Food and agriculture	✓	✓	✓	✓
Motor vehicle manufacturing	Construction and manufacturing	✓	✓	✓	✓
National security and international affairs	Government and public services	✓	✓	-	-
Remediation and other waste management services	Water and wastewater management	✓	✓	-	-
Residential building construction	Construction and manufacturing	-	-	✓	✓
Scheduled air transportation	Transportation and logistics	-	-	✓	✓
Securities and commodity contracts intermediation and brokerage	Financial services	✓	✓	✓	✓
Social advocacy organizations	Government and public services	-	-	✓	✓
Steel product manufacturing from purchased steel	Construction and manufacturing	-	-	✓	✓
Support activities for crop production	Food and agriculture	✓	✓	✓	✓
Support activities for water transportation	Transportation and logistics	✓	✓	-	-
Taxi and limousine service	Transportation and logistics	✓	✓	-	-
Travel arrangement and reservation services	Transportation and logistics	✓	✓	✓	✓
Utility system construction	Energy	-	-	✓	✓
Warehousing and storage	Transportation and logistics	✓	✓	✓	✓
Waste collection	Water and wastewater management	✓	✓	-	-
Waste treatment and disposal	Water and wastewater management	✓	✓	✓	✓

Figure 3 shows boxplots for the log of 2019 and 2020 visit counts to essential POIs in Florida (a) and California (c). Numbers in box plots show median values of raw visit counts. Mann-Whitney tests conducted on raw visit counts revealed no significant drop between 2019 and 2020 for Florida and California at a 5% level of significance. Corresponding box plots for nonessential services are shown for Florida in Figure 3b and California in Figure 3d, where Mann-Whitney tests determined a significant drop in visit counts in both regions for 2020 ($p < 0.01$).

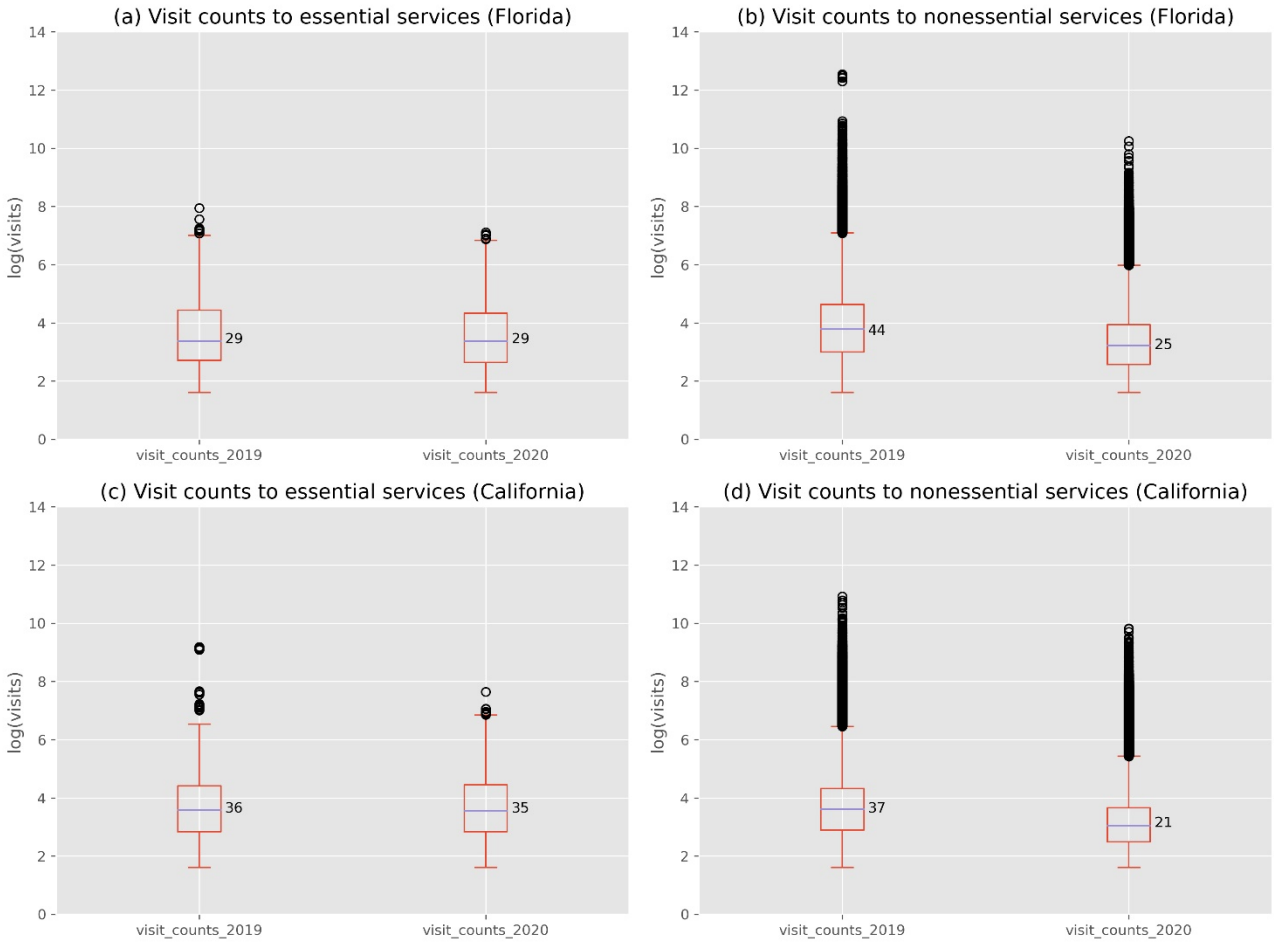

Figure 3. Boxplots of log-normalized visit counts to essential and nonessential services in Florida (a, b) and California (c, d).

