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Judith A. Chevalier
Yale University

Jason L. Schwartz
Yale University

Yihua Su
Yale University

Kevin R. Williams
Yale University

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Recommended Citation

Chevalier, Judith A.; Schwartz, Jason L.; Su, Yihua; and Williams, Kevin R., "Distributional Impacts of Retail Vaccine Availability" (2021). *Cowles Foundation Discussion Papers*. 2610.
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DISTRIBUTIONAL IMPACTS OF RETAIL VACCINE AVAILABILITY

By

Judith A. Chevalier, Jason L. Schwartz, Yihua Su, and Kevin R. Williams

April 2021

Updated July 2021

COWLES FOUNDATION DISCUSSION PAPER NO. 2280

COWLES FOUNDATION FOR RESEARCH IN ECONOMICS
YALE UNIVERSITY
Box 208281
New Haven, Connecticut 06520-8281

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Distributional Impacts of Retail Vaccine Availability*

Judith A. Chevalier, *Yale School of Management and NBER*

Jason L. Schwartz, *Yale School of Public Health*

Yihua Su, *Yale School of Public Health*

Kevin R. Williams, *Yale School of Management and NBER*

July 2021

Abstract

We examine the potential for exploiting retailer location choice in targeting health interventions. Using geospatial data, we quantify proximity to vaccines created by a U.S. federal program distributing COVID-19 vaccines to commercial retail pharmacies. We assess the distributional impacts of a proposal to provide vaccines at Dollar General, a low-priced general merchandise retailer. Adding Dollar General to the federal program would substantially decrease the distance to vaccine sites for low-income, rural, and minority U.S. households, groups for which COVID-19 vaccine take-up has been disproportionately slow.

*Authors are listed alphabetically and contributed equally. The authors thank the Tobin Center at Yale University for funding.

1 Introduction

A substantial literature in industrial organization studies firm locational investments, documenting that locations are chosen in part on the basis of proximity to target customers.[1] In this paper, we explore the potential for leveraging the locational investments of profit-maximizing firms to improve a public health intervention that requires widespread physical distribution. Specifically, we examine the use of commercial retail locations to distribute vaccines against COVID-19 in the United States. While response efforts to this pandemic are unprecedented, the vaccination distribution campaign has important characteristics in common with any potential large-scale public health intervention that requires widespread participation.

During the COVID-19 pandemic, the United States was one of the first countries to transition from vaccine scarcity to abundance. The U.S. distribution effort relied extensively on commercial retail distribution partners through the Federal Retail Pharmacy Program (FRPP), a strategy for reaching the public that contrasts the approaches of several other vaccine-abundant nations (for example, Israel, England, and Canada). In its first six months, the FRPP effort administered over 96 million vaccine doses at approximately 41,000 commercial pharmacy partner locations, including long-term care pharmacies (Centers for Disease Control and Prevention, 2021b). In contrast, while there are 11,500 community pharmacies in England, they were largely not used for COVID-19 vaccines; there were only 1,700 total vaccine sites in England in Spring of 2020 (Chakelian, 2021; NHS, 2021). While the U.S. presdient announced that 90% of Americans live within 5 miles of a vaccine site, the British government has announced that the "vast majority" of people in England live within 10 miles of one (The White House, 2021; NHS, 2021).

Because retailers have an incentive to locate themselves proximate to potential customers, it is unsurprising that distributing the vaccine through large pharmacy chains provides proximity to a substantial number of Americans. In this paper, we use geospatial data to characterize the vaccine proximity created by the FRPP. An important challenge

[1] See, for example, Mazzeo (2002), Jia (2008), Harrison and Seim (2019) for evidence. In addition, literature in operations research prescribes methods for using planning support systems for locational choice, for example Newing et al. (2020).

to the proximity benefits of the FRPP is that the demographics served by large retail may not coincide with the demographics for whom vaccine takeup has proven challenging. We show that overall proximity to retail partners is slightly higher for high-income households than for low-income households, a problematic finding, as the latter group is more likely to face transportation challenges. We additionally show that proximity to FRPP pharmacies is much lower for rural Americans than urban Americans.

We then analyze the distributional implications of potential enhanced retail model. In March 2021, the director of the U.S. Centers for Disease Control and Prevention (CDC) and the company Dollar General (DG) confirmed reports that they were exploring a partnership through which COVID-19 vaccines would be administered in DG retail locations (Dollar General Stores, 2021; Boomey, 2021).[2] DG is a low-cost "dollar store" retailer whose self-described strategy is to provide low-priced necessities in a small store footprint, concentrating in areas that other retailers do not find attractive (Nassauer, 2017). If an agreement were to be reached, such a partnership would likely not ultimately involve all 16,805 DG locations but could nonetheless greatly increase the scope of the current FRPP. We show that the addition of this retailer and/or its major dollar store rival to the extant federal retail-based strategy would demonstrably improve the proximity of low-income households to their closest federal retail vaccine site. Adding DG locations would also substantially improve vaccine proximity for rural Americans. We show that the geographic targeting of dollar stores in general, and Dollar General in particular, greatly improve vaccine proximity for demographic groups for which vaccine takeup has lagged.

The FRPP represents an effort to provide vaccine proximity. Studies in several countries suggest that, on net, policies allowing vaccine administration in pharmacies increase influenza vaccination rates (Spinks et al., 2020). Recent literature also demonstrates that the closure of a local pharmacy can have durable impacts on patient medication compliance (Qato et al., 2019). Of course, while proximity to vaccines is likely important, it is only one factor that influences vaccination rates. In a report issued before the COVID-19 pandemic and applicable to all vaccines (and indeed voluntary public health interventions

[2]To our knowledge, the idea for a DG vaccine partnership was first proposed by researchers at the Rural Health Service Providers Network in West Virginia (Young, 2021).

of many types), the World Health Organization (WHO) Strategic Advisory Group of Experts (SAGE) examined the causes of "delay in acceptance or refusal of vaccination despite availability of vaccination services". SAGE endorsed a "3Cs" model, identifying "complacency, confidence, and convenience" as key impediments to vaccination (MacDonald et al., 2015). These factors can all potentially play a role in hindering or limiting the success of national COVID-19 vaccine campaigns, delaying take-up of essential subsequent booster vaccines, or challenging the response to future pandemics.[3] The highly visible public health impacts of COVID-19 have likely played a role in reducing complacency, as suggested by prior research examining vaccination responses to disease outbreaks (Oster, 2018). Clearly, reducing vaccine hesitancy and promoting vaccine confidence remains a crucial public health challenge (CDC, 2021), both for COVID-19 and for other vaccinations. This challenge is not directly addressed by improving vaccine proximity. However, several studies provide evidence for conforming peer effects in vaccine takeup (see, for example, Rao et al. (2007) and Bodine-Baron et al. (2013) for a discussion of other studies). In a setting with strong conforming peer effects, strategies that improve vaccination among the least reluctant, such as providing convenience and subsidies, may ultimately improve takeup among the reluctant. On the other hand, a vaccination strategy that uses dollar store retailers as one component would be counterproductive if the presence of vaccinations at these outlets erodes confidence. While this is possible, it is unclear why dollar store clinics would be more confidence-eroding than mobile clinics, pop-up clinics at other unconventional sites, and other strategies that have been attempted.

