

1 Introduction

As the coronavirus spread in Philadelphia this year, travel patterns changed. With this shock to human mobility came another to business activity, as far fewer of us traveled to work, amenities or other pastimes. In order to understand the consequences of these changes, we use mobile phone GPS data to explore how Philadelphians changed their travel patterns before and during the pandemic. This analysis will explore general trends before examining night life—the restaurants and bars that both provide jobs and support vibrant streets—and certain bellwether industries, like those with office work, that doubtless provide a foundation for such night life.

With the goal of understanding the time-space patterns of resident movement in Philadelphia, the following section presents data from [SafeGraph](#), a provider of such records.

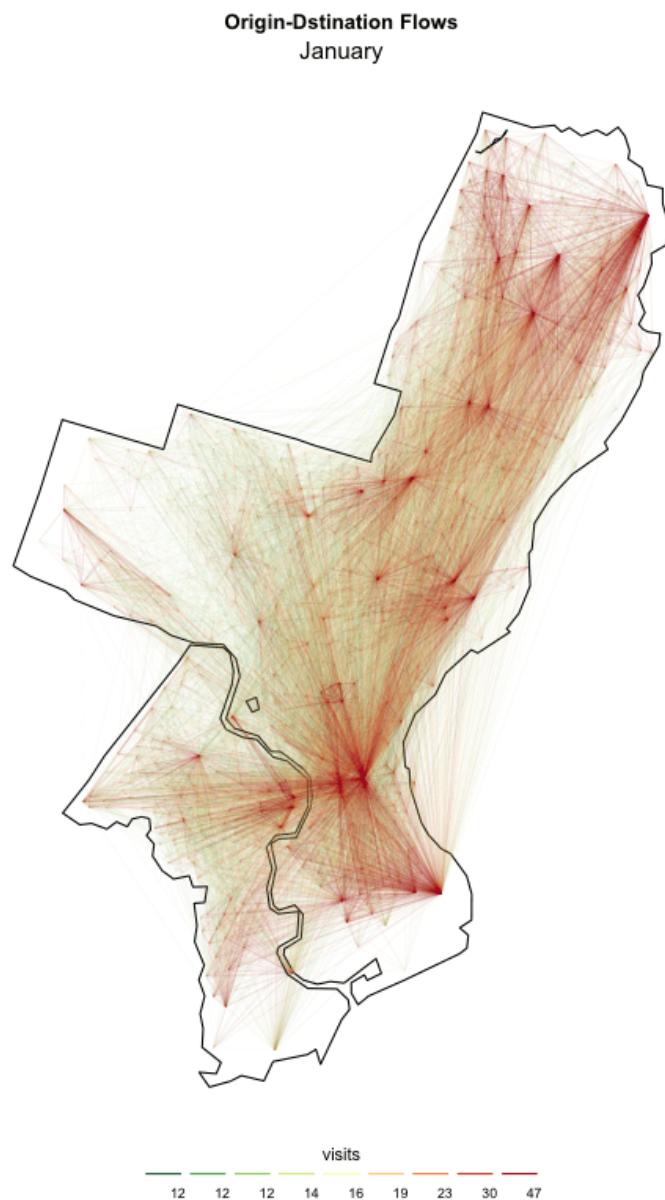
Note that SafeGraph collects data on a [representative sample](#) (10%) of the population across the country, so our indicators are not the true number of visits or journeys, but a slice. The data contain the terms defined in figure 1.1: the number of **visitors** is the count of devices flowing to a point of interest—be it from a given Census Block Group or total—while a **connection** is an origin-destination line between a Census Block Group and a point of interest, regardless of its weight. Our concern here is to track the flow of visitors from an origin location to a destination location in order to map flows over time and space.

1.1 Key definitions



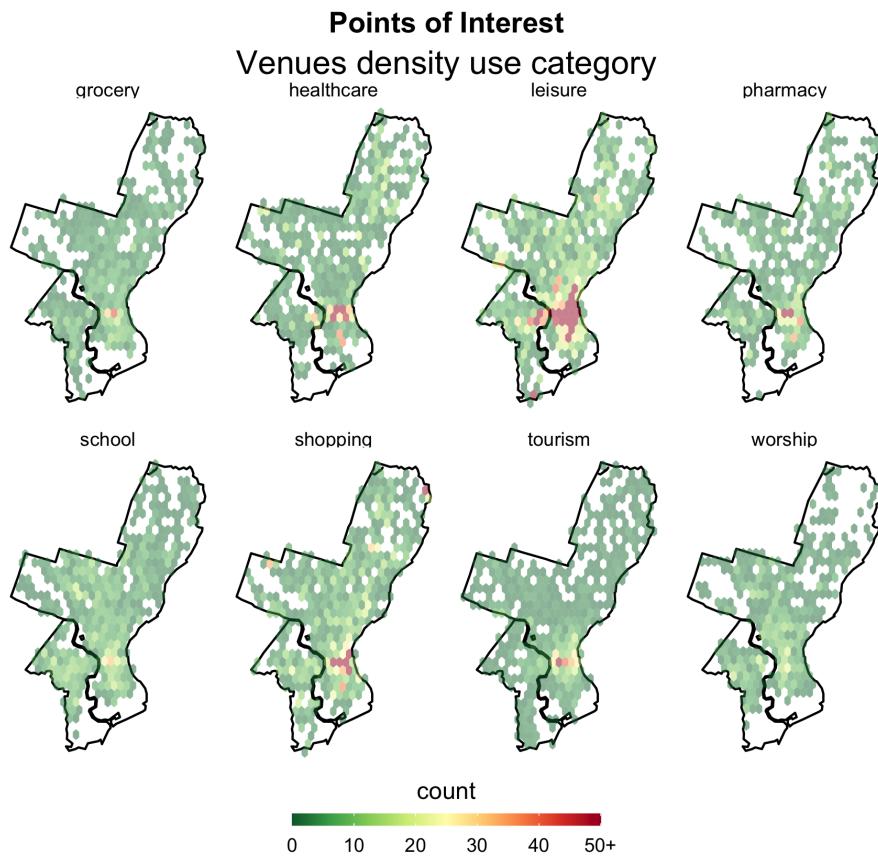
Figure 1.2 below maps these origin-destination flows as network connections to show the extent to which areas throughout Philadelphia are connected to one another. Changes over time reveal how much the network thins out as the pandemic grows.

1.2 Mobility network



Each visit is a mobile device entering into a point of interest; these include parks and museums, restaurants and bars, or offices and hospitals. In figure 1.3 we map the distribution of these venues and businesses for context. We classify each point of interest by its description, which SafeGraph provides. [1] We can see that most businesses cluster in Center City or nearby but no businesses cluster more than restaurants and bars.

1.3 Business landscape



This analysis comprises different spatial scales, Citywide, Neighborhood and Point of Interest. We can look *globally*, across the city, to explore trends throughout; we can also think *locally*, dividing the city up into cells or neighborhoods to probe variations within the city. Finally, we can look at individual businesses or venues. Below, we attempt to understand patterns at each scale.

2 Citywide analysis

In this section we explore trends and relationships manifest most strongly at the global level, across the city. Best described by this focus on the whole over its part are how certain brands and industries are performing, regardless of location, and how certain variables predict changes to activity and mobility in Philadelphia. We see how visitation is changing across time by tracking visits across brands. Figure 2.1 shows that brands associated with necessities (Target and Walmart) saw comparably less of a decline than others, along with fast food restaurants, which one might expect in a time of constrained budgets. The map shows the locations of brands for context.

