CHANGING VISIT PATTERNS IN PHILADELPHIA DURING THE CORONAVIRUS PANDEMIC

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ABSTRACT

This paper addresses changing visit patterns in Philadelphia during the Coronavirus pandemic by examining various trends in visit patterns. The analysis uses aggregated cell-phone geolocation data to test for divergence in the number of visits made to Asian establishments relative to other establishments as well as differences in the changing frequency of visits from tracts with different incomes and racial majorities. The change in visits will be observed by comparing visits in weeks during 2020 to a reference week pre-COVID-19. Event study and differences in differences regressions are used to assess the statistical significance of these trends. Results from this study show that: 1) Changes in visit patterns to Asian establishments are not disproportionately affected by COVID-19; 2) Residents of high-income tracts do appear to reduce their visits by more than residents of other tracts after the local outbreak of COVID-19, but these differences are not statistically significant; 3) There is a statistically significant divergence in visit behavior: residents of Black and Hispanic majority tracts reduce their visit frequency by less than residents of White majority tracts.

INTRODUCTION

Coronavirus (COVID-19) is a highly infectious respiratory disease that originated from bats. The CDC (2020) recognizes Wuhan, Hubei Province, China as the location of the emergence of COVID-19, with the first cases confirmed December 31, 2019. Within three months, COVID-19 spread to over 150 countries leading the World Health Organization to declare a global health emergency (Derrick, 2020).

Researchers have explored the effect of pandemics on public health, economic activity, and psychological wellbeing. In a study of social and behavioral science to support the COVID-19 pandemic response, Bavel (2020) remarks that disease threat can give rise to discrimination against stigmatized or scapegoated groups. Some government officials' mischaracterization of COVID-19 as the "Chinese virus" may contribute to this prejudice. While studying the impacts of SARS and H7N9 in China, Qiu (2018) notes that the way communities behave in these times is often tied to government trust and perceived competence, but also heavily influenced by alternative sources of information, whether credible or not. Uncertainty surrounding the reliability of official information allowed the spread of rumors concerning SARS to exacerbate social panic throughout China.

These studies motivated this paper's exploration of the following questions: 1. Does fear guide retail visit patterns, and are Asian establishments disproportionally affected? This is interesting because understanding where many people continue or avoid visiting may uncover aversion and anxiety behaviors prevalent in the community. 2. Which demographics are overwhelmingly leaving their homes during a pandemic? Are there differences by income? By race profile? And

how do early responses differ from later responses? Shedding light on the demographics of people that continue to travel or finding trends in the pace of adjustment can provide insights on how these behaviors differ by population group profile.

Hypothesis

To address these questions, this paper will assess three distinct hypotheses: 1) Since COVID-19 originated in Wuhan, China, one's propensity to make quick associations may have individuals avoiding Philadelphia's Asian establishments. 2) Individuals with higher income are more responsive to the emergence of COVID-19, while individuals with lower income, possibly due to their employment in essential businesses or a lack of resources to stay home until mandated, are more likely to have a delayed response and continue to leave their homes during a pandemic. 3) There are differences in visit patterns by race profile, potentially given underlying differences in workforce representation or confidence in the government.

In the study, shifts in community behavior are observed in data that describes visits to retail establishments from visitors in different census tracts in Philadelphia county. This visit data is merged with demographic information on census tract residents to identify differences in visit patterns by population group profile.

To explore these hypotheses, general trends— in the change in log visits to Asian establishments and to other establishments, in the change in log visits from high-income origin tracts and from other income origin tracts, and in the change of log visits from various racial majority tracts compared to White majority tracts— will be observed by comparing visits in a week to a

reference week pre-COVID-19. To assess the statistical significance of the trend, several regression models will be estimated that test visit pattern divergence across establishment types and different income and racial make-up of the origin tract. An event study and differences in differences analysis will follow each regression.

Results from this study show that: 1) Asian establishments are not disproportionately affected by COVID-19. 2) Although visits from high-income tracts decline year over year more so than those from other income tracts, the difference after COVID-19 is not statistically significant. 3) There is divergence in visit behavior by race profile. Early response behavior is apparent in visit patterns from White and Asian majority tracts; while visit behavior from Black and Hispanic majority tracts differs significantly from that of White majority tracts, with increasing differences over the study period.

Significance

Findings from this paper have the potential to influence city officials to create more targeted policies to mitigate the effect of loss economic activity due to this pandemic. These policies may include maintenance and support of small local businesses in places with little competition that need them or more focused emergency funding in the sectors/regions that need it most. Furthermore, with a grasp of differences in risk perceptions or behaviors, they can pinpoint areas where residents are most at risk and provide opportunities to fill the gaps. It is possible that knowing who leaves their homes during these pressing times can shed light on the city's populations that are most vulnerable to transmission and allocate resources effectively.

Background on the COVID-19 Epidemic

The World Health Organization's first situation report (2020) summarizes the initial circumstances. At the end of 2019, Wuhan's government confirmed that dozens of cases of pneumonia were being treated that arose from an unknown cause. Within days, Chinese researchers identified a new type of coronavirus, COVID-19, and discovered it had affected dozens in China. On January 13, the first case of COVID-19 was reported in Thailand. Within a week, Japan and South Korea followed with confirmed cases. In an effort to stop the spread of COVID-19, travel restrictions were enforced. On January 23, the Chinese authorities closed off public travel within and outside of Wuhan. By the end of the month, the Trump administration suspended entry into the US by foreign nationals who had traveled to China in the previous two weeks. Around the world, countries enforced lockdown procedures and travel was blocked. On March 13, Trump declared a national emergency (Derrick, 2020). Early discussion in the news about the origin and spread of COVID-19, may have influenced visit behaviors to Asian establishments in Philadelphia.

The first case of COVID-19 in the US was reported on January 20 (Holshue et al., 2020). On March 6, Philadelphia reported its first case of COVID-19. Within a week of the first case, the city prohibited gatherings of 1,000+ people and strongly recommended the cancellation of events with expected attendance of 250+. Schools were shutdown, universities sent students home, and non-essential businesses closed their doors. On March 22, due to the resolution of many people to take the social distancing advisories lightly, Philadelphia Mayor Jim Kenney ordered the city to stay at home in an effort to slow the spread (Walsh, 2020). Pennsylvania's Department of Health (2020) announced that as of March 28, Philadelphia had a reported 709 cases of COVID-

19 and 5 deaths. While it appears that many people in Philadelphia did not adhere to the social distancing guidelines, it may be interesting to observe if some people did in fact shift behaviors in any way, even if not in the manner intended by the original guidance.

LITERATURE REVIEW

While much of the literature surrounding global pandemics discuss the public health implications, there is considerable dialogue concerning their economic and psychological impacts as well. How individuals adjust the way in which they maneuver the world to avoid the contraction of infectious diseases is an important input to these economic losses.

Qiu's study (2018) highlighted the importance of effectively managing responses to infectious diseases. Control efforts for the SARS outbreak of 2003 was perceived to be problematic and the virus spread globally. The outbreak coupled with a lack of trustworthy information led to the spread of social panic in China. Ill-informed, citizens circulated hearsay, panic purchased items for home remedies, and from fear of infection decreased spending on food and entertainment outside of the home. SARS also depressed travel, tourism, and retail sales in Asian states, translating to losses of over 12 billion USD. Additionally, SARS had a global macroeconomic impact estimated at over 3 million USD per case.

When H7N9 began ten years later, control efforts received high praise and in comparison, it was fairly contained. There was no social chaos; citizens felt that they received reliable and timely information. While China's poultry industry experienced losses of over 40 billion RMB, there was little economic impact globally (Qiu, et al. 2018). Less than a decade later, it appears that

responses to COVID-19 are less like H7N9 and much more similar to SARS. It is important to have an understanding of the economic effects that will follow the COVID-19 in order to restore confidence and attenuate losses. This could be roughly estimated by retail store visits. Along with economic effects, community responses, as observed through risk perceptions, behaviors, and psychological distress to the emergence of infectious diseases yields consideration (Lau et al., 2011).