Our findings have implications beyond the U.S. and beyond COVID-19. As modern retail chains optimize their product assortments and locations to target particular demographic groups, our findings suggest that using retail locations to distribute vaccines provides governments a mechanism to exploit corporate locational strategies to bring vaccines to hard-to-reach demographic groups. For example, there are similarities between the U.S. dollar store chains and Oxxo, a retail chain with nearly 17,000 locations in Mexico that offers convenience store items and cash services for the unbanked (FEMSA,

[3] "Complacency" refers to a belief that the benefits of vaccine are low. "Confidence" refers to concerns about the safety of vaccines or vaccination providers. "Convenience" refers to geographic and other difficulties in finding the available vaccines.

2019). While we focus on vaccine distribution, the strategy of using a demographically-targeted retailer as a partner could be employed for a variety of public health or social interventions—such as recruiting diverse clinical trial participants, providing information about government benefits, or distributing disaster preparedness or relief supplies.

Our paper proceeds as follows. Section 2 discusses our data and methodology. In Section 3, we estimate the distributional impacts of using DG as vaccination locations, In Section 4, we undertake a partial analysis of state vaccine locations. Section 5 concludes.

2 Data and Methodology

Our analysis focuses on U.S. vaccine distribution, where, on a weekly basis, nearly all available doses are allocated to state governments or directly to participants in the FRPP.[4] The CDC describes the FRPP for COVID-19 vaccination as "a collaboration between the federal government, states and territories, and 21 national pharmacy partners and independent pharmacy networks to increase access to COVID-19 vaccination across the U.S." (Centers for Disease Control and Prevention, 2021a). The program is intended to work in parallel with vaccination sites established and supported at the state level (and using state-allocated vaccine doses).

We bring together data from several sources. First, we obtain a list by state of FRPP chains from the Centers for Disease Control (Centers for Disease Control and Prevention, 2021a). For each pharmacy partner, in each state, we match these chains by name to the Historical Business Information Files from ReferenceUSA (Infogroup, 2005-2021), accessed March 14, 2021. We were unable to match the pharmacy network CPESN, a partner in eleven states, and MHCN, a partner in four states. From ReferenceUSA, we obtain the universe of retail locations of these federal partners.

It is important to note that not all pharmacy locations for a given chain (and state) are necessarily providing vaccines. Moreover, some locations may have provided vaccinations intermittently. This is because the supply of vaccine was constrained overall at

[4] A small number are reserved for direct federal vaccination efforts, such as those coordinated by the Department of Defense or Department of Veterans Affairs.

earlier stages of the program, but also because some retailers—due to freezer constraints, for example—can only offer a subset of the vaccines authorized for use. Thus, some chains only offered vaccinations when specific vaccines were available. We nonetheless include all locations that may be used as vaccination sites to measure proximity. In March 2021, representatives of these chains explicitly noted that, as the vaccine became more abundant, more of their outlets would supply them, a plan subsequently confirmed by the Biden administration (Barker, 2021; Robbins and Weiland, 2021; The White House, 2021).

We further supplement our analysis using vaccine locations found on state COVID-19 response websites. State vaccine sites are dynamic; we use active vaccine sites as of the week of March 22, 2021. Therefore, our analysis does not necessarily reflect the complete buildout of state capacity at the peak of state vaccination efforts, although we do include in our analysis announced locations that did not have appointments available at the time of data collection. Some states also list pharmacies found through the federal partnership program; our analysis is unaffected by potential duplicates as we select the closest vaccination site to each Census tract. Additionally, these files may allow us to incorporate Federally Qualified Health Centers and locations that we cannot match using the ReferenceUSA data.

We obtain vaccine locations for 21 states that either post a file containing all locations or present users with an interactive map of locations.[5] Figure 4 contains a list of the states and the corresponding websites we used for data collection.

In order to examine the implications of a partnership with DG and a hypothetical partnership with the other large dollar store chain, Dollar Tree, we download all of their locations from ReferenceUSA. We remove from analysis a small number of headquarters, distribution centers, and apparent non-retail outlets that are listed in ReferenceUSA.

We examine the social vulnerability metrics for the Census tracts containing these outlets and measure distances from the these retail outlets to households. We use the

[5]We collect data for AL, AR, CT, GA, IL, KS, MD, ME, MO, MS, ND, NJ, NV, OH, OK, PA, SC, WA, WI, and WV. First, we download either the PDF, HTML, or JSON found on from each state's COVID-19 response website. We then process the files and extract the addresses. We then geocode each site using https://geocode.localfocus.nl/. Our analysis includes "success" and "doubt" matches, and excludes "failed" matches.

latitudes and longitudes of the retail outlets provided by ReferenceUSA and map these to Census data on households. Throughout this analysis, we use Census data at the Census tract level. There are approximately 74,000 Census tracts in the US, with a target population of 4,000 per tract. Some tracts were unavailable for processing, leaving us with 73,088 Census tracts. As is common in the literature, we will assume that all households live at the geographic centroid of the Census tract and calculate the great circle distance from the Census tract centroids to each of the retail outlets in our database. We use the minimum-calculated distance for each Census tract to a vaccine location for our analysis. Because vaccine eligibility was set by individual states until April 2020, many sites require state residency, and allocations are at the state level, we calculate distances to the closest same-state retail location; we assume that people located near a state border will not obtain the vaccine at an out-of-state location.[6]

We also characterize the Census tracts within which the retail outlets are located.[7] To do this, we match each Census tract not only to the Census data provided directly by the Census, but to the tract-level data on the Social Vulnerability Index 2018 Database US (SVI) provided by the CDC. SVI is a composite of Census data used to identify communities that may require the greatest support during, or following, a disaster; it has been widely adopted by federal and state health officials during COVID-19 as a tool to design vaccination efforts and to assess their performance with respect to equity (Centers for Disease Control and Prevention, Agency for Toxic Substances and Disease Registry, 2021; Hughes, 2021). We are able to match 72,173 SVI tracts to the Census data.