2.1 Brand performance

Rankings	Locations
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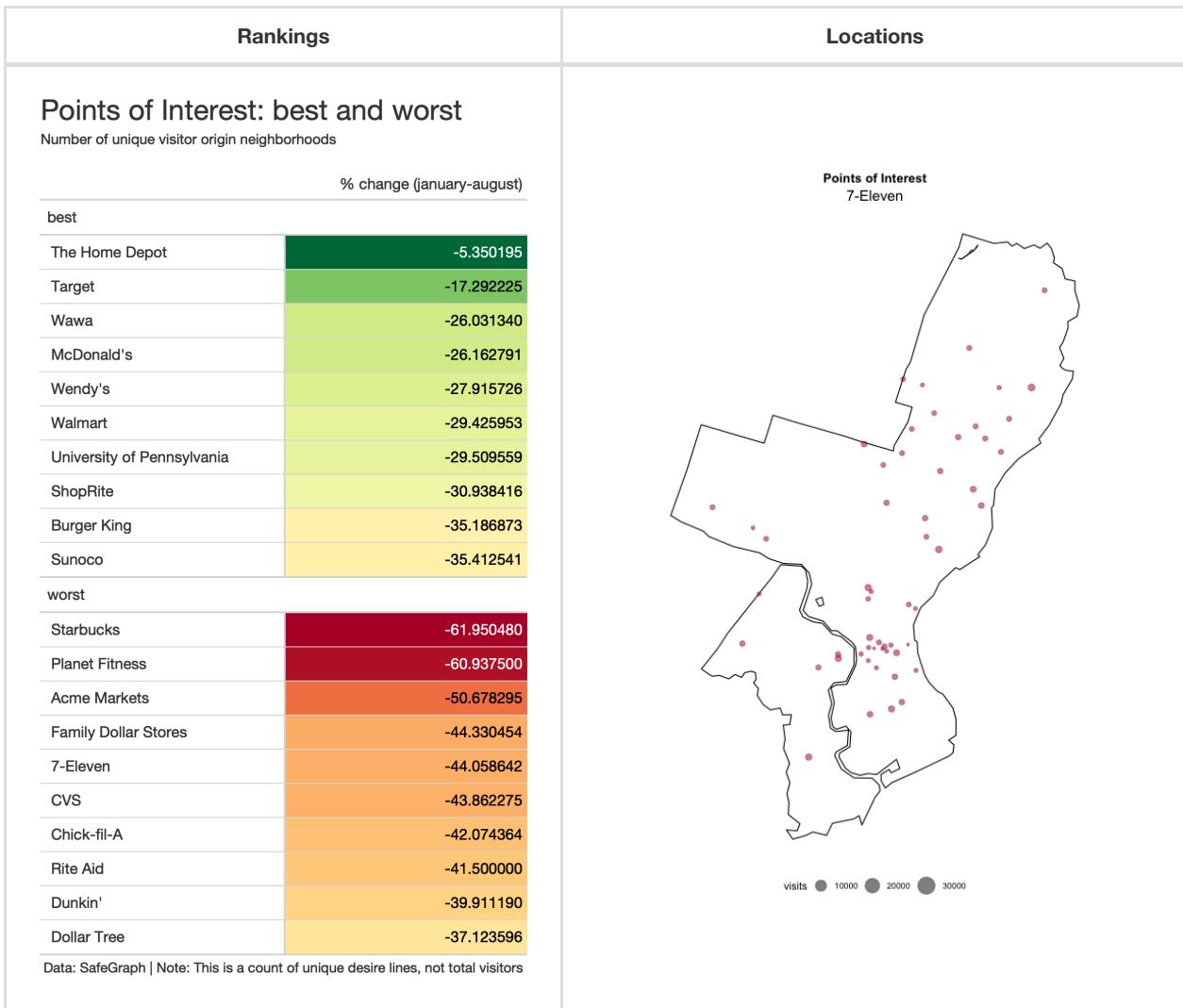
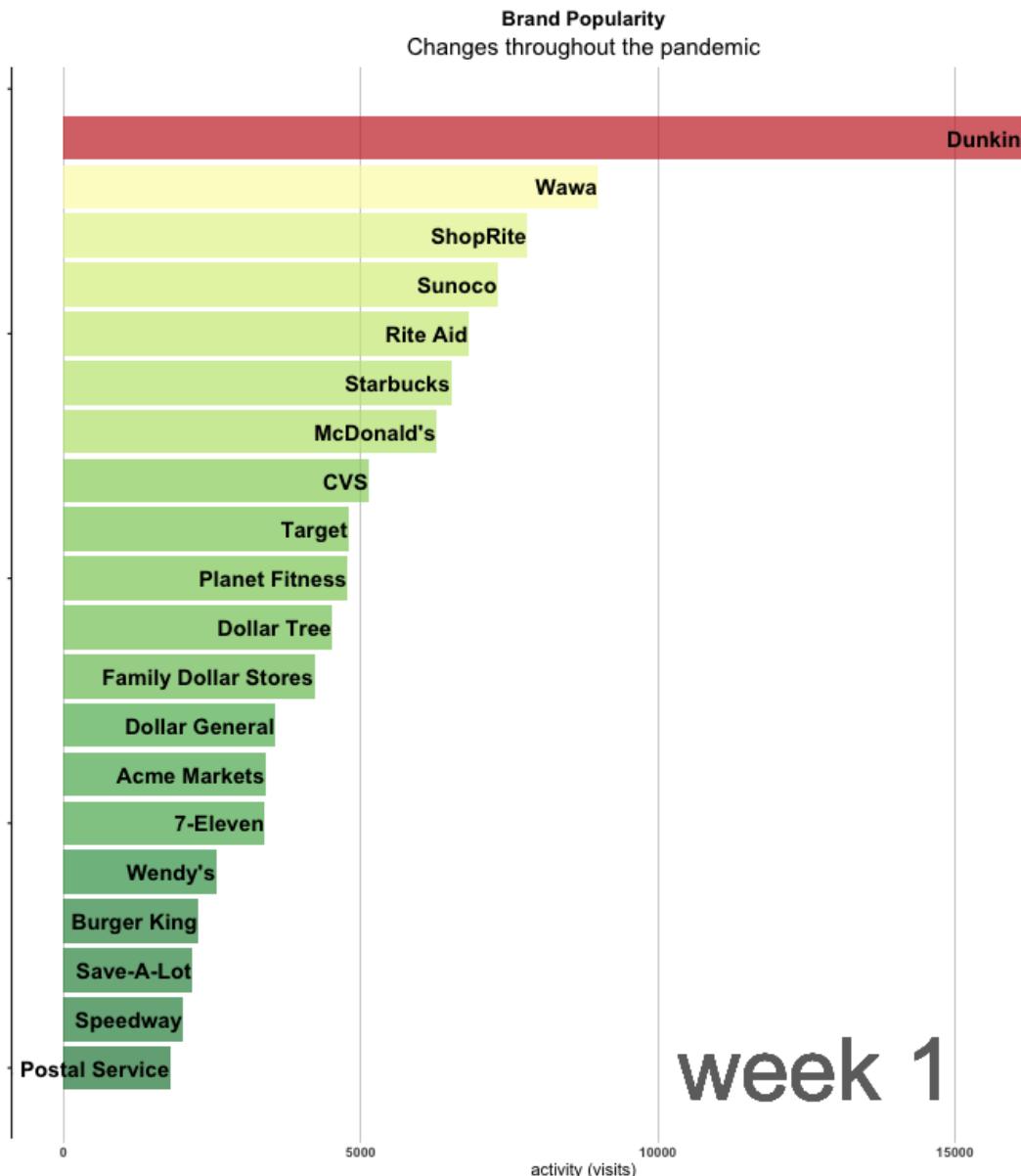


