I used location data from SafeGraph, a company that aggregates anonymized location data from numerous applications. The applications, which include weather, navigation, and social media apps, report the data to SafeGraph when users have opted in to location tracking. The apps span nearly 47 million mobile devices in the United States. The location data is aggregated by certain points-of-interest (POIs) such as schools, airports, and parks.

SafeGraph provides free access to its data for academic researchers. I applied to the program and was granted access. I then downloaded all the data from 2021 in its Weekly Patterns dataset. Weekly Patterns tracks the number of people that visit a POI each week. It breaks down that count by the home census block group of the visitors. (A census block group (CBG) is a subdivision of a census tract; a home census block group is the CBG that SafeGraph thinks an individual's home is in.) For example, the data is able to tell me how many people who live in a certain CBG traveled to a certain POI (e.g. CVS pharmacy) in a given week. However, the data does not tell me who any of the people are, what time they went, or where precisely they live.

In summary, SafeGraph gives me an estimate of, for each point-of-interest that SafeGraph tracks (roughly 4.5 million in the United States), how many people visit it in a given week and from which home census block group. If I can find which POIs distribute vaccines, and if I can find the demographic information of the census block groups from which visitors to those vaccine sites come from, then I can construct an estimate of the demographic makeup of vaccine recipients.

I limit this analysis geographically to Richmond City, Virginia. This limit makes manageable the processing time and policy research required to make a reliable estimate. I picked Richmond because it is a densely populated urban area and, as of April 10, 37.4% of vaccine data records did not include race or ethnicity information. This measure ranks Richmond relatively low compared to the fifty states, as shown in Fig. 1.
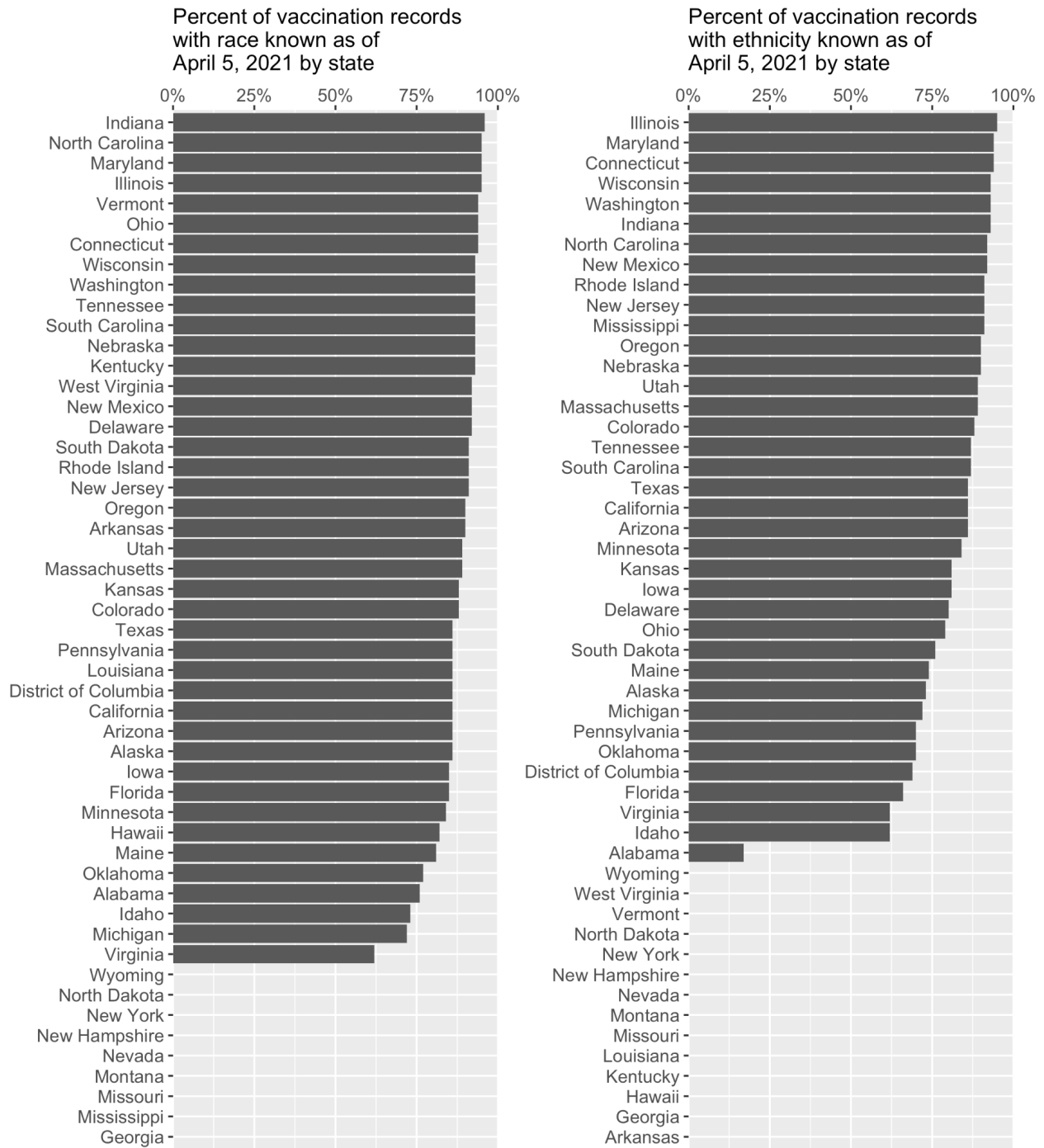
Fig. 1. Source: Kaiser Family Foundation