Using the same methodology as used in Murthy et al. (2021), we use data from the National Center for Health Statistics to classify counties as urban or rural. We classify everyone living in a Census tract in a rural county as a rural dweller and everyone living in a census tract in an urban county as an urban dweller.

In our examination of the current composition of the FRPP, we find 26,246 retail pharmacy outlets that belong to chains that are designated as pharmacy partners in the

[6]We make an exception for North Dakota, for which we have not found retail outlets of any federal pharmacy partner that was listed as a partner for North Dakota on the CDC website.

[7]We use the 2019 American Community Survey 5-Year Data (2009-2019), Census Bureau Geocoder, and TIGER/Line Shapefiles downloaded from
https://www.baruch.cuny.edu/confluence/display/geoportal/US+Census+Population+Centroids

Table 1: Characteristics of U.S. Pharmacy Partner Program

Population Type	Area	Share <1 mile	Share <2 miles	Share < 5 miles
All adults	U.S.	48.3	72.7	86.3
All adults	CONUS	48.7	73.0	86.4
Rural adults	U.S.	22.4	37.8	56.8
Urban adults	U.S.	55.9	80.7	93.2
Households < $35K	U.S.	48.4	71.1	83.3
Households > $100K	U.S.	49.3	73.9	87.8
Black Population	U.S.	53.6	81.8	93.2
White Population	U.S.	44.3	68.6	83.8
AAPI Population	U.S.	65.6	90.3	97.5
Other Population	U.S.	58.5	80.7	90.4
Hispanic Population	U.S.	44.9	70.0	84.6
non-Hispanic Population	U.S.	61.2	84.2	93.7

Notes: Summary statistics for federal U.S. pharmacy partner program. Table entries denote the share of the population type within the denoted proximity to an in-state pharmacy partner. "CONUS" denotes continental US.

state in which the outlet is located. In matching to Census data, we summarize in Table 1 the proximity of various segments of the population to the closest within-state outlet of the FRPP. We examine income groups, urban and rural populations, racial groups, and Hispanic/Latino ethnicity.[8]

Table 1 shows the fraction of people within 1, 2, or 5 miles of a federal pharmacy partner. The federal government announced that the U.S. had a vaccination site within 5 miles of 90% of American adults by April 19, 2021. (The White House, 2021). Our analysis suggests that, without considering any other vaccination sites, the FRPP alone nearly achieved that objective. Table 1 demonstrates that the retail program achieves slightly lower proximity for low-income households than for high-income households. This is concerning because low-income households are less likely to have access to transportation infrastructure, internet access required to book a distant appointment, etc. That the majority of these

[8]To characterize race, we divide the total population into one of four racial groups: white (for which we use the Census categorization "White alone"), Black (for which we use the Census categorization "Black or African American", AAPI (for which we add the Census categorizations of Asian American, Native Hawaiian and Pacific Islander), and other races for which we include all other races. We also characterize the population as "Hispanic" or "non-Hispanic", including the Census categorizations of Hispanic or Latino and including Hispanic or Latino people of all races.

households are more than a mile from the closest pharmacy partner could indeed create a barrier to vaccination. Unsurprisingly, there is a large gap in proximity between adults living in rural versus rural areas. A study by the CDC, using the same metro-urban classification as we use found that, for the period December 14, 2020–April 10, 2021, adult COVID-19 vaccination rates were lower in rural counties (38.9%) vs. urban counties (45.7%) (Murthy et al., 2021). The table also shows a large disparity in proximity between Hispanic and non-Hispanic people. This disparity in proximity is particularly concerning as COVID-19 vaccination rates for Hispanic people have been shown to be low (Ndugga et al., 2021). Furthermore, a survey undertaken during March 2021 identified Hispanic people as disproportionately likely to report that they want a vaccine as soon as possible but have been unable to receive one (Hamel et al., 2021), suggesting a role for access in explaining this group's vaccination rates.

We obtain addresses for 10,439 vaccination sites on state websites, corresponding to 8,455 unique geographic coordinates. The mean and median number of locations per state is 403 and 275, respectively. There are a few outliers. The West Virginia file contains only 23 locations because it lists only state-coordinated vaccine clinics. Missouri and Ohio list over 1,300 locations.

Outlets of the major dollar store chains have more than doubled since 2005. Our data records 16,805 DG stores as of early 2021 and 15,629 Dollar Tree stores (which are branded as Dollar Tree or Family Dollar, following a merger of those two chains in 2015). While dollar stores blanket the continental US, the coverage of the two major chains is particularly dense in the Southeast and in several of the poorest US states. DG is most dense per capita in Alabama, Arkansas, and Mississippi, with nearly 20 stores per 100,000 population. There is also substantial density throughout the South, including West Virginia, where the idea of using DG for vaccinations was first proposed (Young, 2021). The other major dollar store chain, Dollar Tree, although similar in terms of overall store counts, is substantially more dispersed geographically. It is most dense in Louisiana, New Mexico, and West Virginia, with nine to ten stores per 100,000 population. State-by-state data are provided in Figure 5 in the Appendix.

The rapid expansion of dollar stores in the U.S. has been controversial. One recent

report from the Institute for Local Self-Reliance refers to dollar store chains as "an invasive species in America's left behind places" (Donahue and Mitchell, 2018). Activists cite linkages between the variety of food sold at dollar stores and the prevalence of dollar stores and obesity, although recent research has questioned whether there is a causal link from dollar stores to obesity directly (Allcott et al., 2019). While a causal link has not been established, some authors have argued that the influx of dollar stores cause the exit of traditional supermarkets and grocery stores, creating food deserts, and numerous localities have instituted regulations to curb dollar store growth (Misra, 2018).

Whether the growth of dollar stores has negative impacts is beyond the scope of this research. However, our hypothesis is that the criticisms of dollar stores derive precisely from their potential advantage in a vaccine distribution program. If dollar stores are more prevalent in locations proximate to low-income households than are other types of retailers, then they are uniquely suited to improving vaccine access.

The Social Vulnerabiity Index (SVI) was created by the Centers for Disease Control to design and evaluate health and disaster programs. The measure is intended to capture "the degree to which a community exhibits certain social conditions, including high poverty, low percentage of vehicle access, or crowded households may affect that community's ability to prevent human suffering and financial loss in the event of disaster. These factors describe a community's social vulnerability" (CDC-ATSDR, 2018).