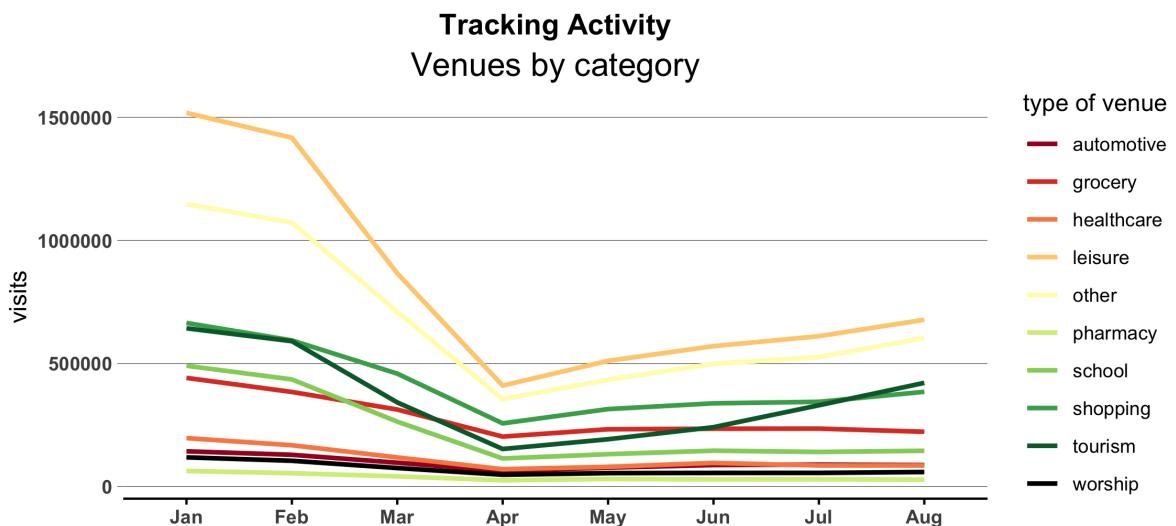
Figure 2.2, which ranks each brand by the number of visitors it received and animates this change through the pandemic. Dollar stores rise gradually throughout the year, an expected change as residents both need more home goods and need to save money; another important shift is away from non-essential retail towards essential businesses like pharmacies. Starbucks and Wawa occupy top spots for the first several weeks of the year but when the shelter-in-place order sets in, patronage immediately collapses and they are replaced in the ranks by essential shops RiteAid and ShopRite.

2.2 Changing fortunes



In figure 2.1 we aggregate by use, grouping by classes like leisure (restaurants and bars) and tourism (museums and theaters). The pandemic had distinct effects on each class, but particularly leisure and other; other includes offices which also explains the steep fall. Interestingly, tourism is recovering while shops and grocers are not, perhaps as many switch to digital commerce.

2.3 Industry trends

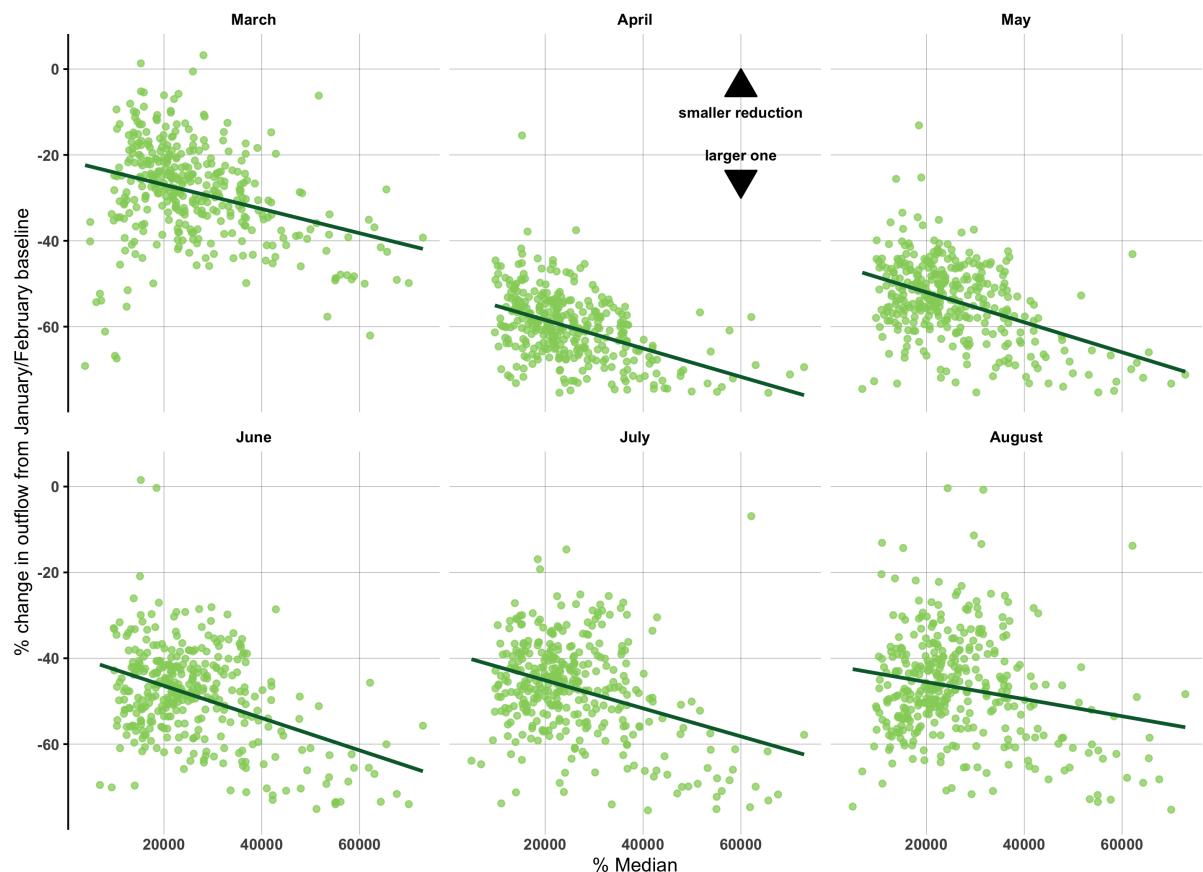


Changing mobility may influence or exacerbate existing problems in Philadelphia, notably around equity and integration. Philadelphia still shows patterns of concentrated poverty, segregated housing and isolated pockets of prosperity; the pandemic could produce deeper disparities. One risk is that communities of color and low income neighborhoods will not be able to socially distance in the same capacity as affluent communities. The data, however, do not give a clear signal. Below we plot the relationship between outflows—individuals visiting points of interest from a given tract—and key predictors: tract income and the percentage of the tract that is African American. (Tracts allow for better demographic estimates.) The story is clear for income, as during the critical month of April few poor communities could afford to shelter in place, but hazy for race.