In order to slow the spread of COVID-19, social distancing has been advised and, in some cases, mandated. To reap the benefits of social distancing measures, there must be considerable by-in; the extent to which this is practiced varies depending on socioeconomic conditions and beliefs. Kavanagh (2020) finds that across US counties, lower socioeconomic status was associated with reduced social distancing. It may be interesting to discover if income disparities exist within a particular county as well.

Large differences in the impact of how the contraction of infectious diseases affects various locations are present even across small geographical units within cities. Almagro and Orane-Hutchinson (2020) study differential exposure to COVID-19 in New York City and exposed this reality by exploring differences within NYC zip codes. Findings from this paper suggest the persistence of racial disparities, although economically small, in rates of positive tests for Blacks and Hispanics compared to Whites.

Laurencin and McClinton (2020) present data on the racial and ethnic distribution of confirmed cases and fatalities of COVID-19 in Connecticut to identify and address racial and ethnic

disparities for those in America affected by the virus. Their findings suggest that Blacks have a higher rate of infection and death compared to their population percentage in the state. The paper concludes with a prediction of the disease to have particularly devastating effects on communities of color— not due to discrimination of the disease which doesn't exist, but due to America's history of discrimination. Additionally, since Black communities often have higher levels of preexisting conditions and lower access to healthcare infrastructure, this group may be hit harder by COVID-19 (Simon, 2020). It may be the case, that Black and Brown people take additional caution and express more aversion behaviors, if they can help it during this pandemic; however, the actual behavior exuded is unpredictable, given threat perception and responses depend on many inputs (Bavel, 2020).

The literature supports lending considerable attention to identifying response behaviors during the outbreak of infectious diseases. With the spread of unreliable information, rumors and fear may be a driving force for these behaviors. This contributes to the plausibility of the first hypothesis, that Asian establishments may face disproportionate effects of decreased visits due to COVID-19. Previous studies confirm the validity of looking within cities for apparent differences explained by socioeconomic factors. Current research has focused on various cities in the US; there is room for research centered on Philadelphia. This study can be a means for more focused attention to the Philadelphia region. Observed differences in rates of visiting retail venues could shed light on contagion factors or perceived risk. To effectively manage future responses to the spread of infectious diseases, there must be a level of understanding of the heterogeneity of community responses. This paper aims to reveal these responses in Philadelphia.

SUMMARY OF DATA AND METHODS

Data

The analysis will rely on anonymized, aggregated smartphone movement data provided by PlaceIQ. This dataset was also used by Couture, Dingel, Green, Handbury and Williams (2020) to create exposure indices that are publicly available to all researchers in the context of the spread of COVID-19 and is described in detail therein. The dataset features retail visit listings from home FIPS code to venue FIPS code on a weekly frequency.

FIPS codes will be used to identify home and venue locations. The Federal Information Processing Standard, or FIPS code, is 12-digit geographical indicator. It maps to 4 locational subgroups: state, county, tract, and block group. Given a focus on the Philadelphia region, the visit data will be filtered for FIPS codes beginning 42101 (i.e. Philadelphia county).

The smartphone movement data will be used to document the frequency of visits to a census tract code, while tracking where the device 'lives,' or sleeps most nights. The use of a device to determine an individual's home and mobile patterns is not new, a few studies have also done this. A notable use appears in the exposure indices, aforementioned by Couture et. al. (2020). The device data for this study will be accessible from 2018 through the end of March 2020. The data is measured in weeks, as defined by the ISO 8601 standard. A table of this standard can be found in Exhibit I. This study will focus on the last two months of 2018/2019 and the first three months of 2019/2020. Changes in retail visits is conceptualized as changes in visits to a venue, or from an origin tract, for January 2020 to March 2020, relative to matched days of a pre-COVID-19 reference week.

Socioeconomic covariates (percentage of racial majorities, medium income) are obtained from a census dataset and sorted by census tract. Altogether these datasets will depict how COVID-19 plays an active role in adjusted retail visit behavior in Philadelphia.

Empirical Strategy

In order to test the hypothesis that Asian establishments are disproportionally affected by COVID-19, the demographics dataset will be used to determine which tracts feature a majority population of Asian residents, greater than or equal to 50% of the residents. Then, the retail visit data will be checked to determine which venues feature greater visit percentages, greater than or equal to 20%, of residents from these tracts. This would carry the assumption that these venues are Asian establishments. For the hypothesis that those living in higher income tracts are more responsive to COVID-19 than those in lower income tracts, the demographics dataset will be used to detect which tracts have medium incomes of $100,000 or greater. Concerning variations in visit patterns from tracts by racial makeup, the demographics dataset will be used to determine which tracts have a majority population of one race of residents, Black, Hispanic, Asian, or White. To explore the hypotheses, general trends will be observed, first plotting the change in log visits to Asian establishments and to other establishments, then from high-income origin tracts and from other income origin tracts, and finally from each racial majority origin tract and from White majority origin tracts.

This study estimates several regression models to assess the statistical relevance of differences in visit patterns across different establishment types and different income and racial make-up of origin tracts. First, the following event study design is used to demonstrate that these differences

emerged after relevant event dates (news of COVID-19 emerging from China in early 2020 and local restrictions in March 2020) and were not predicted by pre-trends in visit behavior. These event study regressions will take the form of:

$$\Delta\log(y_{i,t}) = \Delta\log(y_{i,t}) - \Delta\log(y_{i,t-52}) = b_0 + b_{1,t} + b_2\alpha_i + b_{3,t}\alpha_i$$

In the context of the analysis studying the divergence of visits to Asian versus other establishments in the new year, the left-hand side variable is the year-on-year change in the log count of visits to an establishment from all tracts as a function of the week (t), a dummy variable indicating whether the establishment is an Asian establishment (α), and the interaction of these variables (α* t). The week fixed effect ($b_{1,t}$) is essential in the regression to control for confounding factors that might affect visit patterns to both Asian and non-Asian establishments. To test the robustness of the results, additional covariates will be adjusted, by including a venue tract fixed effect ($b_{6,i}$) to control for underlying trends at the venue-tract level.

Then, a differences-in-differences analysis is run to determine whether there is a statistically significant change in retail visit behavior before and after three events: post the initial case of COVID-19 in the world, post the first reported instance in Philadelphia, and post the State of Emergency announcement. The regression model to explore this analysis is:

$$\Delta\log(y_{i,t}) = \Delta\log(y_{i,t}) - \Delta\log(y_{i,t-52}) = b_0 + post_{\alpha_i} + b_2\alpha_i + post_{\alpha_i}\alpha_i$$

The robustness of the model is tested by controlling for the fixed effects at the venue tract and the week level.

A similar approach will be applied to determine differential changes between high-income and other income tracts. The following event study regression will be fit to the data in order to explore these changes in visit patterns:

$$\Delta\log(y_{i,t}) = \Delta\log(y_{i,t}) - \Delta\log(y_{i,t-52}) = b_0 + b_{1,t} + b_2\delta_i + b_{3,t}\delta_i$$

Here, the left-hand side variable is the year-on-year in the log count of visits by residents of a given tract to all establishments, regressed on a week fixed effect ($b_{1,t}$) to control for average adjustments to behavior, a dummy variable indicating whether the origin tract is high-income (δ), and the interaction of these variables (δ * t) to measure how visits from high-income tracts change differently over time to visits from other tracts. To test the robustness of the results, additional covariates will be adjusted, by including an origin tract fixed effect ($b_{4,i}$) to control for underlying trends at the tract level. The differences-in-differences analysis will be implemented here as well.

The approach will be replicated once more to establish divergent visit behavior between various racial majority tracts and White majority tracts. The following regression will be fit to the data to explore these changes in visit patterns:

$$\Delta\log(y_{i,t}) = \Delta\log(y_{i,t}) - \Delta\log(y_{i,t-52}) = b_0 + b_{1,t} + b_2\tau_i + b_{3,t}\tau_i$$

In this context, the left-hand side variable is the year-on-year in the log count of visits by residents of a given tract to all establishments, regressed on a week fixed effect ($b_{1,t}$) to control for average adjustments to behavior, a variable indicating whether the origin tract holds a majority population of Black, Hispanic, or Asian residents (τ), and the interaction of these variables (τ * t) to measure how visits from certain tracts change differently over time to visits from White majority tracts. To test the robustness of the results, additional covariates will be

adjusted, by including an origin tract fixed effect ($b_{4,i}$) to control for underlying trends at the tract level. The differences-in-differences analysis will also be implemented here.