The SVI is calculated at the Census tract level. For each tract, the overall SVI index (called RPL-THEMES) "ranks the tract on 15 social factors, including unemployment, minority status, and disability...." (CDC-ATSDR, 2018). The numerical value of SVI for Census tract i is the fraction of all Census tracts which are less vulnerable than tract i. Thus, higher values of SVI are more vulnerable, and one tenth of all Census tracts are assigned to each SVI decile bin.

The stated intent of the SVI is to assist health officials in identifying those communities that may—as a result of these characteristics—require additional support during a public health emergency or other hazardous event. It has been used by states and private entities to calibrate disaster response prior to the COVID-19 pandemic (Flanagan et al., 2018) and SVI measures have been shown to be correlated with worse COVID-19 outcomes

(Karaye and Horney, 2020). During the ongoing vaccination program, CDC and states have released data evaluating the relationship between vaccination coverage and social vulnerability as measured via SVI (Hughes, 2021).

Clearly, to improve vaccine access for those least likely to have easy transportation, it is desirable to have vaccine sites located in high-SVI locations. We examine the distribution of SVI measures of Census tracts in which pharmacy partners are located. We compare these to the distribution of SVI measures for DG stores. We also compare these to the distribution of SVI measures for the other major dollar store chain, Dollar Tree/Family Dollar.

In Figure 1, we show the fraction of all pharmacy partners located in each decile bin of SVI, the fraction of all DG stores located in each decile bin of SVI, and the fraction of all Dollar Tree stores located in each decile bin of SVI.

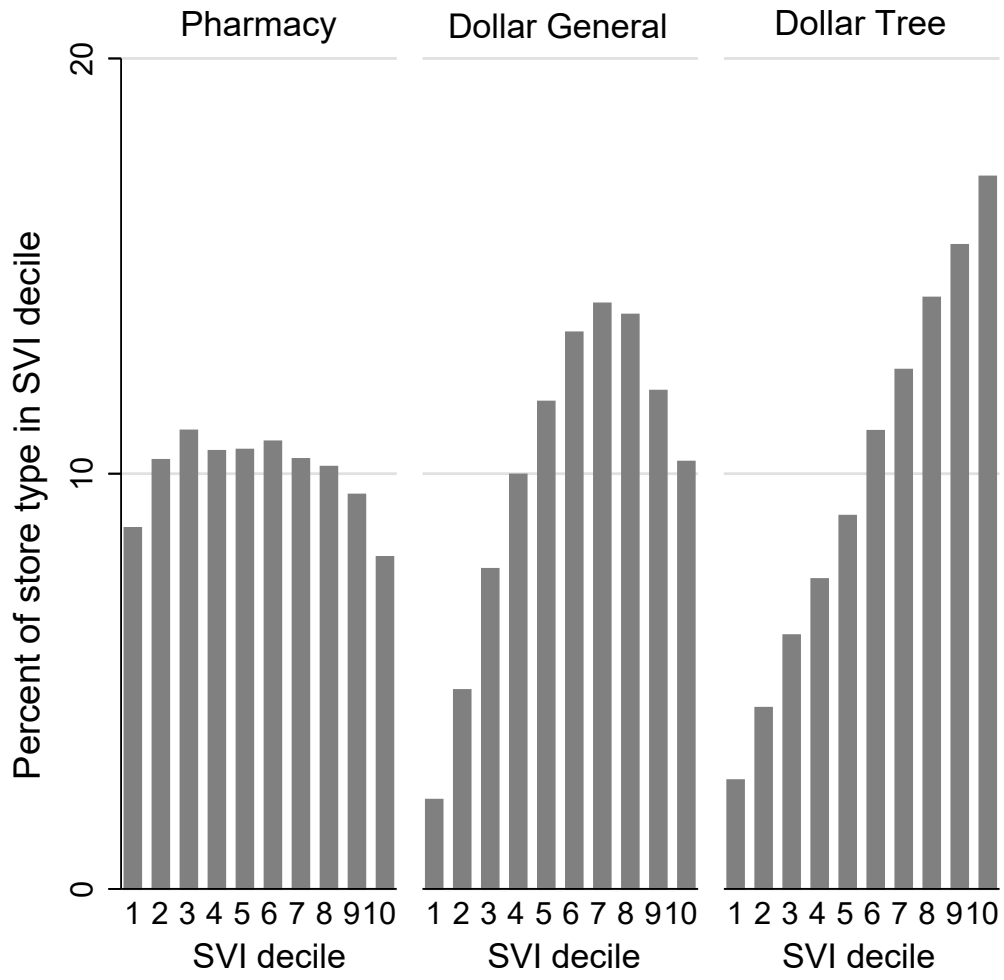
The roughly 26,000 pharmacy partners that we have mapped are nearly evenly distributed across the SVI deciles. However, the highest SVI decile, composed of the Census tracts estimated to have the highest social vulnerability, contain the smallest fraction of the pharmacy partner locations. The figure for DG illustrates why it could be a valuable federal partner in reaching vulnerable communities. DG stores are noticeably underrepresented in the lowest SVI Census tracts. Strikingly, the proportion of Dollar Tree Stores increases monotonically with SVI decile.

Given the vaccination gap between rural and urban areas, we also examine the propensity of these retailers to locate in urban versus rural areas. We find that 87% of the Federal Retail Pharmacy Partners are located in urban counties as are 82% of Dollar Trees and 72% of Family Dollar stores. In contrast, only 59% of Dollar General stores are located in urban counties; we show below that distributing vaccines through Dollar General is particularly powerful in improving vaccine proximity for rural residents.

3 Evidence on the retail program and proximity to vaccines

Household income is an important component of SVI. It is well-established that seasonal flu vaccination rates increase with income (Linn et al., 2010); lower-income households

Figure 1: Distribution of stores by Census tract SVI



Notes: Share of Pharmacy partners, DG, and Dollar Tree Stores by social vulnerability index (SVI) deciles, continental U.S. For example, if an outlet of a chain is located in a Census tract for which 95% of all Census tracts are less vulnerable using the full SVI index, the outlet will be counted to be in the top SVI decile in the graph.

face numerous barriers to vaccination such as access to scheduling technologies and transportation (Schmid et al., 2017; Press et al., 2021). Vaccine take-up for lower-income households would likely improve with greater proximity to a vaccination site, especially a vaccination site within walking distance. Thus, we examine here the proximity to retail pharmacy outlets of low-income households. Following the Census, we consider low-income households to be households with less than $35,000 in annual income. We consider the proximity of the current pharmacy partners to these households, as well as

the proximity that would occur if all DG locations were added as vaccine locations.