2.4 Income and travel

Income's Association with Travel

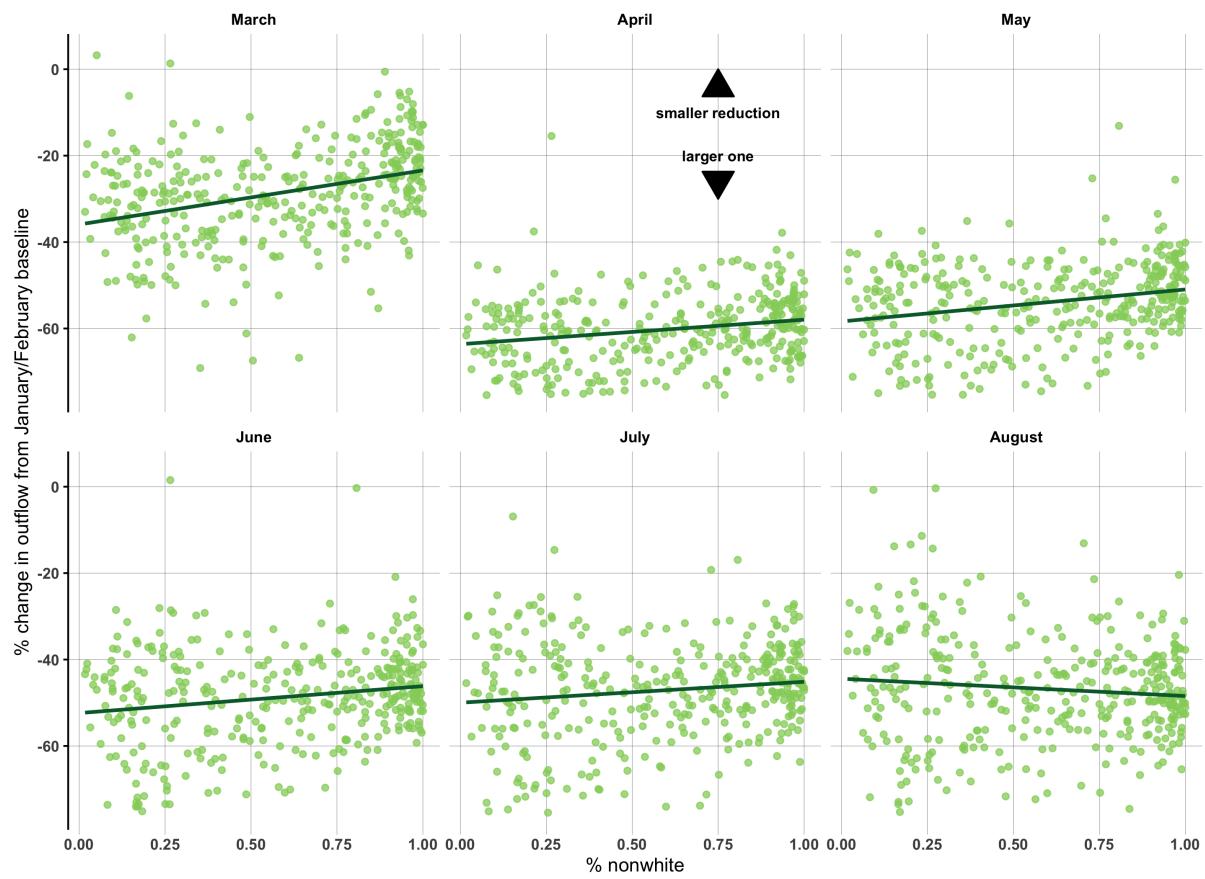
Median income of tract against change in patrons



The pandemic appears to have flattened an existing relationship between race and mobility: in early days of the pandemic, communities of color were more likely to receive visitors from the rest of the city, a pattern that held for peak months of spread, but this relationship weakens as more predominately white communities gained visitors in July and August. When we plot the same travel patterns against income, we see that wealthy communities are well below their baseline visits, perhaps because many of the restaurant clusters are in relatively affluent areas. While poor communities are more likely to have recovered to baseline but some of the poorest areas are still lagging behind, more in line with wealthy ones.

2.5 Race and travel

Demography's Association with Travel
Nonwhite population of tract against change in patrons



The story is similar when we look at inflows, which we document in the appendix. This suggests that poor and minority areas have remained comparable active during the pandemic, which may come with heightened exposure alongside economic stability.

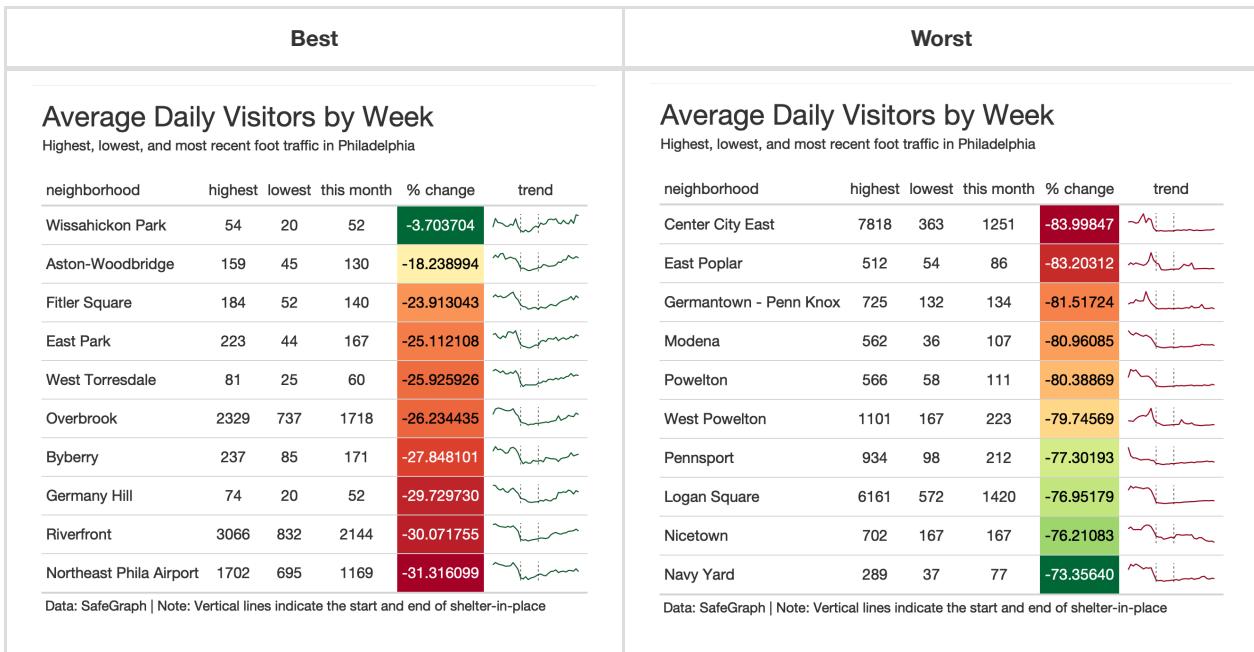
3 Neighborhood variation

Perhaps more valuable than probing individual points of interest is aggregating by areal units, which we do in this section. These allow us to see how visits in particular are changing throughout the pandemic in different parts of Philadelphia. Philadelphia has roughly 150 neighborhoods (we use [definitions](#)

from local firm Azavea) and each responded differently to the pandemic. We explore trends across neighborhoods in figure 3.1; neighborhoods dominated by office work, like the Navy Yard along with Logan Square and Center City, saw precipitous declines in foot traffic, but those with strong amenities and residential communities have recovered. This suggests that demand for food, drink, and shopping may be shifting away from the core. (Note: see the appendix for larger tables.)