Stylized Facts

Exhibit II-i depicts graphical representations of the first hypothesis. The graph of the year on year change in log visits to Asian establishments and other establishments show great variability in visits to Asian establishments. Although the number of visits recorded decreased relative to the previous year in all weeks for both Asian and other establishments, the decline appears to be larger on average for Asian establishments. This may suggest consistency with the hypothesis that aversion behaviors hit Asian establishments harder than others. The second graph of the difference in year on year change in log visits between Asian establishments and other establishments shows a consistently wider spread starting in about week 4 of 2020, however larger spreads appear in previous years as well, so the apparent significance of this spread is unknown.

Exhibit II-ii portrays graphical representations of the second hypothesis. The year on year change in log visits show that residents from high-income tracts consistently reduced their visits to retail venues, relative to the same week in the previous year, by more than residents of lower income tracts in all weeks over the study period. This difference is more pronounced in January 2020, potentially in accordance with the early response hypothesis.

Exhibit II-iii portrays graphical representations of the third hypothesis. The difference in year on year change in log visits between each racial majority tract compared to White majority tracts is key in highlighting distinct visit pattern behaviors. In mid-late February, it becomes apparent that

as changes in Asian majority tracts converge with White majority tracts, changes in Black and Hispanic majority tracts become more variant. The regression and diff-in-diff models, outlined in the next section, are used to determine the statistical significance of observed divergence in visit behavior.

FINDINGS

Hypothesis 1

The regression without fixed effects yields the following model:

$$\Delta\log(y_{i,t}) = \Delta\log(y_{i,t}) - \Delta\log(y_{i,t-52}) = -0.37 + b_{1,t} - 0.21\alpha_i + b_{3,t}\alpha_i$$

Irrespective to the week, the regression suggests there is a 21% greater year-on-year decline in visits to Asian establishments over the whole study period compared to other establishments. Exhibit III-i presents the results of the following event study specification. Each point on the plot shows the additional year on year change in log visits to establishments by week, given it is an Asian establishment (the coefficients of $b_{3,t}$). The error bars signal great uncertainty, therefore there is too much noise in the data to identify any signals here. This model without fixed effects accounts for 48% of variability, while with the inclusion of fixed effects it accounts for 69% of the variability of the change in log visits. The coefficient terms for both are included in Exhibit III-i and the model is robust as there is little variability between the coefficients of both models.

The diff-in-diff analysis shown in Exhibit III-ii suggests inconsistency with the hypothesis. After the first case of COVID-19, in week 1, Asian establishments saw 12% more year on year visits compared other establishments in the same time period. Post the first case of COVID-19 in Philadelphia, in week 4, Asian establishments saw 14% less year on year visits compared to

other establishments. After the State of Emergency, in week 11, Asian establishments saw 40% less year on year visits. While the latter two post specifications align with the hypothesis, neither appear statistically significant. All in all, this suggests the data does not support the first hypothesis that COVID-19 more strongly affects visits to Asian establishments.

Also tested in this study is heterogeneity in the change in log visits to Asian establishments after the COVID-19 outbreak between residents of majority Asian tracts and residents of other tracts. To do so, the data is divided into groups that separately describe the change in visits from Asian majority tracts and other tracts. Then the week and week-by-Asian establishment variables in the baseline study specification are interacted with a dummy variable (β) for whether the visits on the left-hand side are from Asian majority tracts. The following regression is fit to the data:

$$\Delta\log(y_{i,t}) = -0.37 + b_{1,t} - 0.26\alpha + b_{3,t}\alpha - 0.25\beta + b_{5,t}\beta + b_{6,t}\alpha\beta.$$

The regression with venue tract fixed affects is included in the appendix for robustness. The Asian majority origin tract coefficient, -0.25, suggests that residents from these tracts decreased visits to all establishments compared to the previous year by 25% more than residents from other tracts. Exhibit III-iii presents the results of the following event study specification. Each point on the plot shows the additional year on year change in log visits to Asian establishments from Asian majority tracts by week (the coefficients of $b_{6,t}$). The event study exposes variability in the data, as in weeks 7, 9, and 14, residents from Asian majority tracts decreased visits to Asian establishments compared to the previous year, by noticeably more than residents from other tracts. The event study including venue-tract level effects adds an additional point of variability in week 2, which may be explained by fewer visitors to Asian establishments during

Philadelphia's Chinese New Year festival, which occurred earlier in the year 2019 compared to 2020. No explanation is apparent for variability in the later weeks.

Overall the first hypothesis is not supported by the data; Asian establishments do not appear to be disproportionally affected by COVID-19. Asian establishments do see fewer visits post the pandemic, however this is does not differ significantly from the fewer visits year over year to all establishments. Additionally, for the most part there is homogeneity in visits to Asian establishments from Asian majority tracts and other tracts; however, there are a few later weeks where the log change in visits from Asian majority tracts were more negative compared to other tracts.

Hypothesis 2

The subsequent regression analyzing differences in visit responses from high-income tracts relative to others yields the following model:

$$\Delta\log(y_{i,t}) = -0.48 + b_{1,t} + 0.08\delta_i + b_{3,t}\delta_i$$

The regression is run again with the origin tract fixed effect as a robustness check. Exhibit III-iv presents the results of this event study specification. Each point on the plot shows the additional year on year change in log visits from tracts by week, given it is a high-income tract (the coefficients of $b_{3,t}$). With other income origin tracts as the baseline, the negative coefficients suggest that residents from high-income tracts are visiting retail stores even less compared to the previous year. This appears to be a trend as negative visits occurred in the change in log visits before the initial case of COVID-19 as well. Surprisingly, it appears that after the State of Emergency announcement and stay-at-home order, in week 11, the change in visits from high-

income origin tracts shows a reverse trend, with residents from other tracts adjusting their retail visit behavior and visiting retail venues less year on year than those from high-income tracts.

The diff-in-diff analysis shown in Exhibit III-v show whether there is divergence in visit behavior after the three events for one visitor type relative to another. It does not support the second hypothesis that residents from high-income tracts are more responsive to COVID-19. While residents from high-income tracts reduced visits to retail establishments year over year about 14% more than residents from other income tracts, the interactions of the post variables and income indicator are marginally positive but do not appear statistically significant. In fact, there is little variability in visit behavior post all three events; after the very first cases of COVID-19 internationally and locally, and after issuance of the State of Emergency, the coefficients suggest fairly consistent visit behavior.

Overall the results do not support the second hypothesis; residents from high-income census tracts were not more responsive to the emergence of COVID-19. Rather, generally residents from high-income tracts visit retail establishments less year over year compared to residents from other income tracts and could maintain this visit pattern when the pandemic began.

Hypothesis 3

While the interactions of income and post variables do not appear statistically significant, many interactions of racial majority and post variables do. Residents from Black and Hispanic majority tracts have more year over year visits compared to residents from White majority tracts in each post instance: post the first instance of COVID-19 in the world, post the first case in the US, and

post the State of Emergency. This difference in visits is statistically significant and increases after each subsequent post instance suggesting a trend of greater exposure to COVID-19 for residents from these tracts compared to residents from other tracts. After the first case of COVID-19, in week 1, year on year visits from Black majority tracts were 12% higher compared to visits from White majority tracts. After the first case of COVID-19 in Philadelphia, in week 4, year on year visits from Black majority tracts were 16% higher compared to visits from White majority tracts. After the State of Emergency, in week 11, year on year visits from Black majority tracts were 25% higher compared to visits from White majority tracts. For year on year visits from Hispanic majority tracts, these relative differences after each post instance were 7%, 10% and 18%. The change in log visits from Asian majority tracts differ marginally from White majority tracts, but the difference doesn't appear statically significant.