In the continental U.S., 48.9% of low-income households reside within 1 mile of an outlet of one of the current pharmacy partner chains. This may overestimate access if all chain outlets will not supply vaccines. Access climbs to 60.5% if the vaccine were offered at all DG outlets. For comparison, a slightly higher fraction of high-income households (with income greater than $100,000 are close to a federal pharmacy site than are low-income households, 49.5%. However, as might be expected by the high average SVI index of dollar store locations, adding DG as a partner does not increase the fraction of households located within 1 mile of an outlet as dramatically for high-income households as it does for low-income households. While adding DG to the vaccine distribution program increases the share of low-income households within a mile of a partner from 48.9% to 60.5%, for high-income households the share within a mile of a partner is increased from 49.5% to 54.9% with the addition of DG locations. Similarly, when considering less than 2 mile proximity and less than 5 mile proximity, a smaller share of low-income households have proximity to pharmacy partners than do high-income households for each cutoff. Adding DG reverses this, and a larger fraction of low-income households are within 2 or 5 miles of a partner when DG is added to the program.

Adding DG to the FRPP greatly improves overall access to vaccines, but proximity improvements vary greatly across states. Figure 2-(a) shows, for each state, the share of low-income households located less than 1 mile from a pharmacy partner. On the left of each bar pair for each state, the current pharmacy partner is shown and on the right the impact of adding DG is illustrated. In some states, such as Alaska and Hawaii, there are no DG stores and thus the figure shows no improvement (the two bars are of equal height). However, in some states, particularly in the South and Midwest, the hypothetical addition of DG to the pharmacy program dramatically increases the share of low-income households less than 1 mile from a pharmacy partner. The raw data are included in Figure 6 in the Appendix.

In the U.S., substantial disparities have also been identified between urban and rural populations (Murthy et al., 2021). Racial and ethic disparities in COVID-19 vaccine distribution have been identified in the U.S. and other countries with otherwise successful

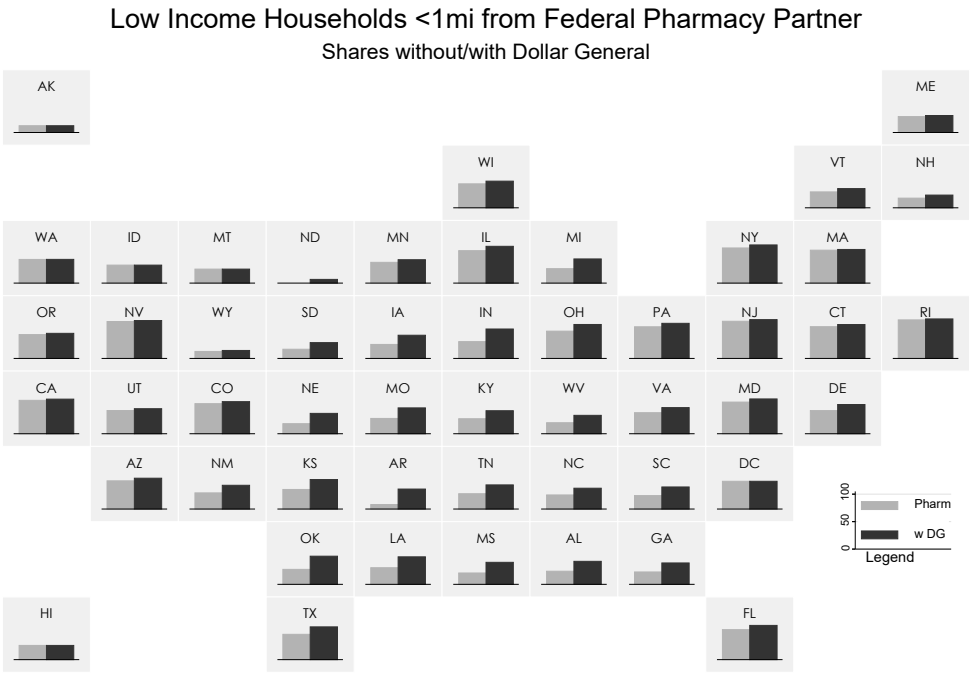
vaccination programs (Paton, 2021; Rosen et al., 2021). In the U.S., White and Asian individuals have been vaccinated at a rate greater than their share of the population, of cases, and of deaths. In contrast, Black and Hispanic individuals had, as of the end of March 2021, been undervaccinated by these metrics (Ndugga et al., 2021). Improving proximity of vaccine providers to these groups may help ameliorate such disparities. To explore this, we measure the impact of adding DG to the FRPP on proximity of vaccination cites to different racial and ethnic subgroups of the population. These are shown in Table 2.

A few patterns are notable. Importantly, we find that the impact of adding DG to the program particularly improves proximity in rural counties. Only 22.4% of rural adults live within a mile of a current Federal Retail Pharmacy Partner, but this improves to 33.5% by adding DG to the program. For rural adults, the fraction living within 5 miles of a partner improves from 56.8% to 79.7% by adding DG to the program.

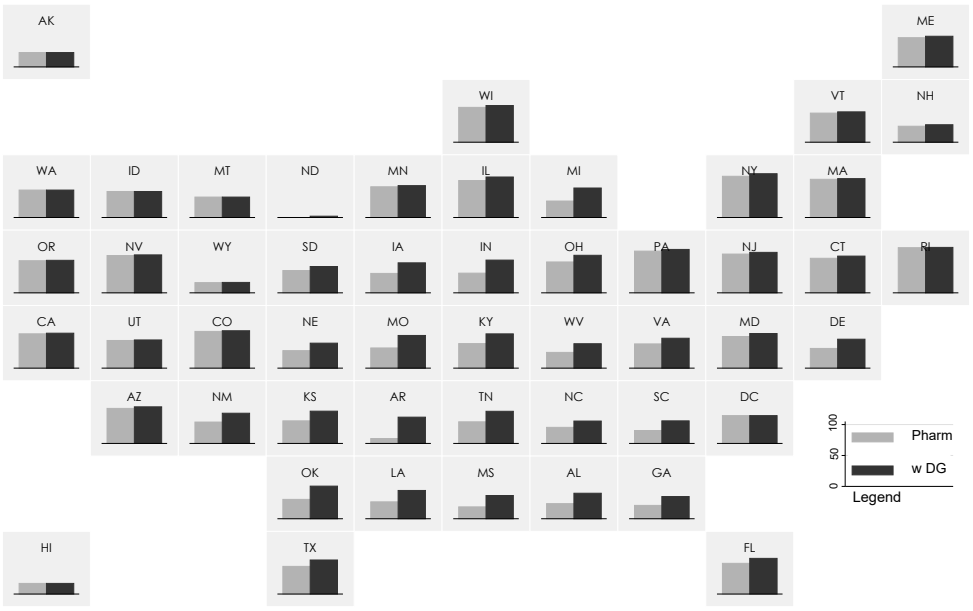
While we find that a higher share of the Black population is within 1 mile of a pharmacy partner than the white population, the improvement in proximity of adding DG outlets as vaccine sites is particularly large for the Black population. Adding DG to the program would improve the fraction of Black individuals within a mile of a partner site from 53.6% to 66.1%. The improvement in proximity from adding DG to the program is also disproportionately large for the Hispanic population relative to the non-Hispanic population. The share of Hispanic people less than a mile from a partner site is 44.9% without DG and 53.4% with DG.