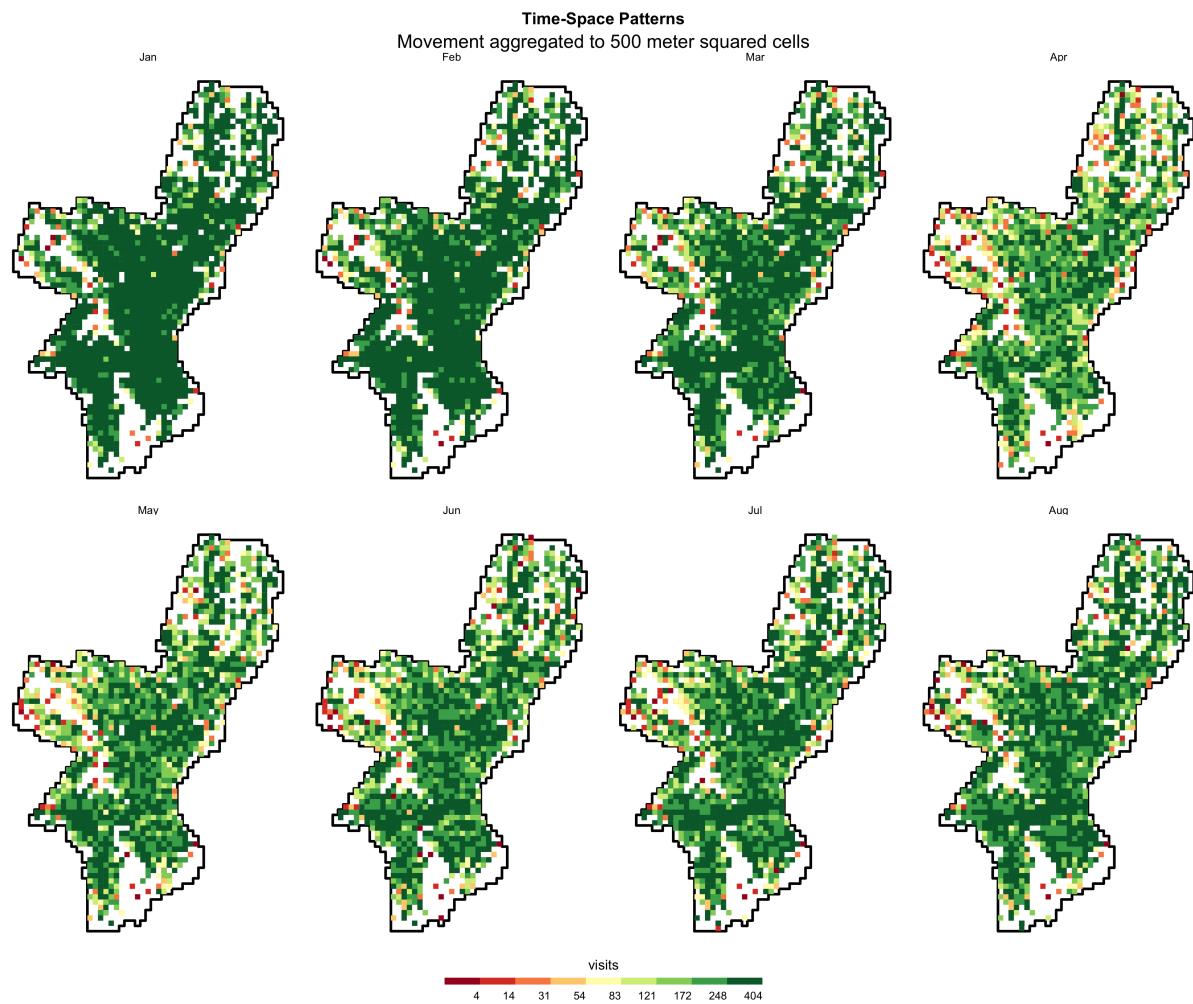
3.1 Neighborhood trends

Best	Worst
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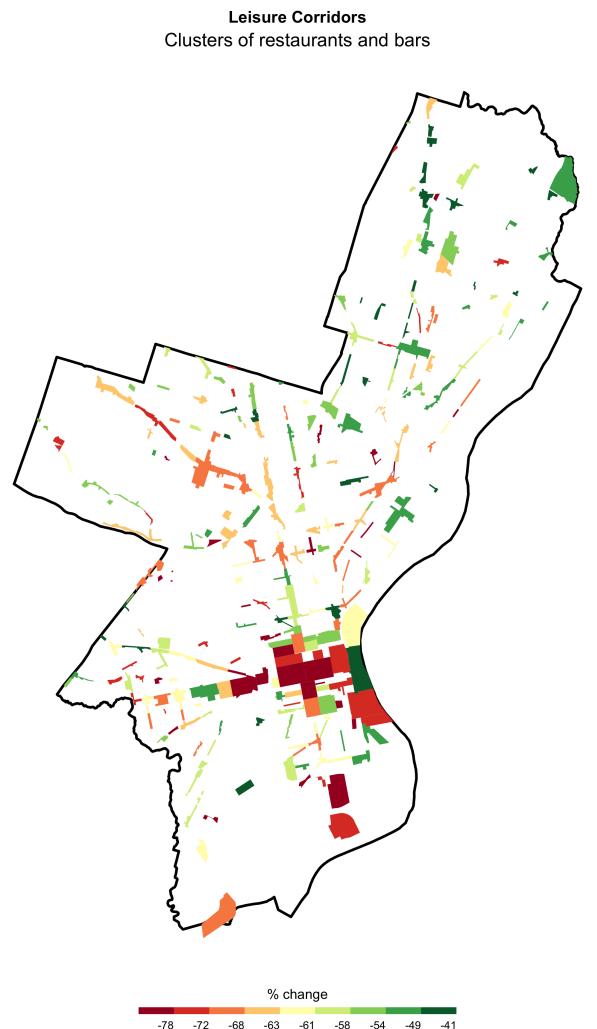
Using a regular grid, in figure 3.2, we aggregate to a grid of 500 meter cells to see how this manifests across space. We are still aggregating from points of interest, so this is visits to businesses, parks, museums and the like, but by tile; this does not include visits to the particular patch of land without setting foot in a point of interest. The city hollowed out during the worst months of the pandemic but the Old City, Center City, University City axis still appears to have pockets of thriving activity in these maps.

3.2 Variation by time and geography



Businesses cluster together and we can explore the strength of this phenomenon by looking at commercial corridors, of which the city has designated roughly 280. Looking at night life in figure 3.3, the largest are Market West and Market East, on either side of city hall, with 1712 and 1263 restaurants and bars respectively, following by Old City at 654 and another in University City with 493: most of the business activity is concentrated in a few locales.

3.3 Commercial corridors



When we plot trends in these clusters over time, it is clear that many of the most successful areas are toward the periphery, perhaps dormitory communities supported by remote work, and several of the least successful are situated in the core. Notably among the worst performers are the two central corridors, which depend on office work, and the Sports Complex, which saw sports leagues take measures of protect players and ban fans early on—and many of these restrictions are still in place. Peripheral plazas like Oxford and Levick, home to a supermarket, and City and Haverford are among the best.

3.4 Corridor trends

Best	Worst
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Best							Worst							
Night Life Hubs: top ten														
	corridor	high	low	average	% change	trend		corridor	high	low	average	% change	trend	
1	Oxford and Levick	670	307	490.4857	-54.17910		1	Sports Complex	2429	31	538.5143	-98.72375		1
2	Cheltenham & Ogontz	898	402	588.4857	-55.23385		2	Broad and Cecil B. Moore	11687	418	3355.4857	-96.42338		2
3	Aramingo Avenue	2807	1254	1941.2000	-55.32597		3	5th and Lehigh	1244	70	397.7714	-94.37299		3
4	Leo Mall/Lumar Center & Vicinity	1106	494	837.0286	-55.33454		4	36th Street and vicinity	15454	873	5034.0857	-94.35098		4
5	City and Haverford	724	306	491.9429	-57.73481		5	Rising Sun Avenue/Olney	2743	178	531.0000	-93.51075		5
6	Point Breeze Avenue	598	251	397.3429	-58.02676		6	36th and Lancaster	2683	181	715.7429	-93.25382		6
7	2nd and Lehigh	608	249	371.7714	-59.04605		7	30th Street	8732	635	3027.2857	-92.72790		7
8	Bustleton and Red Lion	960	389	708.1143	-59.47917		8	Market East	41022	3091	12053.0857	-92.46502		8
9	Elmwood Avenue	1191	479	782.3143	-59.78170		9	Market West	27629	2241	10252.2571	-91.88896		9
10	Penrose Plaza and vicinity	1073	431	760.0286	-59.83225		10	Central Waterfront/Penns Landing	774	66	346.4857	-91.47287		10