Exhibit III-vi presents the results of a single event study with all of the group fixed effects and the income fixed effect conjointly. Each point on the plot shows the additional year on year change in log visits from origin tracts, given the racial majority origin tract indicator (τ) or high-income indicator (δ). The baseline group for racial majority is the White majority origin tract, and all trends are relative to this base. For income, the high-income group is based on the other income group. The coefficients from Asian majority origin tracts are noisy, so it is difficult to determine the strength of initial aversion behaviors from this alone; however, it is apparent that after the State of Emergency in week 11 there is a convergence in visit behavior between residents from Asian majority and White majority tracts. For Black and Hispanic origin tracts, it appears that these groups have greater differences in visits year over year each week compared to White majority tracts. Unlike visit behavior from Asian majority tracts, the change in log visits

from Black and Hispanic tracts become increasingly divergent compared to the White majority baseline group after the State of Emergency.

Summary of Results

The data does not support the first nor second hypotheses. Asian establishments do not appear to be disproportionally affected by COVID-19. While there are fewer visits to Asian establishments relative to other establishments, a similar trend appears pre-COVID-19 as well. Residents from high-income census tracts do not demonstrate early responses to COVID-19 by decreasing retail visits in the first weeks of 2020 more so than residents from other income census tracts. Instead, residents from high-income tracts maintained consistent decreased visit behavior from pre-COVID-19. The data does support the third hypothesis; there is divergent retail visit behavior by race profile. The data suggests that residents from White majority census tracts displayed early response behavior to the emergence of COVID-19 and decreased retail visits more than other racial majority origin tracts for the duration of the epidemic. During this time Black and Hispanic majority origin tracts however, displayed the greatest positive difference in the change in retail visits compared to the White majority tract baseline.

Speculation

The data describes what has occurred but does not present a cause for observations. The differences in visits from high-income tracts compared to other income tracts may be due to resource allocations, as high-income residents have more resources to sustain staying home. It appears that this advantage was not just a result of COVID-19 but represents a past trend.

The differences in visits from various racial majority tracts may be due to many distinctions. Differences following the State of Emergency could reflect underlying disparities in employment representation. If a certain demographic is more likely to work in an essential business, this may be reflected by the interaction coefficient differences of later weeks. Likewise, if a certain demographic is more represented in professional roles and can work from home, this may be demonstrated in fewer visits over the study period.

Concerns

To determine socioeconomic trends, this study used tracts where one racial majority constituted 50% or more of the tract. Other studies often use a ratio race factor variable rather than majority. It is possible that grouping census tracts as majority rather than as a ratio unnecessarily narrowed the dataset. Additionally, retail visits are not separated by duration of visit, so it was not possible to determine whether the visit represented an employee or patron of the retail establishment. This supplemental information may have aided in the interpretation of the results. If included, it may have provided a means to discover if there are groups of people most at risk by job design and to explore whether those that are most at risk affected are appropriately compensated for future recommendations. Additional limitations of this study include that the data does not sample all cell-phone users, nor does it reflect non-users. More information detailing Philadelphia's positive test rates would be useful in correlating these findings to tell the full story of COVID-19 in the city.

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“Week Numbers for 2020.” Accessed April 7, 2020. https://www.epochconverter.com/weeks/2020.

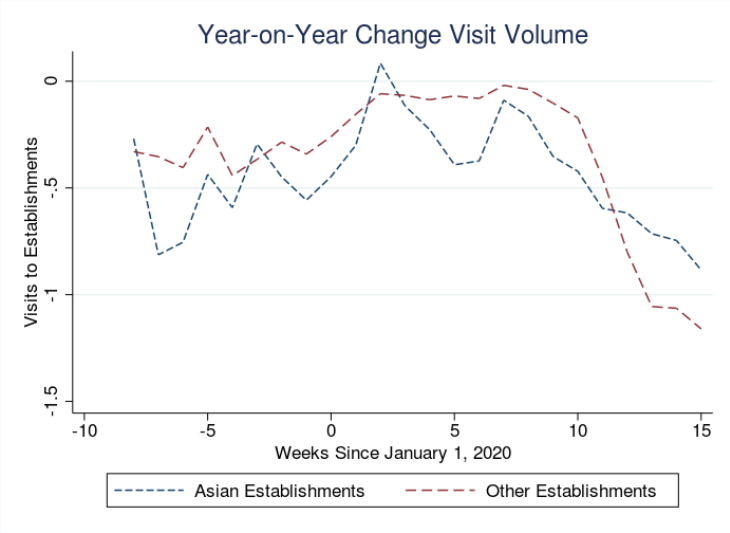
APPENDIX

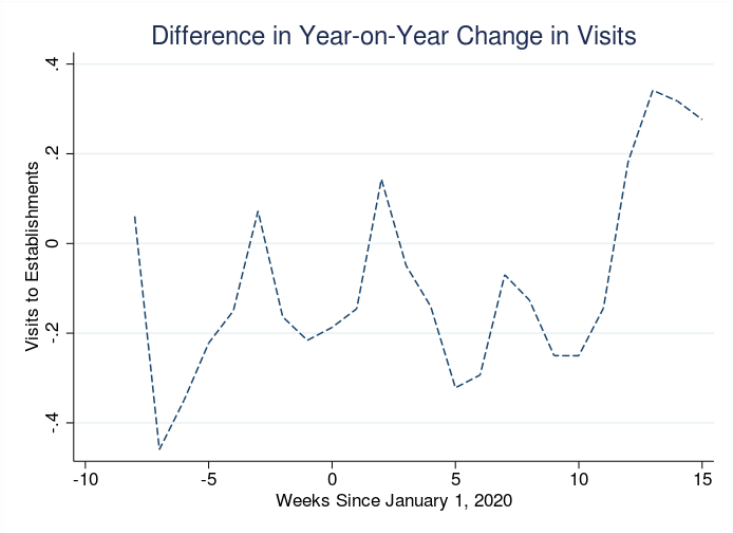
Exhibit I. ISO 8601 standard

	2018		2019		2020	
Week number	From Date	To Date	From Date	To Date	From Date	To Date
1	1-Jan-18	7-Jan-18	31-Dec-18	6-Jan-19	30-Dec-19	5-Jan-20
2	8-Jan-18	14-Jan-18	7-Jan-19	13-Jan-19	6-Jan-20	12-Jan-20
3	15-Jan-18	21-Jan-18	14-Jan-19	20-Jan-19	13-Jan-20	19-Jan-20
4	22-Jan-18	28-Jan-18	21-Jan-19	27-Jan-19	20-Jan-20	26-Jan-20
5	29-Jan-18	4-Feb-18	28-Jan-19	3-Feb-19	27-Jan-20	2-Feb-20
6	5-Feb-18	11-Feb-18	4-Feb-19	10-Feb-19	3-Feb-20	9-Feb-20
7	12-Feb-18	18-Feb-18	11-Feb-19	17-Feb-19	10-Feb-20	16-Feb-20
8	19-Feb-18	25-Feb-18	18-Feb-19	24-Feb-19	17-Feb-20	23-Feb-20
9	26-Feb-18	4-Mar-18	25-Feb-19	3-Mar-19	24-Feb-20	1-Mar-20
10	5-Mar-18	11-Mar-18	4-Mar-19	10-Mar-19	2-Mar-20	8-Mar-20
11	12-Mar-18	18-Mar-18	11-Mar-19	17-Mar-19	9-Mar-20	15-Mar-20
12	19-Mar-18	25-Mar-18	18-Mar-19	24-Mar-19	16-Mar-20	22-Mar-20
13	26-Mar-18	1-Apr-18	25-Mar-19	31-Mar-19	23-Mar-20	29-Mar-20
14	2-Apr-18	8-Apr-18	1-Apr-19	7-Apr-19	30-Mar-20	5-Apr-20
15	9-Apr-18	15-Apr-18	8-Apr-19	14-Apr-19	6-Apr-20	12-Apr-20
44	29-Oct-18	4-Nov-18	28-Oct-19	3-Nov-19		
45	5-Nov-18	11-Nov-18	4-Nov-19	10-Nov-19		
46	12-Nov-18	18-Nov-18	11-Nov-19	17-Nov-19		
47	19-Nov-18	25-Nov-18	18-Nov-19	24-Nov-19		
48	26-Nov-18	2-Dec-18	25-Nov-19	1-Dec-19		
49	3-Dec-18	9-Dec-18	2-Dec-19	8-Dec-19		
50	10-Dec-18	16-Dec-18	9-Dec-19	15-Dec-19		
51	17-Dec-18	23-Dec-18	16-Dec-19	22-Dec-19		
52	24-Dec-18	30-Dec-18	23-Dec-19	29-Dec-19		