Figure 2: Sub-populations with federal partner with and without DG at <1mi

(a) Percentage of Low-Income Households with Federal Pharmacy Partner at <1mi



(b) Percentage of Black population with Federal Pharmacy Partner at <1mi



Note: (a) State-by-state data on the share of households earning less than $35K per year that are located less than a mile from a federal pharmacy partner. The grey bar represents the current pharmacy partners and the black bars add DG as a partner. (b) State-by-state data on the share of Black people that are located less than a mile from a federal pharmacy partner. The grey bar represents the current pharmacy partners and the black bars add DG as a partner.

Table 2: Impacts of adding Dollar General vaccine sites

Population type	Current partners Share <1 mile	Current partners Share < 5 miles	w/ Dollar General Share <1 mile	w/ Dollar General Share < 5 miles
All adults	48.3	86.3	56.3	94.3
Rural adults	22.4	56.8	33.5	79.7
Urban adults	55.9	93.2	62.2	97.2
Black Population	53.6	93.2	66.1	98.0
White Population	44.3	83.8	52.3	93.3
AAPI Population	65.9	97.5	68.5	98.4
Other Population	58.5	90.4	65.0	94.7
Hispanic Population	44.9	84.6	53.4	93.7
Non-Hispanic Population	61.2	93.7	68.0	97.0

Summary statistics for FRPP. Table entries denote the share of the total U.S. population type within the denoted proximity to an in-state pharmacy partner.

For Black individuals, the overall data again masks substantial heterogeneity across states. As shown in Figure 2-(b), the improvement to proximity for Black Americans is particularly pronounced throughout the Southeast and Midwest. Arkansas is one of the starkest examples. There, the pharmacy partners are within a mile of only 10.0% of Black people and 11.2% of white people. The addition of DG improves one-mile proximity to 32.3% of whites and 53.6% of Black individuals. The benefit to Black Americans of adding DG is large in several Midwestern states, including Michigan. The raw data underlying Figure 2-(b) can be found in the Appendix; we provide a similar table for the Hispanic population (Figure 8).

Dollar General and the CDC have confirmed that a vaccine partnership has been discussed. However, given the high-SVI locations of Dollar Tree, it could be that Dollar Tree as a vaccine partner would provide even better proximity to vaccines for low-income households than DG.We examine this question by again measuring the proximity of low-income households to current pharmacy partners and to Dollar Tree. We found that 60.5% of low-income households in the continental U.S. are less than 1 mile from current pharmacy partners plus DG while 61.6% of low-income households are less than 1 mile from current pharmacy partners plus Dollar Tree. Thus, Dollar Tree would provide

slightly higher within 1 mile access to low-income households. Interestingly, this finding is not true for wider distance bands. More low-income households are within 2 or 5 miles from the current pharmacies plus DG than are within 2 or 5 miles from the current pharmacies plus Dollar Tree.

As suggested above, if the goal were to improve vaccine access in rural areas, Dollar Tree is a somewhat less valuable partner than Dollar General. While 33.5% of rural adults live within a mile of a current pharmacy partner or Dollar General, that share is only 28.9% for current pharmacy partners or Dollar Tree/Family Dollar.

The overall findings again mask some cross-state heterogeneity. As Figure 3 in the Appendix shows, the share of low-income households within a mile of a pharmacy partner plus hypothetical dollar store partner is, in many states, similar whether the dollar store partner is DG or Dollar Tree. Dollar Tree's locations are particularly attractive relative to DG in the West. DG provides better proximity in the South and Midwest, especially in states with a large rural population fraction, such as Alabama, Arkansas, Kansas, Iowa, and West Virginia.

4 State Allocations and State Vaccination Sites

We find that dollar stores vaccine sites would substantially expand vaccine proximity for low-income and rural households, particularly in the South and Southeastern U.S. Thus far, our analysis has examined only dollar stores plus chains that are partners in the FRPP. However, as discussed above, while some vaccine doses are allocated to this program, doses are also allocated to states to supply the vaccination sites that states support. The state sites consist of mass vaccination sites as well as any small pop-up sites organized by the state. While some states augment the federal program by distributing vaccine to retail pharmacies not part of the FRPP, others do not. While we have characterized the retail program as novel, and the federal government's stated purpose for using it is to improve geographic access, without direct evidence on the state vaccine programs, it is difficult to assess the importance of the federal retail program (or a proposed partnership with DG) in improving proximity.

To examine this, we scraped 21 state COVID-19 vaccine websites to find the full listing of vaccination sites in the state. These listings typically included federal pharmacy partners and Federally Qualified Health Centers. However, they typically included only sites that were actively providing vaccinations when we scraped the site. For each of the states, we match the listings with our current list of FRPP and create a listing of state sites that excludes federal retail partners.[9] Having constructed that set, we then calculate the distance of households to their closest within-state state vaccination site, using the methodology described above. It is possible that some states offer vaccines at locations not listed on their state site, such as temporary pop-up sites. We then examine, for low-income households, the proximity benefits of adding the FRPP to the roster of vaccine sites and the potential benefits of adding DG to the set of vaccine sites.

Table 3 shows the share of low-income households within 1 mile or 5 miles of a state site, the share within a mile of a pharmacy partner and/or state site, and the share within a mile of a pharmacy partner, state site, and/or DG. States vary considerably in the extent to which their vaccine sites provide substantial proximity to low income people. For example, we find that fewer than 15.2% of the low-income population lives within a mile of a state vaccination site for Georgia, Kansas, Maine, South Carolina, and West Virginia. For all of these states, adding the locations of federal retail pharmacy partners share of low-income households living within a mile of a vaccine site (state plus federal retail partner). For West Virginia, proximity improves from 3.2% of low income households less than a mile from a vaccine site to 23% including the federal retail partners. For the other low-proximity states (Georgia, Kansas, Maine, and South Carolina), the addition of the federal retail pharmacy partners improves the share of low-income households within a mile of a partner to at least 30%. The proximity benefits of DG are also not redundant with the state sites; adding DG to the federal program plus state sites would improve the share of low-income households within a mile of a vaccine site by more than 14 percentage points in all of the states with initially low proximity except Maine.

