Mobility and phased re-opening in Washington

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What do we already know?

People in Washington State stayed home in March as schools closed and the "Stay Home, Stay Healthy" emergency order required many non-essential businesses to close and for people to avoid non-essential trips outside the home. In May and June, these closures began to ease. At the same time, COVID-19 transmission has been gradually increasing throughout the state.

What does this report add?

In this report, we use anonymized mobility data from SafeGraph to analyze how the aggregate behavior of Washingtonians was impacted by these policy directives. People gradually started to leave their homes and spend more time outside the home starting in April, and the amount of **time spent outside the home may have increased when Phase 2** started in each county. In June, these trends started flattening. **In King county, we see a strong association between people staying home and lower transmission.** In contrast, in Yakima County, transmission declined as more people were leaving their homes.

Businesses that were directly impacted by the phased reopening in Safe Start generally saw a large dropoff in visits in March, followed by a gradual increase throughout phase 1. **Shopping, full-service restaurants, and bars saw more dramatic increases in visits when modified Phase 1 or Phase 2 started**.

What are the implications for public health practice?

From the mobility data, it is not possible to identify whether particular businesses are driving changes in transmission. This is partially because **many businesses opened at the same time, making it impossible to tease apart the relationship between specific openings and transmission**. Additionally, some people probably visit many businesses, and we are not able to determine from this data which combination of locations was visited by a single person.

The implications of this analysis show us that, unfortunately, there is not a single business or single risk that we can mitigate to control transmission. **With a highly contagious pathogen, even small increases in activity can spur widespread transmission in the community. Every decision to interact contributes to increasing the cumulative risk we take as individuals and as a community**.

Executive summary

Reducing contact with others and staying home have been effective in slowing the spread of SARS-CoV-2. Here, we characterize the mobility behavior of the population in response to the

SARS-CoV-2 pandemic by using an aggregated, anonymized dataset that tracks the movement of the cell phones of hundreds of thousands of people in Washington State.

We found that people stayed at home as schools closed and the emergency proclamation was issued in March. Starting in April, people gradually left their homes more and increased visits to shops. Soon after counties graduated from Phase 1 of the State's phased Safe Start plan, we observed a modest bump in the amount of time people spent outside their homes and a sharp increase followed by a leveling-off in trips to businesses whose restrictions were loosened, such as full-service restaurants, malls, department stores, and bars. This increase in activity after Phase 1 occurred shortly before the recent rise in cases across Washington State. Entering Phase 3 has not so far produced a noticeable increase in visits to the locations tracked in this dataset.

Since several classes of businesses re-open simultaneously when counties advance to new phases, it is impossible to determine which specific businesses (or business types), if any, are associated with the increased transmission. Also, these business re-openings occurred as people left their homes for social activities more often. We believe that data like these can be used to monitor changes in the population's behavior when new policies are implemented (or as the weather changes or as quarantine fatigue grows), but they do not tell us which locations or behaviors cause transmission since people have been going out more for many different kinds of activities.

We cannot conclude from these data that any individual business or type of business is causing a significant increase in transmission. Rather, it is likely the combination of many small risk-taking behaviors day after day that leads to a cumulative increase in risk across the population. With highly infectious viruses like SARS-CoV-2, even small changes in aggregate risk can lead to exponential increases in transmission. We must each, as individuals, assess how our choices are impacting overall risk. From a policy perspective, we can further these individual choices by using detailed data, such as from contact tracing, to identify outliers for transmission.

Introduction

Reducing contact with others and staying home have been effective in slowing the spread of SARS-CoV-2. However, people can't sustain isolation indefinitely, and as people go out more, we expect COVID-19 cases to increase.

Some of the earliest SARS-CoV-2 outbreaks were in Washington State. To slow the spread of coronavirus, schools were shut down and an emergency stay-at-home order was issued in March. In April, the weather improved and quarantine fatigue began to set in. At the same time, the number of cases waned in most Washington counties, and businesses were allowed to re-open starting in May or June, under the Safe Start guidelines to phased reopening. In June, the number of cases began to rise again in several counties.