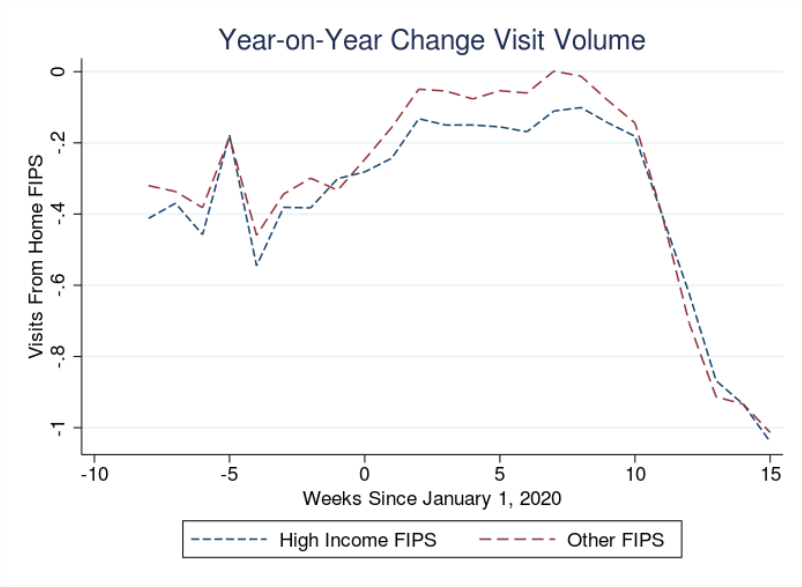
Exhibit II. General Trends

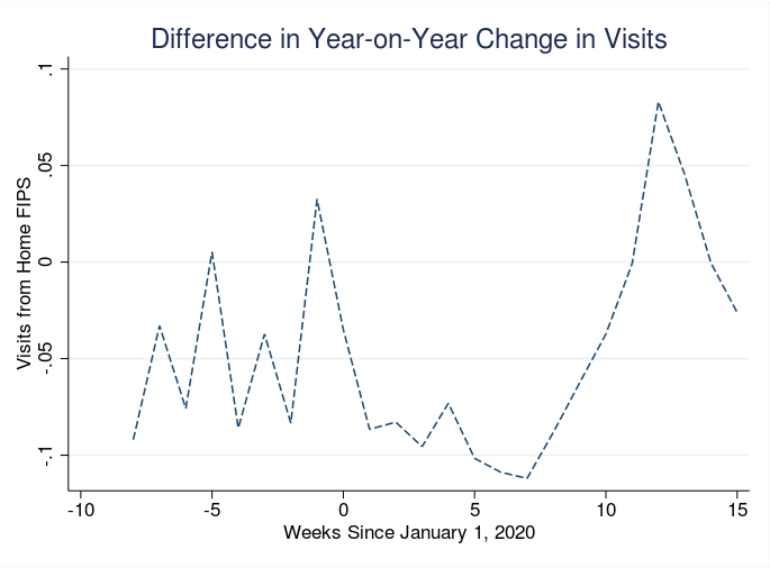
i. Asian establishments and other establishments



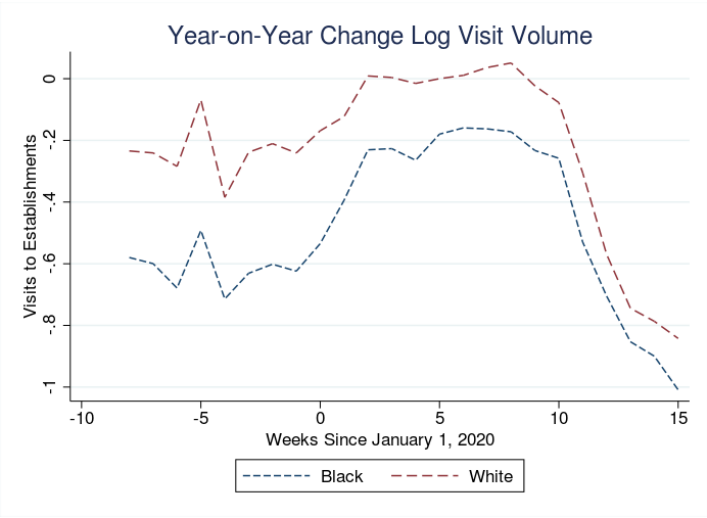


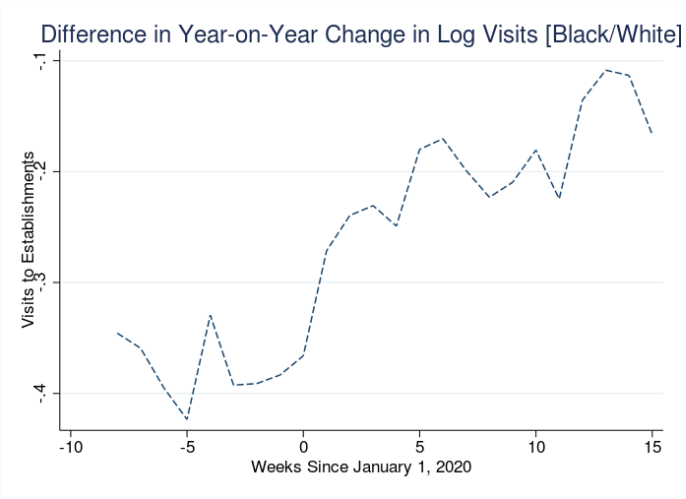
ii. High-income tracts and other income tracts

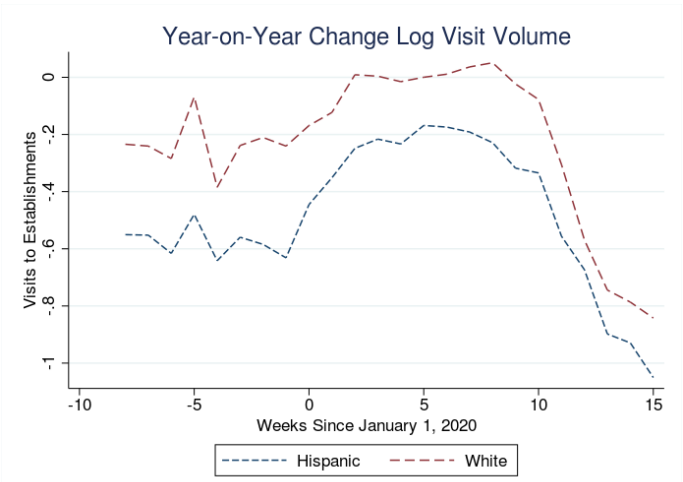


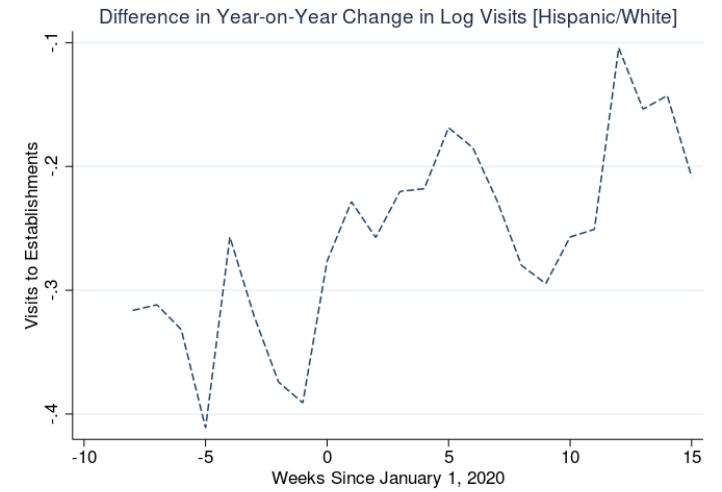


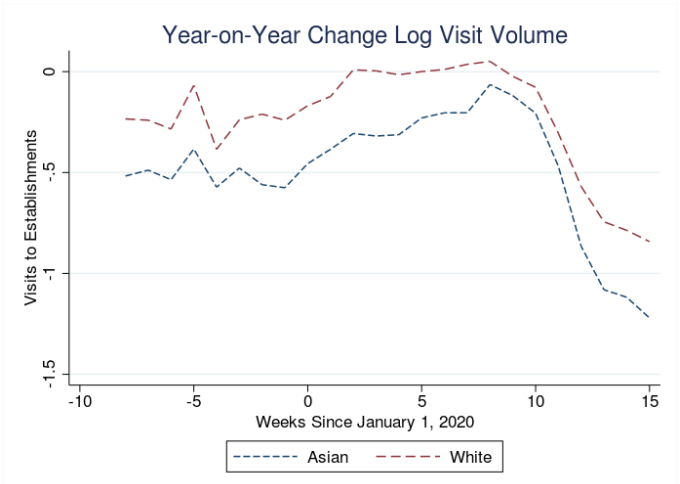
iii. Racial majority tracts and White majority tracts