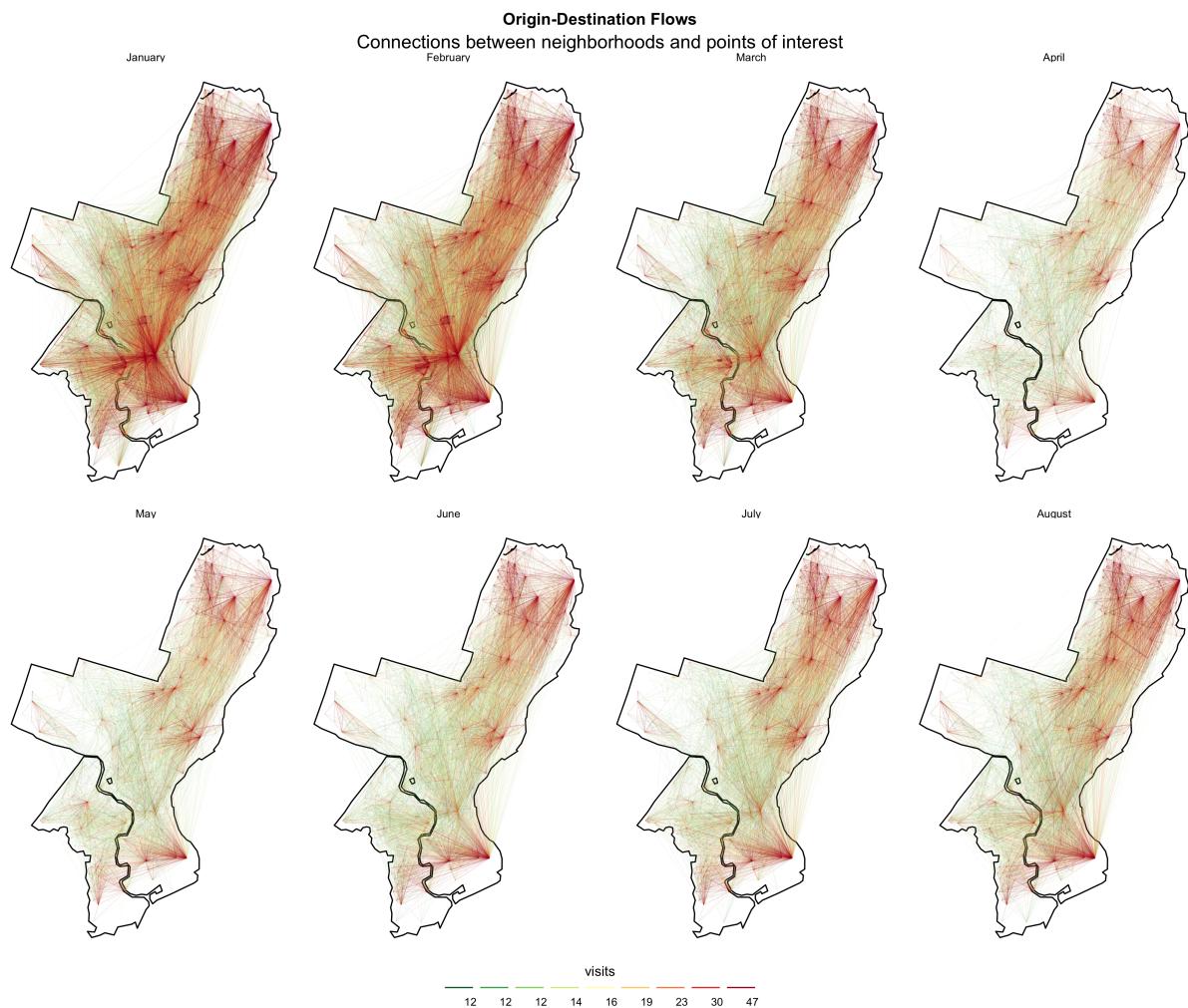
Data: SafeGraph | Note: Period spanning January to August 2020

Data: SafeGraph | Note: Period spanning January to August 2020

4 Points of Interest in focus

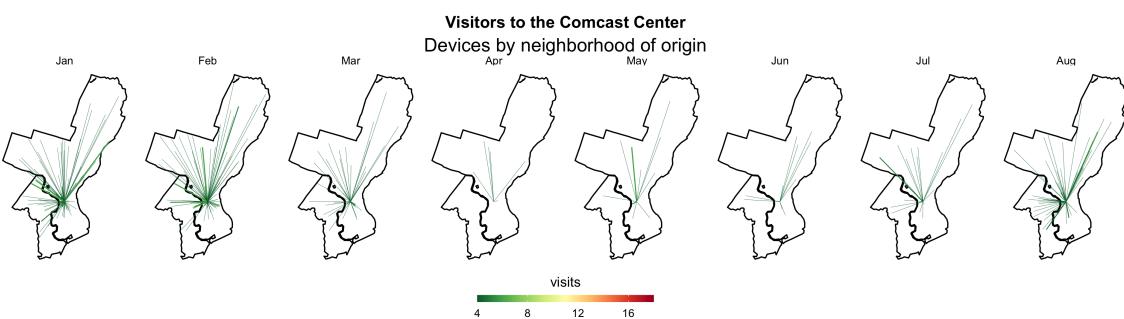
This section looks at individual points of interest, how they perform over time and whether or not we can identify certain bellwether businesses within the city. These cases can provide further insight into how the pandemic is changing mobility. We start by looking at the network of connections across the city. Drawing a line between each origin (neighborhood) and destination (point of interest), there is a dense web—a nearly saturated graph where all neighborhoods send visitors to all other corners of the city. This web becomes sparser as the pandemic came to the fore and there during the late summer there were fewer links than during the late winter.

4.1 Aggregate mobility



As we saw above, the data show that big box stores like Target and Walmart appear to have weathered the pandemic well, but the shift to remote work should also appear in the data. We can look at visits to the Comcast Center and the Plaza below it; visits in April and May, as the coronavirus took hold in the city, fell substantially.

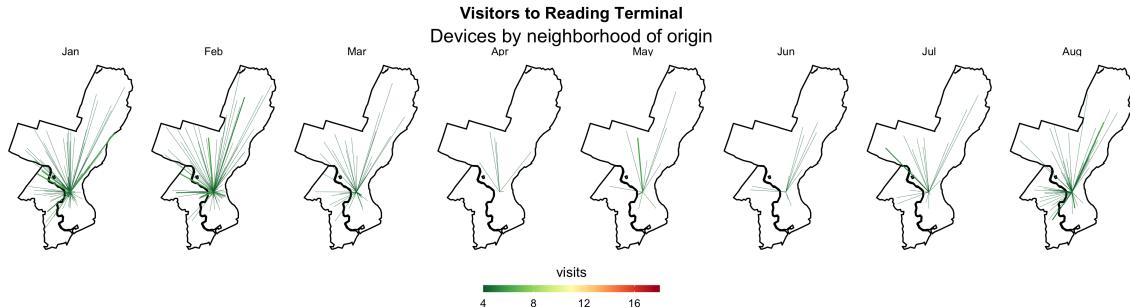
4.2 Business in focus



Yet with offices vacant, parks should have swelled with visitors. We see mixed evidence of this in the data. Philadelphia has four central squares—Rittenhouse, Washington, Logan, and Franklin—which provide important community amenity; all saw fewer visits in April and May than

later in the summer, suggesting winter patterns continued even as the weather improved. As a signal for tourism, we can look at Reading Terminal Market; vendors between its walls saw marked declines in visits beginning in April.