We characterize the mobility behavior of the population in response to the SARS-CoV-2 pandemic and the directives meant to control it by using a dataset that anonymously tracks the movement of the cell phones of hundreds of thousands of people in Washington State. Monitoring changes in SARS-CoV-2 transmission in response to changes in the population's behavior could help us evaluate and refine social distancing policies to control the growth of COVID-19 cases.

Key inputs and assumptions

In this report, we use mobility data from SafeGraph to analyze the movement of people in Washington State. SafeGraph produces anonymized and aggregated datasets on travel and foot traffic at the census block group (CBG, roughly 600 to 3000 people) level by processing cell-phone location data. They infer the "home" location of each of these devices by observing the latitude and longitude they tend to be at during nighttime.

- **We use mobility metrics that measure "time away from home", as well as percent of devices that stay completely at home** based on a home location inferred by SafeGraph from cell-phone location data. We choose this metric for interpretability reasons, but it is not clear how well this metric captures mobility variation across types of housing or for individuals who live in non-traditional housing. These groups may be at high-risk for COVID-19, both in home locations and away from home.
- We also use data on **"points of interest" (POIs), mostly retail businesses**, that SafeGraph has mapped, to estimate the number of visitors to different businesses over time.
- To estimate county-level metrics, we took the population-weighted means of the CBGs in each county, using 2018 ACS population estimates of each CBG.
- SafeGraph tracks about 400,000 phones that appear to be based in Washington State, **covering 3-5% of the state's population**. Because the demographics of the people associated with these mobile devices is not known, we can not assess how well the data represents the population nor how well their POI data represent all businesses in Washington State. Therefore we describe trends over time instead of reporting raw numbers.

To calculate R effective (R_e), we use a COVID-specific transmission model fit to testing and mortality data to estimate the effective reproductive number over time and the associated COVID-19 prevalence and incidence. The key modeling assumption is that individuals can be grouped into one of four disease states: susceptible, exposed (latent) but non-infectious, infectious, and recovered.

- For an in-depth description of our transmission modeling approach and its assumptions and limitations, see our technical report.
- In this report, we use data provided by Washington State Department of Health through the Washington Disease Reporting System (WDRS). **We use the WDRS test and death data compiled on July 7, and to hedge against delays in reporting, we analyze data up to July 1.**
- Estimates of R_e describe average transmission rates across large regions, and **our current work does not separate case clusters associated with super-spreading events from diffuse community transmission.**

Results

People leaving their homes is correlated with transmission in many counties

People in Washington State stayed home in March as schools closed (March 13) and the "Stay Home, Stay Healthy" emergency order (March 23) required many non-essential businesses to close and for people to avoid non-essential trips outside the home. People gradually started to leave their homes and spend more time outside the home starting in April, and the amount of time spent outside the home may have increased when Phase 2 started in each county (Figure 1, top two rows). By June, these trends started flattening. It is not clear how from these data much of the time spent outside of home was people going back to work, how much was essential vs leisure activity, or how much was behavior that contributed to increasing transmission of coronavirus. Residents of King County spent more time at

home since April compared to other counties (Figure 1, top row). There was a small increase in mobility shortly after phase 1 ended in Spokane, Thurston, Snohomish, Clark, and King counties. At the same time, daily positive tests increased in those counties (Figure 1, bottom row).