[9]The few federal partners that we could not match to RefUSA will not be eliminated from the state site list by this method.

Table 3: Characteristics of federal pharmacy and state vaccine sites

State	<1 mile state	<1 mile state + pharm	<1 mile state + pharm + DG	<5 miles state	<5 miles state + pharm	<5 miles state + pharm + DG
AK	37.73	37.97	37.97	58.66	58.66	58.66
AL	22.58	35.91	51.98	73.82	76.98	93.58
AR	27.23	31.51	48.14	71.46	73.78	87.63
CT	48.38	72.19	74.62	93.51	97.94	98.65
GA	13.67	32.74	47.5	69.34	84.29	95.97
IL	24.29	69.97	77.11	84.81	90.65	96.37
KS	15.18	47.38	61.80	53.16	81.63	90.28
MD	30.60	69.59	74.34	81.88	94.37	97.30
ME	14.19	33.56	35.75	38.58	64.70	73.47
MO	48.12	56.33	64.81	81.15	84.23	92.02
MS	22.63	35.77	49.78	60.01	68.23	87.16
ND	50.53	50.53	51.12	72.60	72.60	74.11
NJ	38.56	79.29	81.96	90.52	99.07	99.69
NV	41.44	77.65	79.64	88.97	92.31	93.16
OH	40.06	65.82	74.44	87.85	92.25	97.29
OK	20.95	43.17	62.76	65.42	78.41	92.85
PA	30.29	69.19	73.94	81.5	92.76	97.68
SC	11.73	31.37	46.81	59.29	78.69	93.86
WA	28.39	55.59	55.70	80.49	88.75	88.85
WV	3.16	23.10	37.63	13.47	70.11	87.03

Notes: Share of low-income households less than one mile/5 miles from state sites, pharmacy partners plus state vaccine sites, and pharmacy partners plus state vaccine sites plus DG. Data from RefUSA and state vaccine sites.

5 Discussion and Conclusions

We show that using retail pharmacies as vaccination sites, as has been done in the U.S., disburses vaccines such that the vast majority of Americans are within 5 miles of a vaccine site. We show that using Dollar General stores as vaccination sites would offer considerable proximity benefits, particularly for low-income households, people living in rural counties, Black Americans, and Hispanic Americans in several regions of the continental U.S.

While a retail strategy provides proximity benefits, there are challenges to using retail sites to distribute vaccinations. First, reports suggest substantial dose wastage in the

FRPP, though most of this waste appears to have occurred when Walgreens and CVS (two federal retail partners) were exclusively vaccinating long term care centers (Pfeiffer, 2021). In addition, a retail pharmacy cannot achieve the throughput per hour of a mass vaccination site. The use of dollar stores as vaccination sites would require addressing additional logistical challenges; importantly, dollar stores currently lack employees trained to administer vaccines. While the logistical challenges of coordinating vaccines with a dollar store company may be formidable, policymakers have shown a willingness to undertake logistically challenging initiatives to reach these populations. For example, the Biden administration announced a "Shots at the Shop" initiative in which up to 1,000 independently-owned beauty shops and barbershops could apply for $1,000 grants to provide vaccination information and host vaccine sites. Like dollar stores, these shops would not normally be staffed with personnel who can provide injections. In contrast to an initiative involving a dollar store chain, this effort requires creating incentives for myriad independent entities to participate and the sites that apply to participate may not necessarily be the most locationally valuable.

Of course, enhancing proximity to vaccination sites is not sufficient to ensure high rates of vaccination due to vaccine reluctance. Nonetheless, a retail distribution strategy that includes dollar stores provides a template for other public health efforts. For example, subsequent COVID-19 boosters may be required on a large scale. Annual influenza vaccination similarly relies on rapidly delivering vaccines to tens of millions of Americans in a compressed period, often through the use of temporary large-scale vaccination clinics outside of traditional health care settings. Reported rates of influenza vaccine administration are lower among low-income older adults, the age group—as with COVID-19—at the greatest risk of severe disease-related outcomes (Artiga et al., 2020). Such sites could be similarly variable for a variety of other health screenings or services, including providing information and signup opportunities for state and federal benefits programs; many such benefit programs are plagued by incomplete take-up by eligible populations (Wright et al., 2017; Finkelstein and Notowidigdo, 2019). The extant locational infrastructure of retail chains in general, and dollar stores in particular, make them a credible partner for any initiative that requires the large-scale in-person participation of the general public.

6 References

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7 Appendix

Table 4: State-Coordinated Vaccine Locations

State	Website
Alabama	https://bamatracker.com/providers
Alaska	https://anchoragecovidvaccine.org/providers/
Arkansas	https://www.healthy.arkansas.gov/programs-services/topics/covid-19-map-of-1-a-pharmacy-locations
Connecticut	https://www.211ct.org/search?page=1&location=Connecticut&taxonomy_code=11172&service_area=connecticut
Georgia	http://www. dph.georgia.gov/locations/covid-vaccination-site
Illinois	https://coronavirus.illinois.gov/s/vaccination-location
Kansas	https://kdhe.maps.arcgis.com/apps/instant/nearby/index.html?appid=2cf619afb6c74320a26855840a8ca3e3
Maine	https://www.maine.gov/covid19/vaccines/vaccination-sites
Maryland	https://maryland.maps.arcgis.com/apps/instant/nearby/index.html?appid=0dbfb100676346ed9758be319ab3f40c&find=
Mississippi	https://msdh.ms.gov/msdhsite/_static/14,0,420,976.html#providerMap
Missouri	https://covidvaccine.mo.gov/map/Approved-Vaccinators.pdf
North Dakota	https://app.powerbigov.us/view?r=eyJrIjoiNmY1ZWFiMzktYzMzNC00ZTQxLTkxZTAtNWRiMzkyYzYzMjk0IiwidCI6IjJkZWEwNDY0LWRhNTEtNGE4OC1iYWUyLWIzZGI5NGJjMGM1NCJ9
Nevada	https://www.immunizenevada.org/covid-19-vaccine-locator
New Jersey	https://newjersey.github.io/vaccine-locations/NJ-COVID-19-Vaccine-Locations.pdf
Ohio	https://coronavirus.ohio.gov/wps/portal/gov/covid-19/dashboards/covid-19-vaccine/covid-19-vaccine-provider-dashboard
Oklahoma	https://vaccinate.oklahoma.gov/en-US/vaccine-centers/
Pennsylvania	https://padoh.maps.arcgis.com/home/item.html?id=d169e1d2ae454bec928d046156dd7186
South Carolina	https://sc-dhec.maps.arcgis.com/apps/instant/nearby/index.html?appid=514e64ead13e4f508147dad8f483da38
Washington	https://www.doh.wa.gov/YouandYourFamily/Immunization/VaccineLocations#
West Virginia	https://dhhr.wv.gov/News/2021/Pages/COVID-19-Vaccination-Clinics-March-2-7,-2021.aspx
Wisconsin	https://dhsgis.wi.gov/server/rest/services/DHS_COVID19/COVID19_Vaccine_Provider_Sites/MapServer/0/query?where=1%3D1&text=&objectIds=&time=&geometry=&geometryType=esriGeometryEnvelope&inSR=&spatialRel=esriSpatialRelIntersects&relationParam=&outFields=*&returnGeometry=false&returnTrueCurves=false&maxAllowableOffset=&geometryPrecision=&outSR=&returnIdsOnly=false&returnCountOnly=false&orderByFields=&groupByFieldsForStatistics=&outStatistics=&returnZ=false&returnM=false&gdbVersion=&returnDistinctValues=false&resultOffset=&resultRecordCount=&queryByDistance=&returnExtentsOnly=false&datumTransformation=&parameterValues=&rangeValues=&f=pjson