Richmond is also worthy of investigation given that that percentage of missing data has grown in the last month, as evidenced by the blue line in Fig. 2.
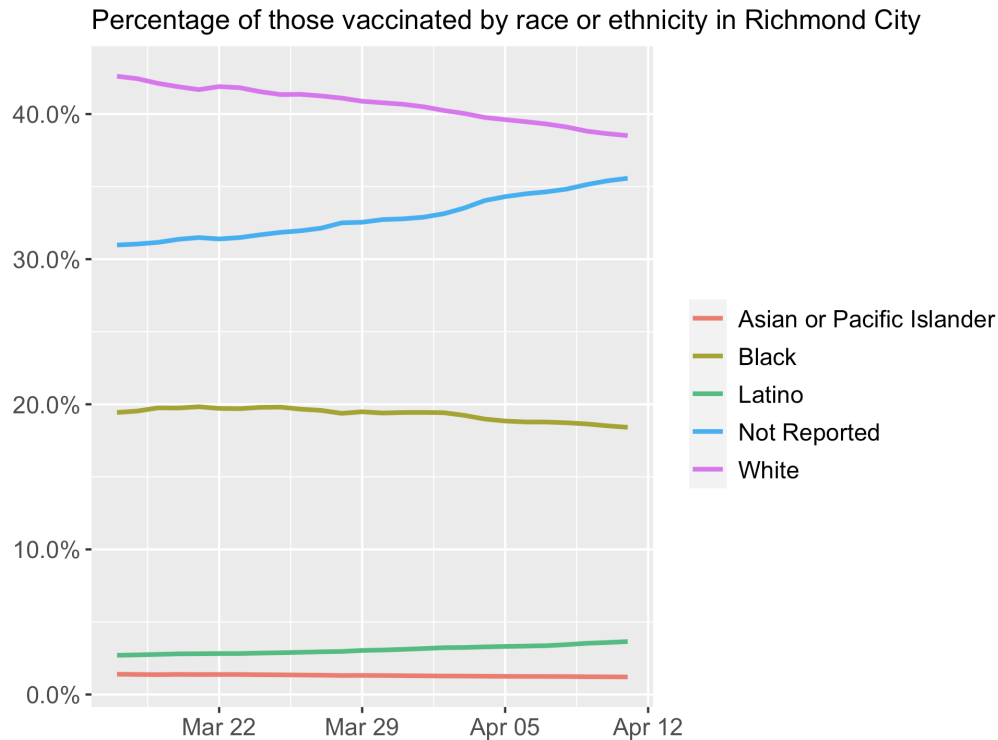
Fig. 2. Source: Virginia Department of Health

To find out the POIs that distribute vaccines, I downloaded a master list of vaccine providers[1] compiled by URISA's GISCorps, a program that offers volunteer geographic information systems services. I also scraped the CDC's VaccineFinder[2] website, which lists additional local pharmacies. I then filtered out the providers that weren't in Richmond. The final list contains the latitude-longitude coordinate of each vaccine provider. SafeGraph's POI dataset is a collection of polygons, each of which represents the footprint of the POI's building. I used Python to match each latitude-longitude point to a POI by finding a polygon that contained that point. In the case where the polygons of several POIs encompassed a point, I assigned the point to the most reasonable POI (e.g. if a point was inside both a CVS and the surrounding Mall of America, CVS was likely the true vaccine provider).