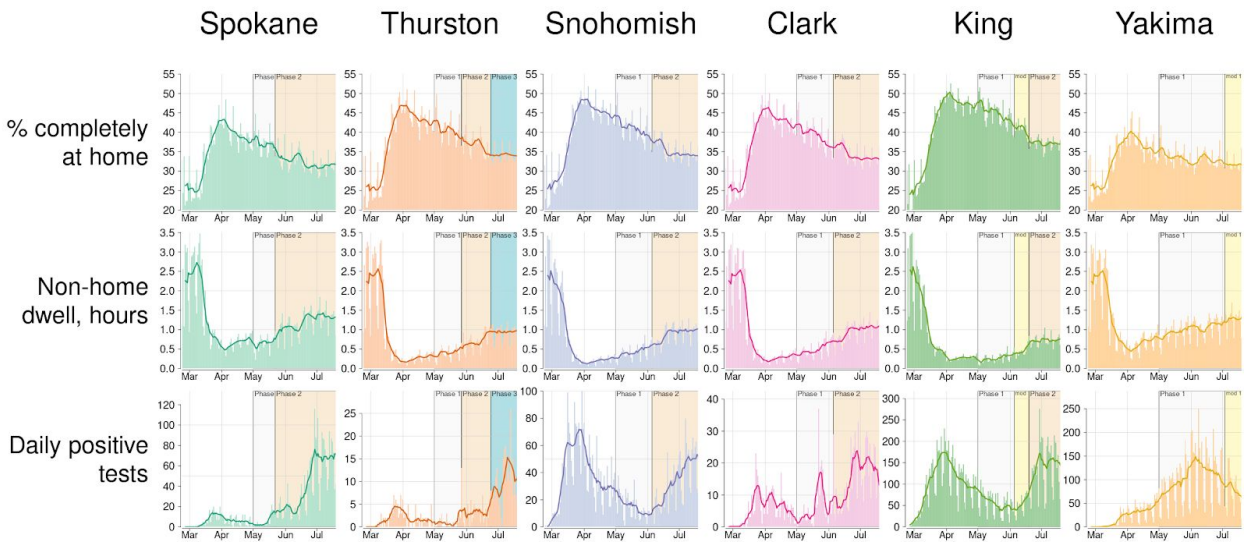

Figure 1. Population mobility and coronavirus testing in several counties in Washington State. Top row: number of positive tests. Middle row: The daily percent of mobile devices that are "completely-at-home" (i.e., "shelter in place") each day. Bottom row: The median number of hours people spent outside the home each day. These numbers reflect the amount of time tracked by SafeGraph, which does not account for 100% of everyone's time. Mobility data was obtained from SafeGraph. Vertical bars represent the counts per day, and the lines represent the centered 7-day average. The dates of phases are shown as colored backgrounds ("mod 1" is "Modified Phase 1").

When comparing the percent of devices completely at home over time to transmission measured as R_e, we see a strong negative correlation in King county (Figure 2). In King County, Re dropped when people stayed home in March, then R_e gradually increased as people left home more through June. However, in Yakima County, people increasingly left home starting in April, but R_e was generally decreasing at the same time. There are several potential explanations for this lack of correlation in Yakima County. First, seasonal agricultural workers who represent a large part of the population in Yakima are largely not represented in the SafeGraph data. Additionally, the data do not capture other non-pharmaceutical interventions, such as mask wearing, that can play a role in reducing transmission despite increases in mobility.