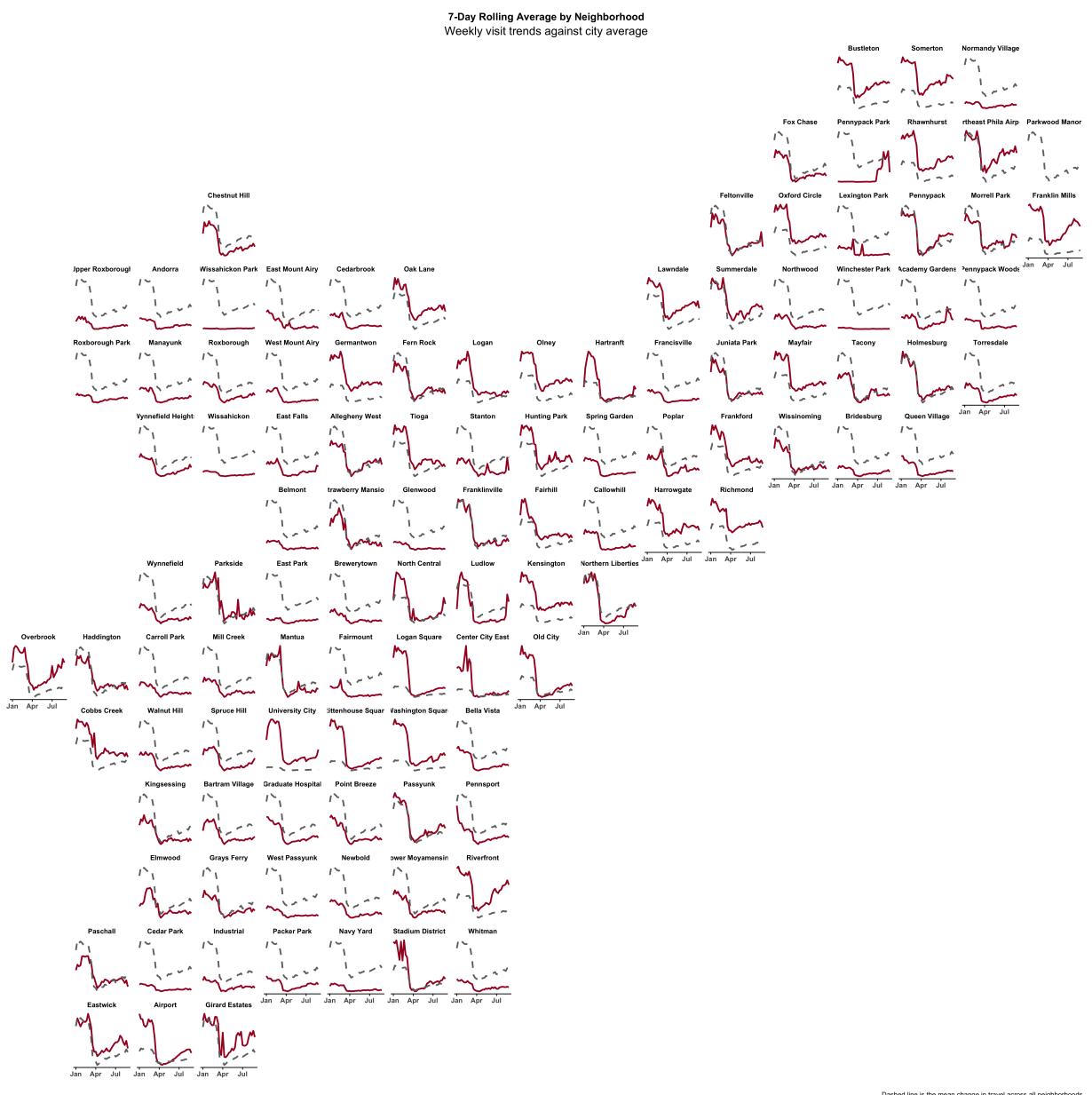
4.3 Tourism in focus



5 Detecting trends

In order to understand trends we fit a rolling average to these neighborhoods and plot these trends for context. The many neighborhoods in the Northeast and Northwest are rebound while the axis of University, Center and Old City are still down substantially.

5.1 Rolling averages



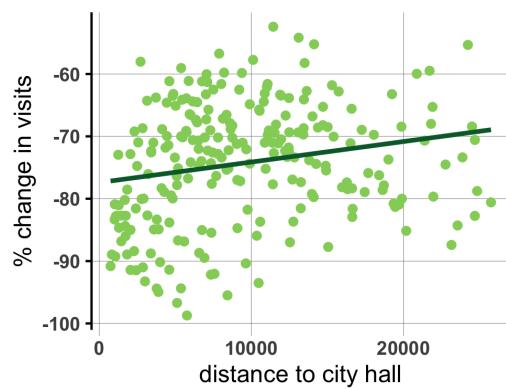
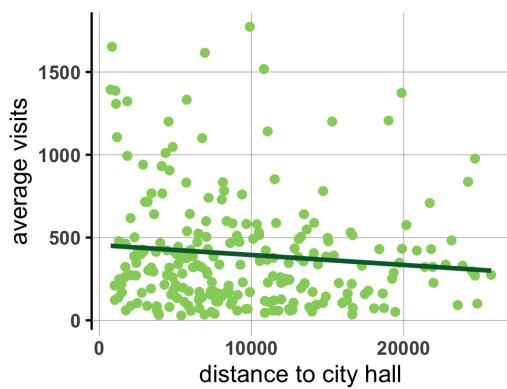
Appendix

A.1 Expanding neighborhood ranks

Best						Worst					
Average Daily Visitors by Week						Average Daily Visitors by Week					
neighborhood	highest	lowest	this month	% change	trend	neighborhood	highest	lowest	this month	% change	trend
Wissahickon Park	54	20	52	-3.703704		Center City East	7818	363	1251	-83.99847	
Aston-Woodbridge	159	45	130	-18.238994		East Poplar	512	54	86	-83.20312	
Fitler Square	184	52	140	-23.913043		Germantown - Penn Knox	725	132	134	-81.51724	
East Park	223	44	167	-25.112108		Modena	562	36	107	-80.96085	
West Torresdale	81	25	60	-25.925926		Powelton	566	58	111	-80.38869	
Overbrook	2329	737	1718	-26.234435		West Powelton	1101	167	223	-79.74569	
Byberry	237	85	171	-27.848101		Pennsport	934	98	212	-77.30193	
Germany Hill	74	20	52	-29.729730		Logan Square	6161	572	1420	-76.95179	
Riverfront	3066	832	2144	-30.071755		Nicetown	702	167	167	-76.21083	
Northeast Phila Airport	1702	695	1169	-31.316099		Navy Yard	289	37	77	-73.35640	
Roxborough Park	297	123	198	-33.333333		Fairmount	659	126	177	-73.14112	
Girard Estates	1786	673	1189	-33.426652		Rittenhouse	6627	663	1800	-72.83839	
Normandy Village	89	33	59	-33.707865		Lexington Park	656	178	184	-71.95122	
Spruce Hill	926	251	597	-35.529158		Ludlow	206	40	60	-70.87379	
East Falls	668	132	430	-35.628743		Airport	4433	362	1310	-70.44891	
Somerton	3669	1305	2314	-36.931044		Chinatown	663	80	201	-69.68326	
Bridesburg	474	167	296	-37.552743		Old City	3516	396	1076	-69.39704	
Pennypack	1518	461	942	-37.944664		Logan	3096	798	974	-68.54005	
Dearney Park	65	22	40	-38.461538		Dunlap	170	56	56	-67.05882	
Southwest Germantown	437	164	268	-38.672769		Spring Garden	689	125	229	-66.76343	
Data: SafeGraph Note: Vertical lines indicate the start and end of shelter-in-place						Data: SafeGraph Note: Vertical lines indicate the start and end of shelter-in-place					