I was able to find the SafeGraph points of interest for 27 of the 29 vaccine providers I found. The Weekly Patterns data, for each POI in each week, details the home CBG for each visitor to that POI. For each home CBG, I downloaded its proportion of white, Black, Asian, and Hispanic residents, as well as its median income, from the United States Census.

The 27 providers fell under the following 7 corporations. Through press releases and news articles, I identified the opening date of each provider and only considered Weekly Patterns data for each provider from after their opening date.

CVS has offered vaccines in Richmond since February 12, 2021[3]; Walgreens since February 24, 2021[4]; JenCare Senior Medical Center since February 23, 2021[5]; Kroger since February 24, 2021[6]; MinuteClinic since February 12, 2021[7]; Publix Super Markets since March 25, 2021[8]; Rite Aid since January 21, 2021[9]; Walmart Pharmacy #10-2821 since February 24, 2021[10]; Westwood Pharmacy since January 19, 2021[11].

I then took the weighted average of the proportion of each demographic category of the CBGs that had residents visit vaccine providers since February. The results, as of April 11, are in the second column of the table below. The third column of the table contains the racial and ethnic makeup of vaccine recipients in Richmond City at the same time. Their makeup does not include the 37.4% of vaccine recipients who did not have their race/ethnicity reported. The fourth column contains the overall racial/ethnic makeup of Richmond City according to the 2015–2019 American Community Survey.

Race or ethnicity	SafeGraph-based estimates	VA Department of Health data	Richmond City Demographics
White	57.3%	59.0%	45.5%
Black	34.4%	28.6%	46.9%
Asian	3.5%	1.8%	2.1%
Hispanic	5.6%		6.9%
Latino		6.4%	

Given that the Virginia Department of Health's racial and ethnic classification does not completely align with that of the United States Census, we are only able to compare the figures for White, Black, and Asian vaccine recipients.

As stated before, the Virginia Department of Health only reports race and ethnicity for 62.6% of Richmond City's vaccination data. We see that the incomplete data reported by the state seems to overrepresent the share of White people getting vaccinated by about 2.7

[3] https://www.wric.com/health/coronavirus/cvs-expanding-virginia-vaccination-locations-from-28-to-36/
[4] https://www.wavy.com/covid-19-vaccine/the-latest-some-hampton-roads-pharmacies-and-their-customers-await-covid-19-vaccine-delivery-this-week/
[5] https://www.prnewswire.com/news-releases/chenmed-accelerates-safe-covid-19-vaccine-administrations-to-tens-of-thousands-of-high-risk-seniors-where-they-receive-care-301233089.html
[6] https://www.wavy.com/covid-19-vaccine/the-latest-some-hampton-roads-pharmacies-and-their-customers-await-covid-19-vaccine-delivery-this-week/
[7] https://www.wric.com/health/coronavirus/cvs-expanding-virginia-vaccination-locations-from-28-to-36/
[8] https://www.valdostadailytimes.com/news/business/publix-pharmacy-opens-appointments-for-covid-19-vaccinations-in-three-states/article_51388f06-ecf3-5a6a-a5af-d68a42bc1007.html
[9] https://www.wavy.com/covid-19-vaccine/pharmacies-administering-covid-19-vaccine/
[10] https://www.wavy.com/covid-19-vaccine/the-latest-some-hampton-roads-pharmacies-and-their-customers-await-covid-19-vaccine-delivery-this-week/
[11] https://www.wavy.com/covid-19-vaccine/the-latest-some-hampton-roads-pharmacies-and-their-customers-await-covid-19-vaccine-delivery-this-week/

percentage points. The SafeGraph analysis also indicates that Black people are being vaccinated at a share of 6 percentage points above what is being reported, and Asian people are being vaccinated at a share of 1.7 percentage points above what is being reported.

There are many nuances in Virginia's vaccine rollout that are ignored in this preliminary analysis. For one, this model does not account for days when a pharmacy had no appointments available due to a lack of vaccine supply. It also does not account for bias in the SafeGraph dataset: An audit of SafeGraph's data by Amanda Coston, et al.[12] — the first of its kind — found that older and non-White people were less likely to be captured by mobility data. (The study did not break out "non-White" into more specific groups.)

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[12] https://dl.acm.org/doi/pdf/10.1145/3442188.3445881