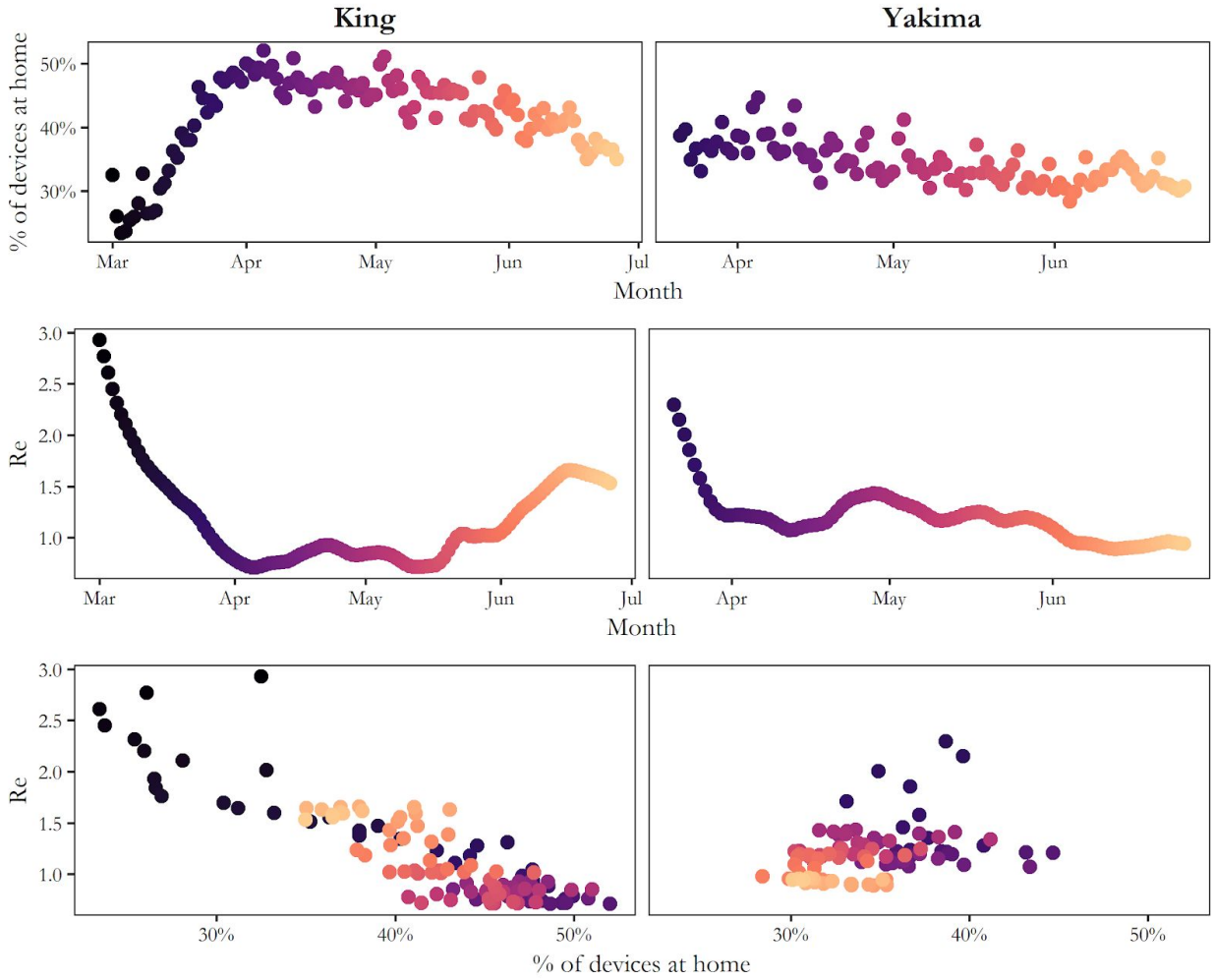

Figure 2. Top: percent of devices completely at home over time in King and Yakima counties. Middle: Transmission measured as R effective (R_e) overtime. Bottom: Percent of devices at home versus R_e. In King county there is a clear negative correlation between staying at home and transmission, but that relationship is not clear in Yakima. Color represents time from March through July.

Visits to specific types of business increased gradually through the spring and faster after leaving Phase 1

As expected based on the overall mobility trends presented above, visits to businesses dropped in March, even to essential businesses such as supermarkets (Figure 3). Visits dropped the most in King County, and less in Snohomish, Pierce, Clark, and Yakima. Visits slowly increased over time, and supermarket visit numbers appear to have reached February "pre-pandemic" levels by June in Yakima, Benton, and Franklin Counties but not in other counties. Visits to gas stations have also increased steadily, and have surpassed numbers of visits in February in many counties, possibly an indication of summer travel and other activity requiring driving. Hardware stores saw large numbers of visits in April, likely with the arrival of spring weather. Liquor stores have experienced steadily increasing visits from April through June, possibly leveling off or even decreasing a bit in July.

Businesses that were directly impacted by the phased reopening in Safe Start generally saw a large dropoff in visits in March, followed by a gradual increase throughout phase 1 (Figure 3). Shopping, which includes malls, department stores, and especially retail, saw increasing activity as counties graduated from Phase 1. Full-service restaurants (unlike fast-food restaurants) and bars saw more dramatic increases in visits when modified Phase 1 or Phase 2 started, but visits did not visibly increase in Phase 3.

We cannot determine from this data if increasing visits to classes of businesses reflects increasing willingness of people to shop or gradual re-opening of different individual businesses. Importantly, visits were increasing throughout phase 1 (Figure 3), indicating that customer behavior was changing even before phased reopening. However, there does appear to be a shift in the rate of increasing visits after phase 1, as evidenced by the change in slope in Figure 3 after the end of phase 1.