A.2 Explanatory variables

Corridor Activity
The relationship between distance to City Hall and visits



A.3 Expanding corridor ranks

Best						Worst					
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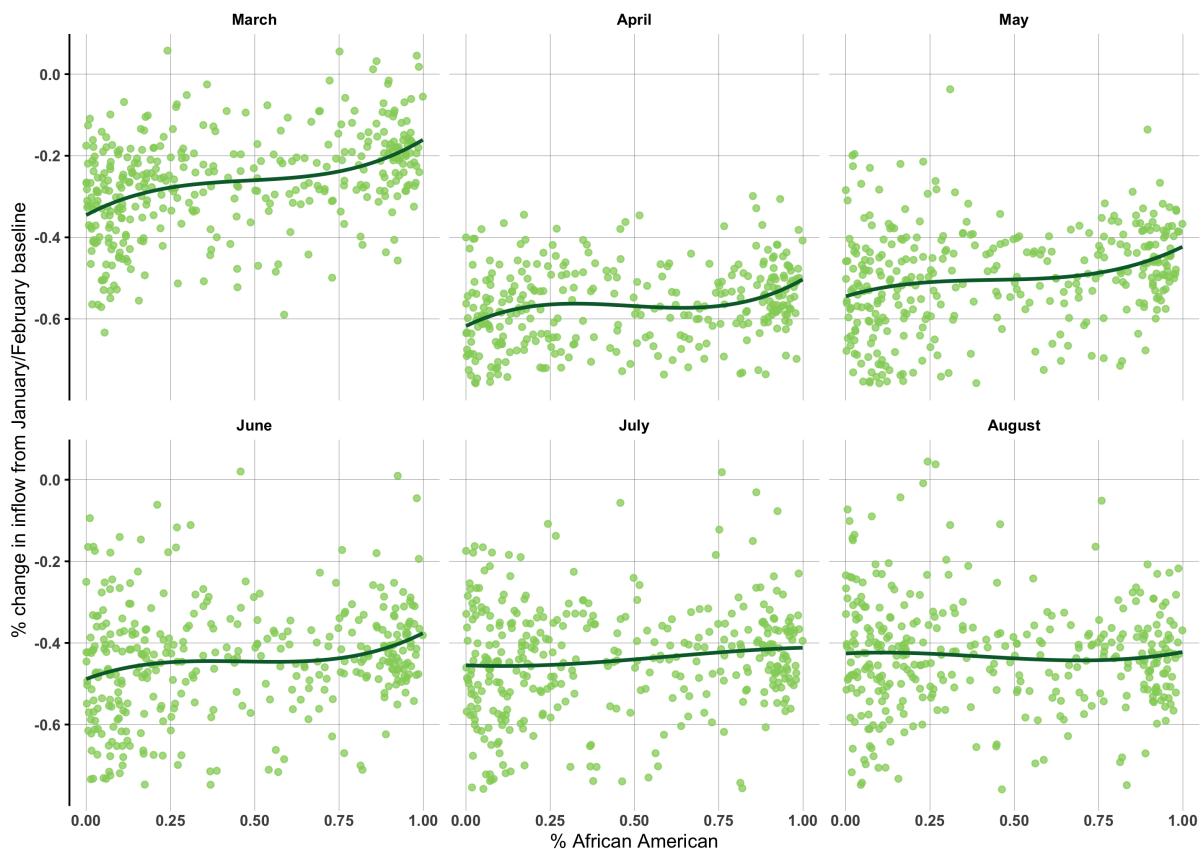
Best							Worst						
Night Life Hubs: top twenty							Night Life Hubs: bottom twenty						
	corridor	high	low	average	% change	trend		corridor	high	low	average	% change	trend
1	Oxford and Levick	670	307	490.4857	-54.17910		1	Sports Complex	2429	31	538.5143	-98.72375	
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11	Presidential/Belair	637	255	420.9429	-59.96860		11	Fairmount/19th-25th	2295	197	616.8000	-91.41612	
12	Quartermaster Plaza and vicinity	1416	550	905.6000	-61.15819		12	49th and Woodland	952	82	318.0286	-91.38655	
13	Woodland Avenue	1690	656	1099.7143	-61.18343		13	Central Waterfront/Spring Garden	2089	188	939.8571	-91.00048	
14	Adams and the Boulevard	1690	649	1141.2857	-61.59763		14	Parkway/Logan Circle	3568	328	1393.5143	-90.80717	
15	Frankford Ave - Mayfair	1901	726	1200.9429	-61.80957		15	Pier 70 Plaza and vicinity	1679	165	467.2571	-90.17272	
16	One and Olney Square	559	212	365.3714	-62.07513		16	Broad and South	3705	398	1386.7143	-89.25776	
17	54006000 Lancaster Ave	544	204	385.5429	-62.50000		17	Chinatown	4280	473	1652.0286	-88.94860	
18	Rising Sun and Wyoming	787	295	472.7429	-62.51588		18	South Street/Front-8th	3219	356	1323.0286	-88.94066	
19	Frankford Avenue - Lower Mayfair	805	300	548.7143	-62.73292		19	Pennsport Mall/South Second	659	74	191.7429	-88.77086	
20	Hunting Park West	1010	371	599.0000	-63.26733		20	Old City	4528	521	1888.8000	-88.49382	

Data: SafeGraph | Note: Period spanning January to August 2020

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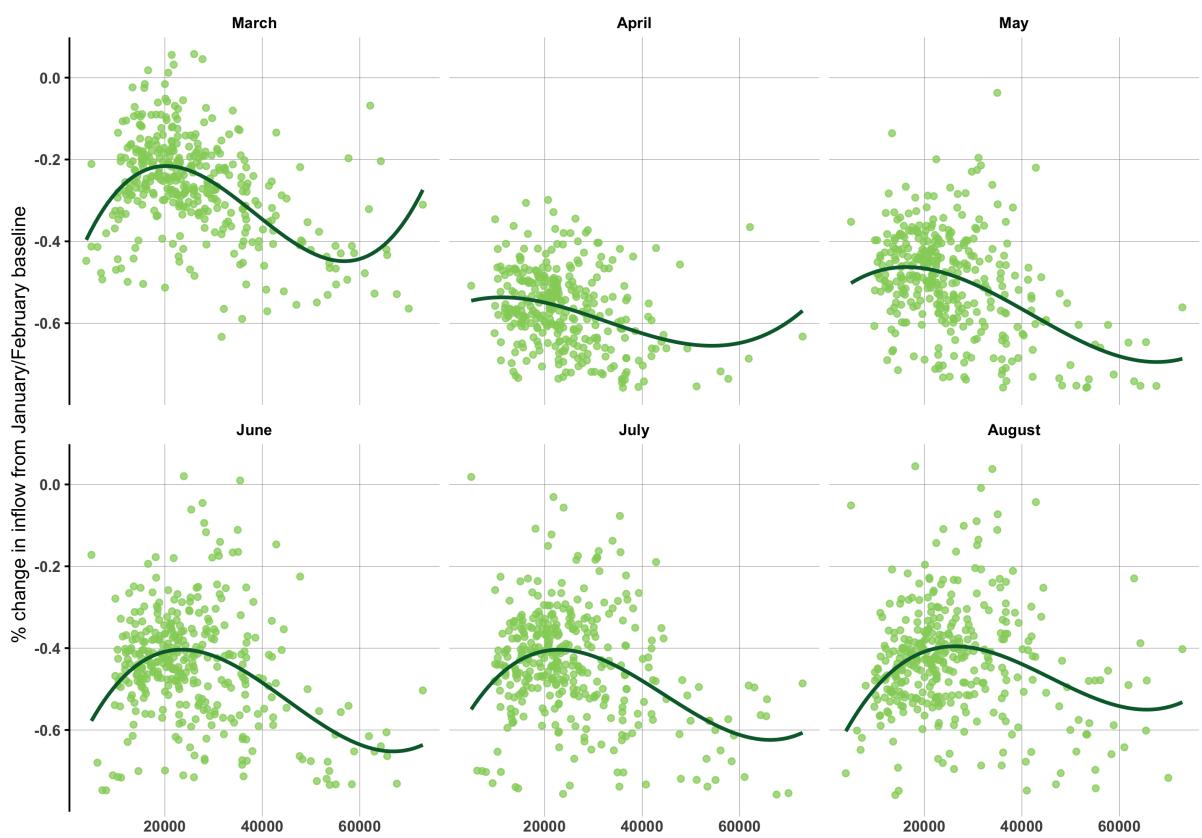
A.4 Visits by race and income

Demography's Association with Travel
African American population of tract against change in visits



Note: these plots aggregate to the tract rather than the block group, third degree polynomial added strictly as visual aid

Income's Association with Travel
Median income of tract against change in visits



% Median

Note: these plots aggregate to the tract rather than the block group, third degree polynomial added strictly as visual aid

[1] If that description contains “restaurant” or “bar”, we classify that as leisure. Anything educational, from tutoring to public, private or charter schools to tertiary education, we call that education. Tourism includes museums and parks.