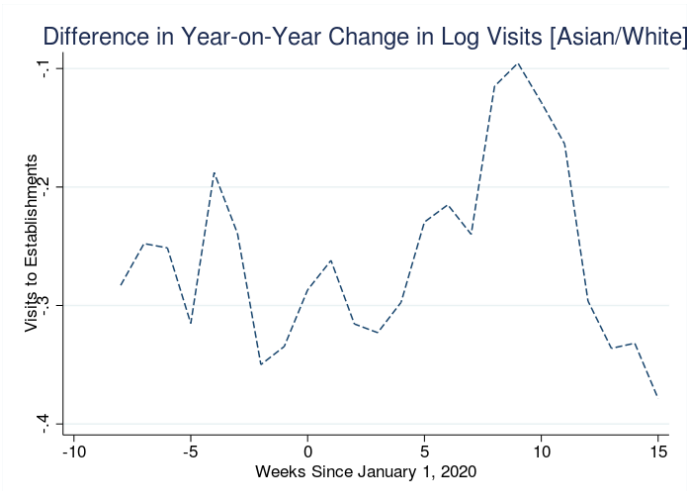
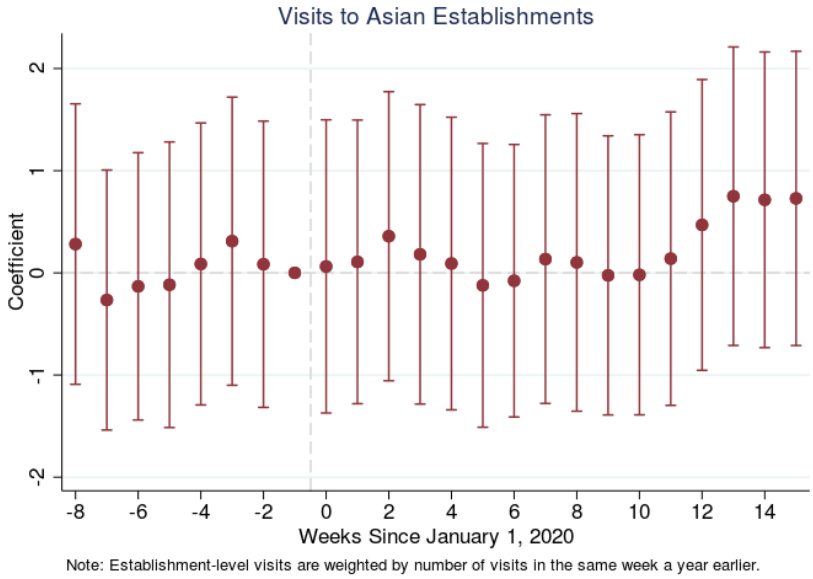


Exhibit III. Regression outputs

i. Event Study 1a - Coefficients on Week*Asian Establishment Indicator

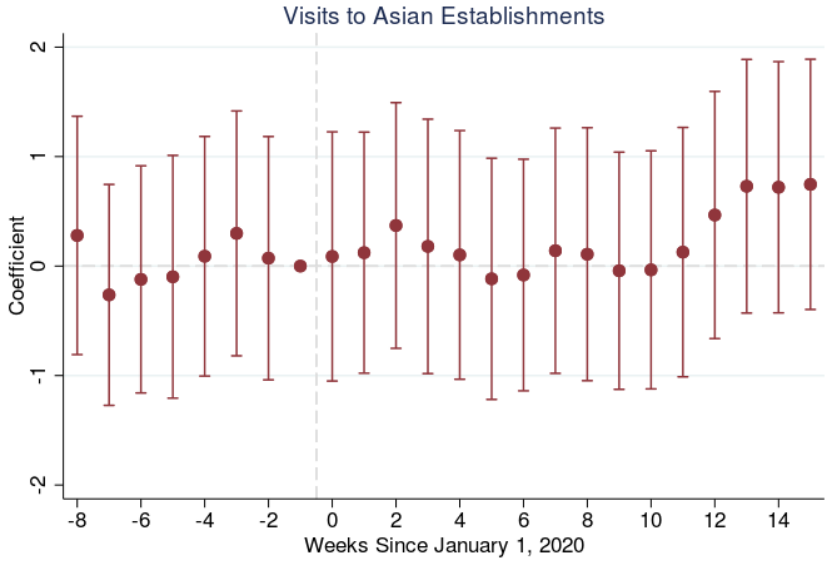
$$\Delta\log(y_{i,t}) = -0.38 + b_{1,,t} - 0.21\alpha_i + b_{3,t}\alpha_i$$



Note: Establishment-level visits are weighted by number of visits in the same week a year earlier.

Note: For robustness, the regression with venue-tract level fixed effects, and the coefficient terms are included below.

$$\Delta\log(y_{i,t}) = -0.38 + b_{1,,t} - 0.15\alpha_i + b_{3,t}\alpha_i + b_{4,i}$$



Note: Establishment-level visits are weighted by number of visits in the same week a year earlier.

ii. Diff in Diff 1 – Post Variables with Fixed Effects

VARIABLES	(1) Model	(2) Fixed Effects	(3) Fixed Effects	(4) Fixed Effects
Post=1	0.248***	0.252***		
	(0.00877)	(0.00727)		
Post=2	0.255***	0.262***		
	(0.00634)	(0.00526)		
Post=3	-0.724***	-0.726***		
	(0.0069)	(0.00574)		
Asian Estab Indic=1	-0.264	-0.187	-0.263*	-0.2
	(0.168)	(0.143)	(0.156)	(0.127)
Post_Asian Estab = 1	0.127	0.135	0.132	0.139
	(0.356)	(0.295)	(0.330)	(0.262)
Post_Asian Estab = 2	-0.138	-0.139	-0.138	-0.138
	(0.259)	(0.214)	(0.240)	(0.190)
Post_Asian Estab = 3	0.4	0.39	0.394	0.385*
	(0.30)	(0.25)	(0.28)	(0.22)
Constant	-0.379***	-0.381***	-0.434***	-0.434***
	(0.00405)	(0.00336)	(0.00238)	(0.00189)
Observations	30,514	30,498	30,514	30,498
R-squared	0.397	0.602	0.482	0.686
Venue FIPS FE		YES		YES
Week FE			YES	YES

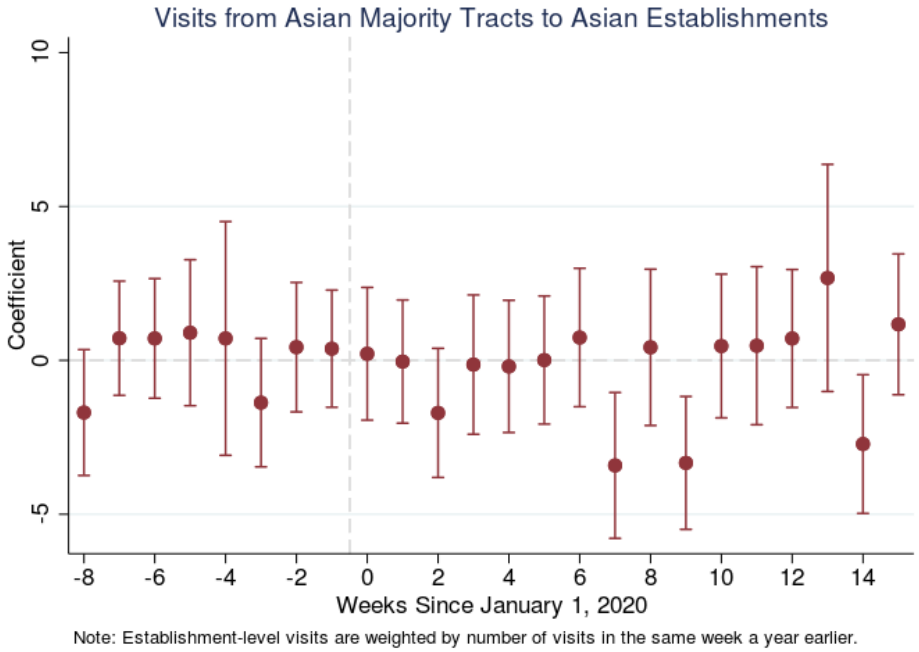
Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Post=1 After 1st case novel COVID-19 | Post=2 After 1st case in Philadelphia| Post=3: After State of Emergency