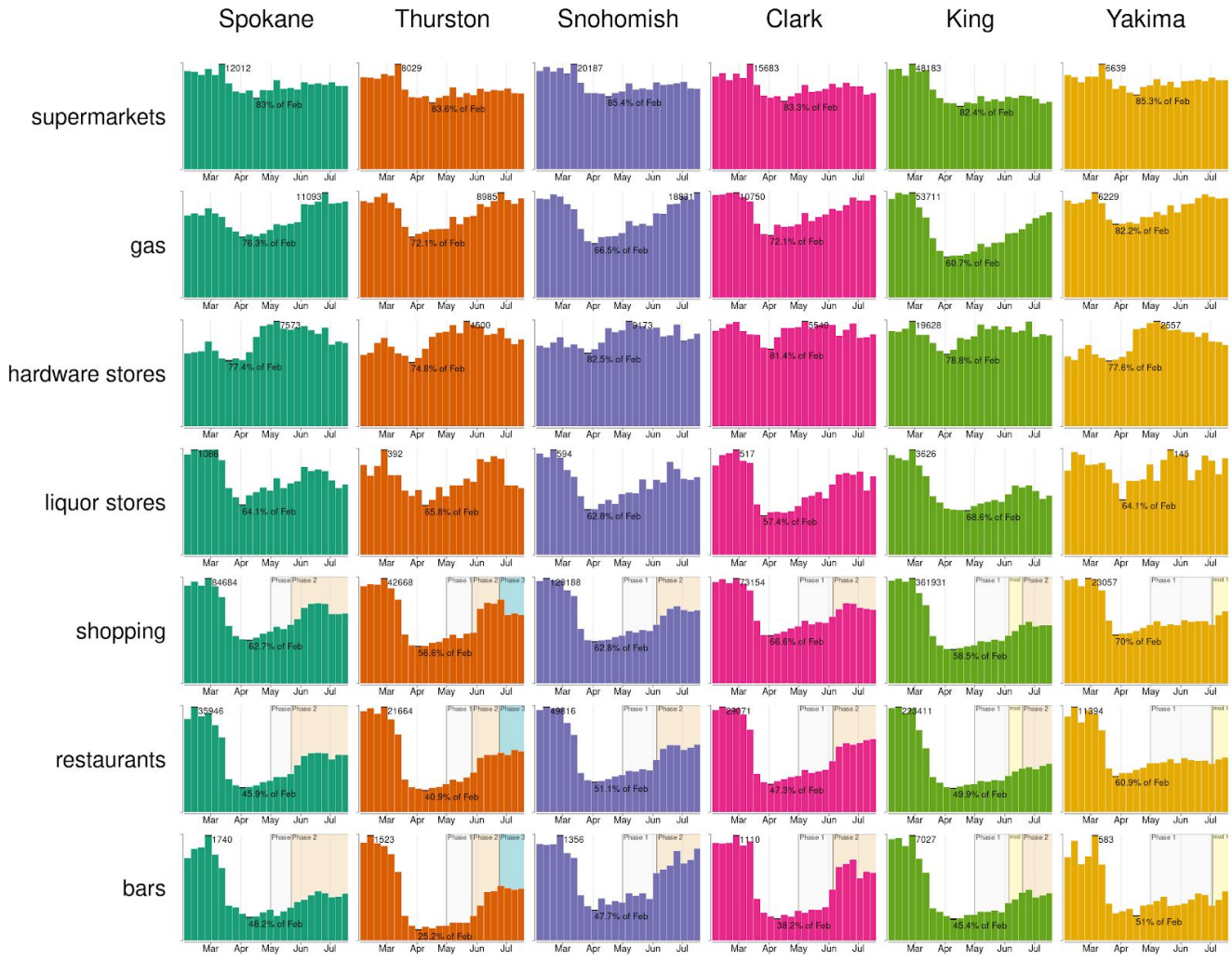

Figure 3. How did numbers of visits to businesses change over time? Panels show the weekly number of visits to businesses in seven categories from February through early July. The maximum number of weekly visits is printed at the top of each panel, and the minimum number is annotated with the % of visits with respect to average weekly visits from February 3-March 1 2020. For business categories affected by phased re-openings, the time under modified Phase 1 is highlighted in yellow, Phase 2 in tan, and Phase 3 in light blue. "Shopping" includes department

stores and malls, but not "general merchandise" stores that tended to remain open throughout Phase 1. "Breweries" were included in the "Bars" counts. "Liquor stores" includes beer and wine stores.