Figure 4 shows boxplots of log normalized distances from home to essential POIs in Florida (a) and California (c). Figure 4b and Figure 4d show corresponding plots for nonessential services. Mann-Whitney tests conducted on raw distance counts showed no significant drop between 2019 and 2020 for essential services in any of the study regions ($p > 0.05$) but identified a significant drop in travel distance to essential POIs in both regions ($p < 0.01$). The test results associated with visits and distances support therefore the stated research hypothesis and demonstrate the impact of COVID-19 lockdown had on nonessential services.

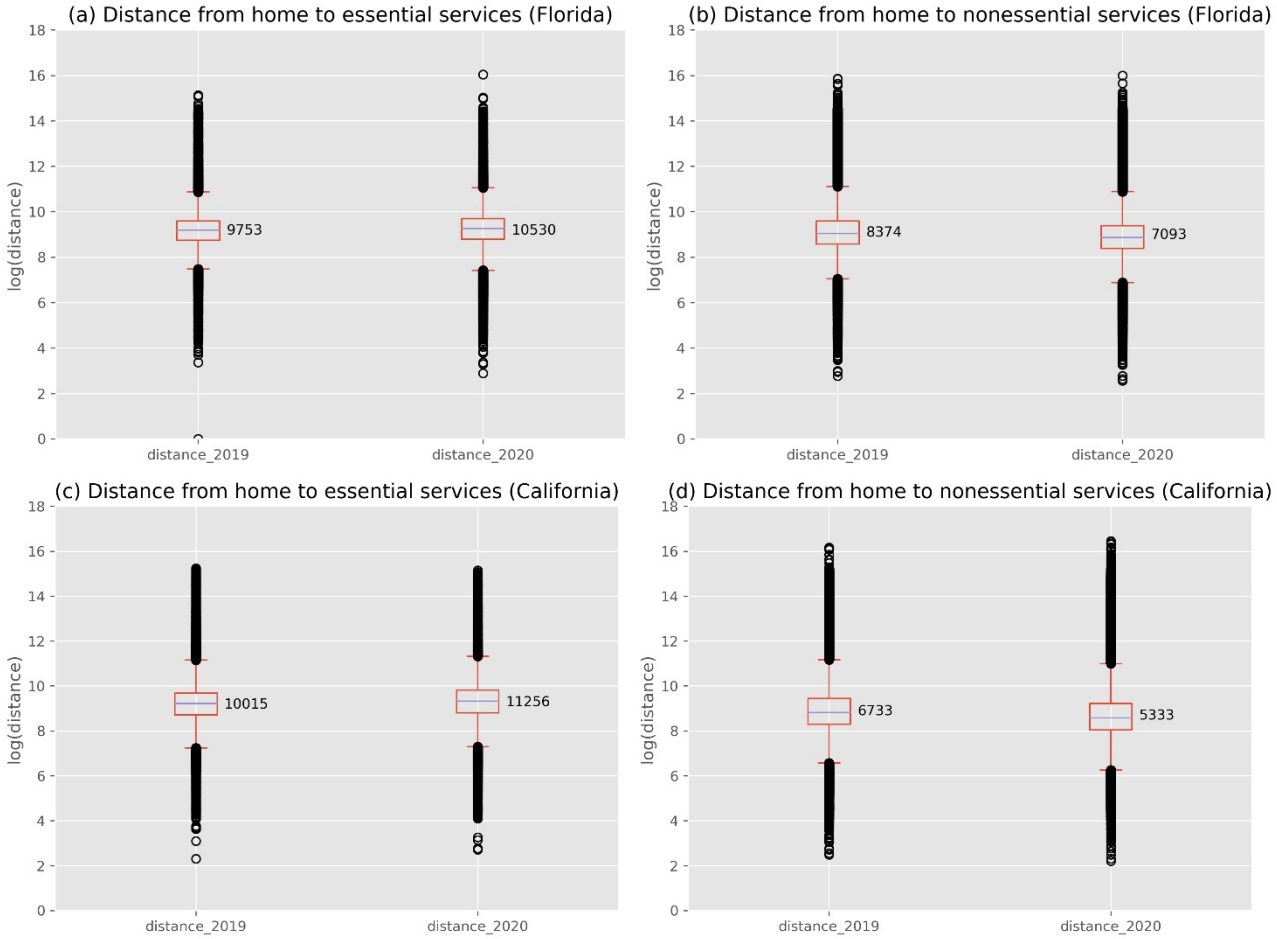

Figure 4. Boxplots of home distance to essential and nonessential services in Florida (a, b) and California (c, d).

4. Conclusions

The study has identified essential services based on the hypothesis that such services experience no significant drop in visit counts and access distance from home in the onset of the COVID-19 pandemic (2020) when compared to corresponding weeks in the pre-pandemic period (2019). It confirms that these essential services were continuously used and visited during the pandemic, as was probably intended by policy makers. Future research will compare results of changed mobility patterns derived from SafeGraph data to those provided in Google and Apple mobility reports to get better insight into the comparability of these different mobility datasets.

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