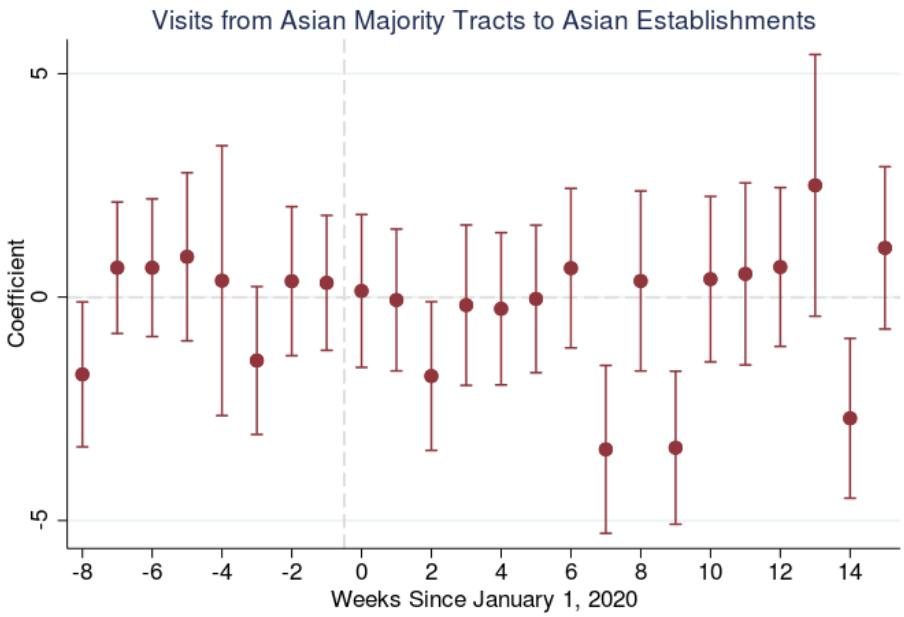
iii. Event Study 1b – Coeff. on Week*Asian Estab. Indic.*Asian Majority Origin Tract

$$\Delta\log(y_{i,t}) = -0.37 + b_{1,t} - 0.26\alpha + b_{3,t}\alpha - 0.25\beta + b_{5,t}\beta + b_{6,t}\alpha\beta.$$



Note: For robustness, the regression with venue-tract level fixed effects, and the coefficient terms are included below.

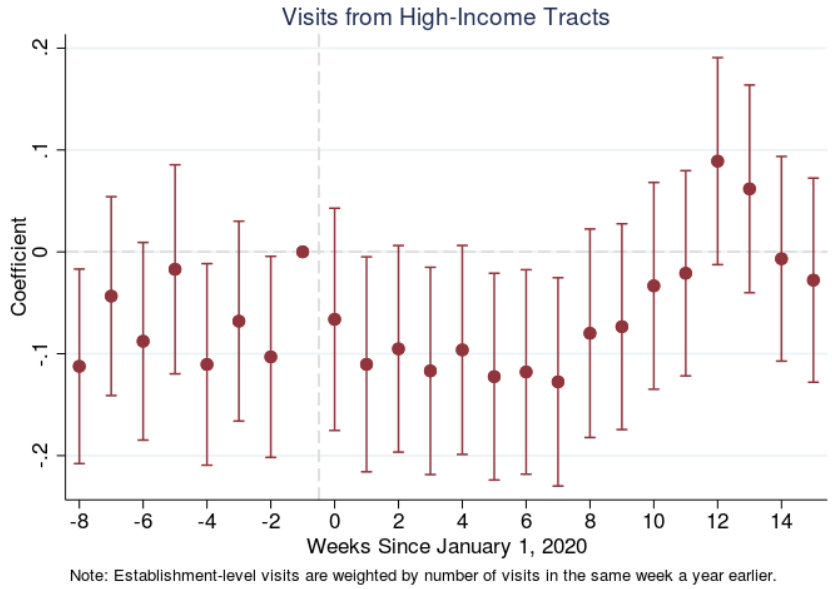
$$\Delta\log(y_{i,t}) = -0.38 + b_{1,t} - 0.2\alpha_i + b_{3,t}\alpha_i - 0.21\beta_i + b_{5,t}\beta_i + b_{6,t}\alpha_i\beta_i + b_{7,i}$$



Note: Establishment-level visits are weighted by number of visits in the same week a year earlier.

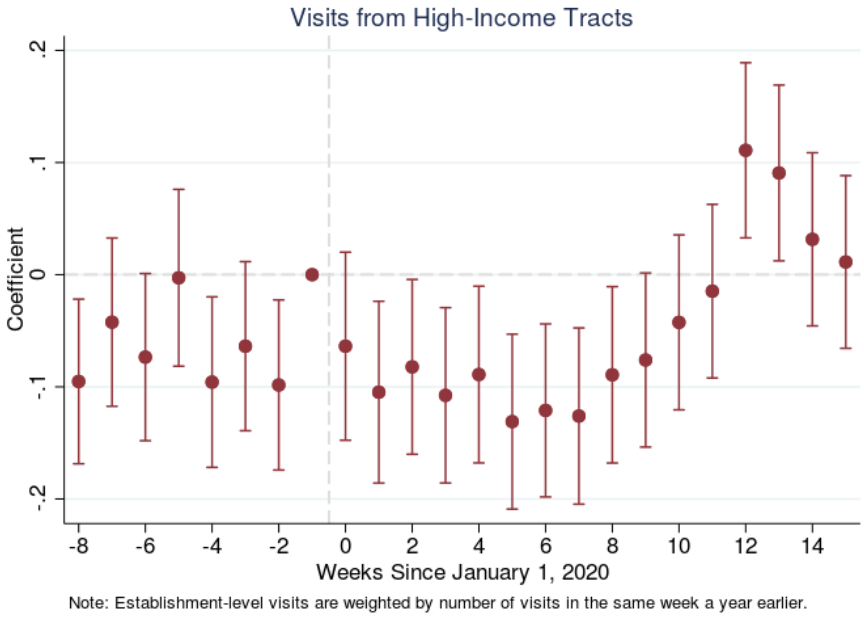
iv. Event Study 2 - Coefficients on Week * High-Income Indicator

$$\Delta\log(y_{i,t}) = -0.48 + b_{1,t} + 0.08\delta_i + b_{3,t}\delta_i$$



Note: For robustness, the regression with origin-tract level fixed effects, and the coefficient terms are included below. These results are robust for showing consistency in the negative trend in the early weeks.