Restaurants and malls have many visitors, but it's not possible to identify clear drivers of transmission

For each industry in Washington, we looked at the change in visits from the final two weeks of phase 1 to the following 2 weeks. We also considered the time individuals spent at a particular business, which we represented as the percent of visits in the first two weeks after phase 1 ended that were more than 20 minutes in duration. Restaurants and malls stand out as having the biggest increase in visitors after phase 1. However, these are business types that tend to have large numbers of customers. Additionally, SafeGraph curates data on a particular subset of businesses, of which restaurants and malls tend to be included, and may not represent all business classes equally. No particular business(es) stand out as particularly high risk for transmission based on both increased visits and time of interactions. Therefore we cannot identify any causal relationships between increasing visits to particular business classes and transmission.

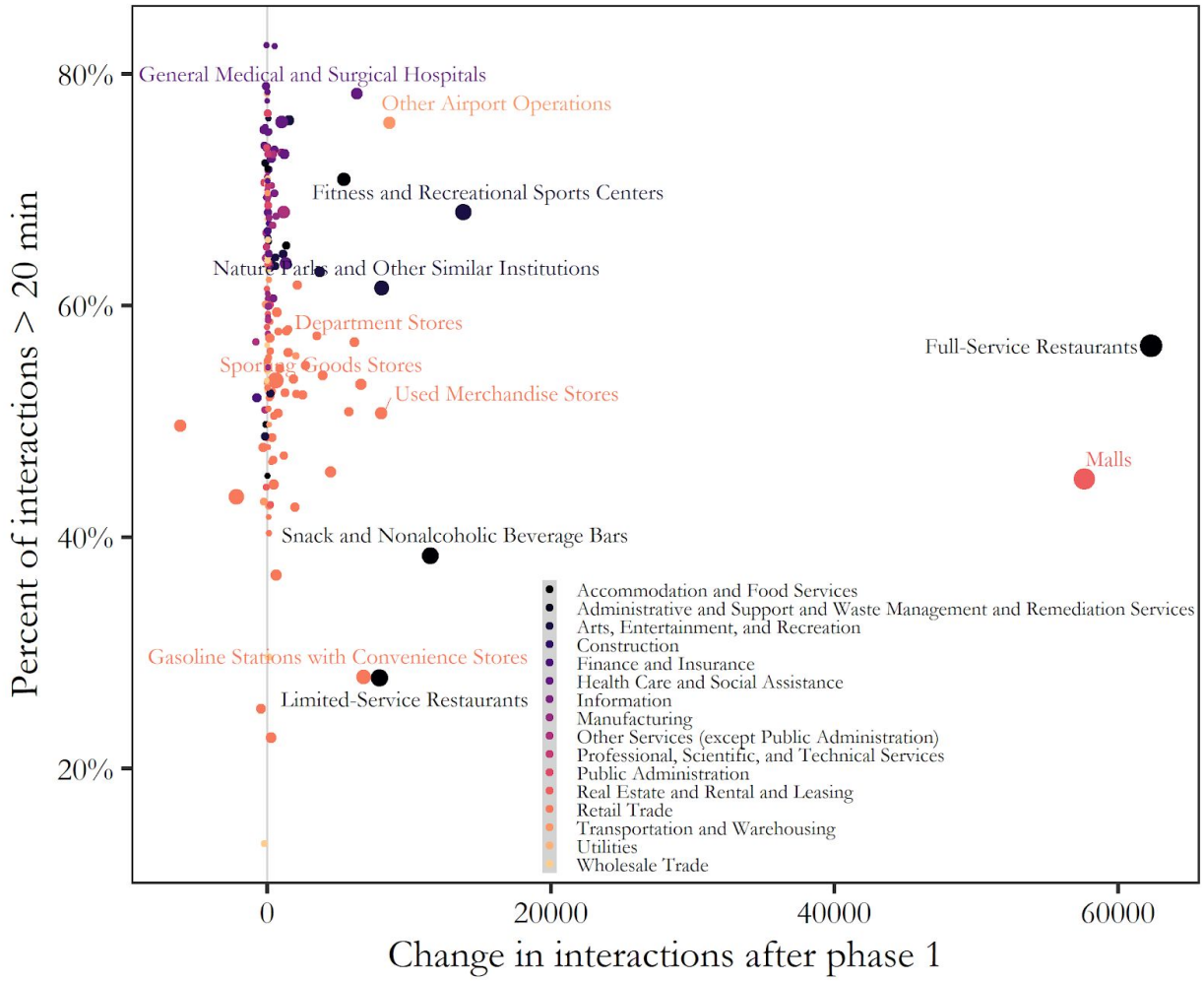

Figure 4. Each point represents one business category in Washington. The x-axis is the change in interactions, measured as counts of devices in the SafeGraph data, from before to after phase 1. The y-axis is percent of visits

that were more than 20 minutes. The SafeGraph data covers 3-5% of people in Washington, and not all businesses are sampled equivalently.

From the mobility data, it is not possible to identify particular businesses driving changes in transmission. This is partially because many businesses opened at the same time, making it impossible to tease apart differences between businesses. Additionally, customers likely visit several businesses, and we cannot determine from this data which combination of locations was visited by a single person. We cannot identify where transmission is occurring. The best way to overcome these challenges would be to utilize a high quality contact tracing system which collects data on locations visited and infections. If used at a large scale, contact tracing data could allow us to directly identify classes of places and activity where pockets of transmission occur, and target these for mitigation.

Conclusions

After a sudden drop in mobility in March, people gradually began going out more and more in Washington. Coronavirus transmission generally began to rise in the state in June and July. Policies that restrict businesses (and schools) are one way to reduce the population's exposure to each other and coronavirus. We observed that visits to some businesses directly affected by phased reopening plans, such as restaurants and non-essential shopping, had been increasing during Phase 1 and increased more quickly after the end of Phase 1. Some places with stricter operating limits during Phase 1, such as beauty salons, saw spikes in visits upon re-opening but the total number of visits to them was relatively small. We are able to document how policies impact traffic to different types of businesses, but because phased re-opening affects many kinds of businesses simultaneously, and re-opening occurs against a backdrop of increased family gatherings, travel, and general quarantine fatigue, it is not possible to identify which business types are associated with recent increases in coronavirus transmission.

We suspect that a large proportion of transmission in the community happens during low- to moderate-risk daily activities in a variety of places that would be difficult to identify. People make many small choices that increase their cumulative risk, which leads to an overall risk increase without one single root cause. One way to mitigate these small but frequent risks is to implement strategies that decrease risk within restaurants and other high-volume businesses rather than closing them, such as limiting party size at bars and restaurants when cases are rising in the community.

One limitation of the data used in this report is that social gatherings in homes or other non-commercial locations are not captured. It is possible that a significant portion of an individual's cumulative risk profile is driven by attending social gatherings or working in high-risk industries. For example, a recent event in the University of Washington greek system would not be well represented in this dataset, but did cause an increase in transmission in King county. This may explain some of the residuals we see in the relationship between mobility and transmission. The data also indicate that there is increasing out-of-state travel, particularly on weekends, which we assume is associated with recreational activity, though this can not be confirmed.

There are several factors that increase risk of transmission, and as we have shown above, visiting commercial business is only one piece of the puzzle. It is important to additionally consider workplace risk and social gatherings, total number of people interacted with and in what proximity, as well as time of interaction with others and other mitigation strategies such as mask-wearing and hand washing. Taking all of these aspects of risks into account, it may not be possible to identify key drivers of

transmission in most cases, but we can better understand how transmission may change at a population level.

The implications of this analysis show us that, unfortunately, there is insufficient evidence that a single retail business type or single risk factor to focus on to control transmission in the general community. Rather, we must consider, as individuals, what we are doing to control transmission. Each small decision contributes to an increase in cumulative risk, and these decisions have consequences. We must also think carefully about economic tradeoffs. It is not clear that any particular business is increasing transmission, but we do know that there are negative economic consequences of shutting businesses down. Contact tracing could be used to identify outliers for high transmission (i.e., crowded bars, occupations, or demographic groups), but absent high fidelity information closely tied to epidemiological data we have to rely more on individual risk decisions rather than blunt business closures to reduce transmission.