$$\Delta\log(y_{i,t}) = -0.48 + b_{1,t} + 0.19\delta_i + b_{3,t}\delta_i + b_{4,i}$$



v. Diff in Diff 2 – Demographics of Origin Visits & Post Variables

VARIABLES	(1) Model	(2) Fixed Effects	(3) Fixed Effects	(4) Fixed Effects
Post=1	0.209***	0.208***		
	(0.0090)	(0.0072)		
Post=2	0.238***	0.232***		
	(0.0065)	(0.0052)		
Post=3	-0.472***	-0.484***		
	(0.0071)	(0.0057)		
High-income Indic=1	-0.144***	0.133***	-0.144***	0.131***
	(0.0125)	(0.0172)	(0.0122)	(0.0163)
Racial Majority=1	-0.426***		-0.427***	
	(0.0063)		(0.0061)	
Racial Majority=2	-0.402***		-0.404***	
	(0.0126)		(0.0123)	
Racial Majority=3	-0.387***		-0.389***	
	(0.0291)		(0.0284)	
Post_High-Income = 1	0.00137	0.00454	0.000549	0.00368
	(0.0263)	(0.0209)	(0.0257)	(0.0199)
Post_High-Income = 2	0.00722	-0.00287	0.00623	-0.00409
	(0.0194)	(0.0154)	(0.0189)	(0.0147)
Post_High-Income = 3	0.0255	0.0199	0.0296	0.0242
	(0.0213)	(0.0170)	(0.0208)	(0.0162)
Post=1 & Racial Majority=1	0.124***	0.126***	0.127***	0.129***
	(0.0135)	(0.0108)	(0.0132)	(0.0102)
Post=2 & Racial Majority=1	0.164***	0.165***	0.165***	0.166***
	(0.0099)	(0.0079)	(0.0096)	(0.0075)
Post=3 & Racial Majority=1	0.247***	0.235***	0.245***	0.233***
	(0.0109)	(0.0087)	(0.0106)	(0.0083)
Post=1 & Racial Majority=2	0.0694**	0.0992***	0.0722***	0.102***
	(0.0271)	(0.0216)	(0.0265)	(0.0206)
Post=2 & Racial Majority=2	0.0953***	0.104***	0.0973***	0.106***
	(0.0199)	(0.0159)	(0.0194)	(0.0151)
Post=3 & Racial Majority=2	0.184***	0.175***	0.179***	0.169***
	(0.0223)	(0.0179)	(0.0218)	(0.0170)
Post=1 & Racial Majority=3	-0.0926	-0.0555	-0.0871	-0.0505
	(0.0639)	(0.0513)	(0.0625)	(0.0488)
Post=2 & Racial Majority=3	0.03	0.0657*	0.0319	0.0673*
	(0.0471)	(0.0380)	(0.0460)	(0.0362)
Post=3 & Racial Majority=3	0.0207	0.011	0.0211	0.0111
	(0.0528)	(0.0425)	(0.0516)	(0.0404)
Constant	-0.297***	-0.490***	-0.301***	-0.499***
	(0.0042)	(0.0248)	(0.0026)	(0.0237)
Observations	234,289	219,537	234,289	219,537
R-squared	0.21	0.575	0.246	0.614
Origin FIPS FE		YES		YES
Week FE			YES	YES

Standard errors in parentheses

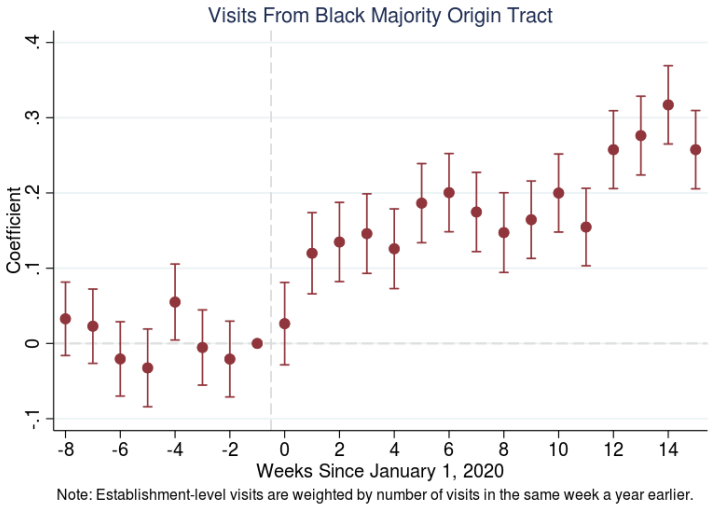
*** p<0.01, ** p<0.05, * p<0.1

Post=1 After 1st case novel COVID-19 | Post=2 After 1st case in Philadelphia| Post=3 After State of Emergency

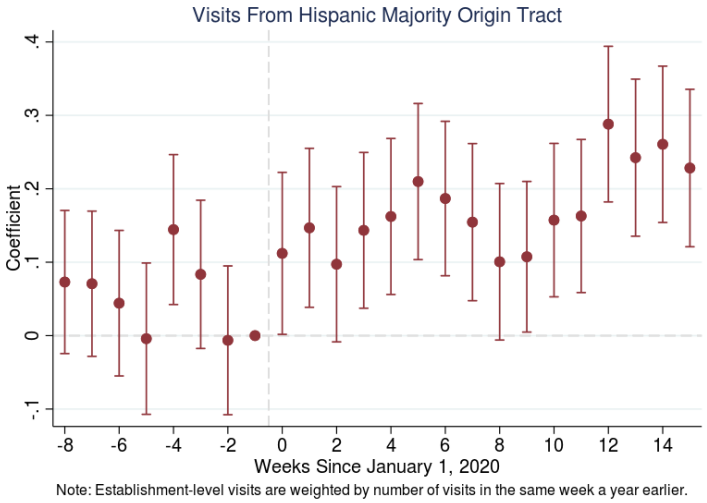
Origin Tract Racial Majority: 1-Black 2-Hispanic 3-Asian (White omitted)

vi. Event Study – Coefficients on Week * Tract Type

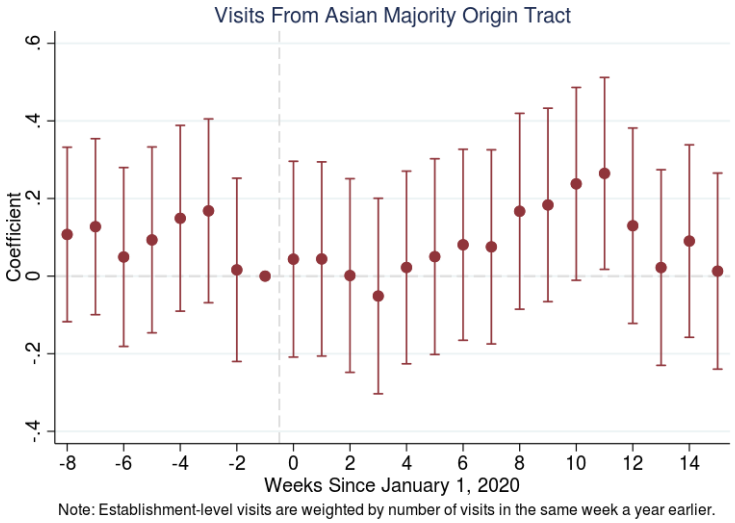
Regression: $\Delta\log(y_{i,t}) = -0.31 + b_{1,t} + \delta_i + b_{2,t}\delta_i + \tau_i + b_{3,t}\tau_i$



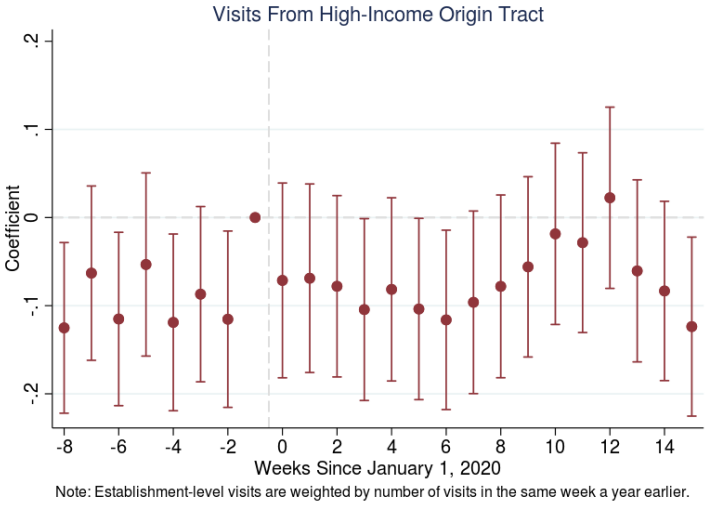
Note: Establishment-level visits are weighted by number of visits in the same week a year earlier.



Note: Establishment-level visits are weighted by number of visits in the same week a year earlier.



Note: Establishment-level visits are weighted by number of visits in the same week a year earlier.



Note: Establishment-level visits are weighted by number of visits in the same week a year earlier.