Notes: Websites used to gather state-coordinated vaccine locations.

Table 5: Summary Statistics for U.S. Dollar Stores, Selected Years

	Dollar General	Dollar Tree	Dollar General per 100K	Dollar Tree per100K
Alabama	791	317	16.26	6.52
Alaska	0	0	0	0
Arizona	123	306	1.77	4.4
Arkansas	463	198	15.48	6.62
California	229	781	.58	1.99
Colorado	56	234	1.01	4.23
Connecticut	69	126	1.93	3.52
Delaware	48	65	5.06	6.85
District of Columbia	0	6	0	.88
Florida	927	1160	4.5	5.63
Georgia	944	719	9.17	6.98
Hawaii	0	0	0	0
Idaho	0	95	0	5.63
Illinois	587	547	4.58	4.27
Indiana	596	371	8.98	5.59
Iowa	276	110	8.81	3.51
Kansas	250	121	8.59	4.16
Kentucky	596	346	13.42	7.79
Louisiana	586	453	12.57	9.71
Maine	59	103	4.43	7.73
Maryland	138	237	2.3	3.95
Massachusetts	54	250	.79	3.66
Michigan	588	648	5.91	6.51
Minnesota	170	190	3.08	3.44
Mississippi	549	249	18.37	8.33
Missouri	564	302	9.26	4.96
Montana	0	40	0	3.84
Nebraska	130	70	6.83	3.68
Nevada	21	113	.72	3.87
New Hampshire	40	71	2.98	5.28
New Jersey	156	317	1.76	3.57
New Mexico	106	190	5.07	9.08
New York	499	662	2.54	3.37
North Carolina	896	743	8.82	7.32
North Dakota	44	36	5.85	4.79
Ohio	887	552	7.62	4.74
Oklahoma	472	241	12.05	6.15
Oregon	60	100	1.47	2.45
Pennsylvania	806	654	6.3	5.11
Rhode Island	21	73	1.99	6.91
South Carolina	575	396	11.6	7.99
South Dakota	60	42	6.94	4.86
Tennessee	832	403	12.51	6.06
Texas	1591	1732	5.71	6.21
Utah	11	126	.36	4.14
Vermont	38	24	6.08	3.84
Virginia	441	459	5.24	5.46
Washington	3	140	.04	1.92
West Virginia	240	191	13.12	10.44
Wisconsin	210	275	3.63	4.76
Wyoming	3	45	.52	7.73

Notes: Number of dollar stores and stores per 100,000 population, by state. Data from RefUSA.

Table 6: Vaccine Access—Low-Income Households

State	<1 mile pharmacy	<1 mile pharmacy plus DG	<1 mile pharmacy plus DT
AK	13.79	13.79	13.79
AL	26.79	46.9	41.11
AR	9.12	40.72	35.31
AZ	57.43	62.87	68.73
CA	68.07	70.54	75.08
CO	61.29	65.38	69.58
CT	64.68	69.05	69.3
DC	56.56	56.56	67.3
DE	47.17	59.53	63.72
FL	61.17	69.83	70.23
GA	25.21	43.6	44.73
HI	28.99	28.99	28.99
IA	28.51	47.28	41.84
ID	36.7	36.7	44.84
IL	66.15	75.04	73.2
IN	34.25	59.97	57.58
KS	39.9	60.15	53.04
KY	30.54	46.91	41.38
LA	33.85	56.07	59.33
MA	67.16	68.61	75.03
MD	64.53	70.91	73.05
ME	32.45	34.65	37.41
MI	29.44	49.28	60.31
MN	42.34	47.67	50.43
MO	31.21	52.68	50.61
MS	23.14	44.85	40.4
MT	28.58	28.58	31.65
NC	28.7	42.44	42.97
ND	0	7.6	23.82
NE	20.42	41.46	45.31
NH	19.72	25.96	31.73
NJ	75.75	79.11	81.37
NM	32.91	48.43	55.49
NV	75.25	77.24	80.29
NY	71.69	77.85	79.62
OH	55.62	69.18	68.72
OK	30.52	57.38	52.22
OR	48.51	51.17	52.67
PA	64.49	71.52	68.89
PR	35.41	35.41	35.41
RI	78.53	80.53	82.48
SC	27.38	44.97	40.21
SD	18.73	32.22	28.89
TN	31.18	49.18	44.69
TX	51.61	66.81	68.41
US	48.39	59.58	60.65
UT	47.28	51	62.43
VA	42.92	53.26	57.26
VT	32.4	39.16	33.42
WA	48.27	48.38	51.62
WI	48.81	54.4	58.52
WV	22.45	37.47	33.71
WY	14.21	16.23	35.24

Notes: Share of low-income households less than 1 mile from pharmacy partners, pharmacy partners plus Dollar General, and pharmacy partners plus Dollar Tree/Family Dollar. Data from RefUSA.

Table 7: Vaccine Access—Black Population

State	<1 mile pharmacy	<1 mile pharmacy plus DG	<1 mile pharmacy plus DT
AK	29.27	29.27	29.27
AL	30.74	52.02	51.04
AR	9.96	53.57	52.26
AZ	71.43	74.65	79.63
CA	69.93	71.25	77.09
CO	74.88	76.23	81.43
CT	70.39	74.85	74.83
DC	56.72	56.72	71.66
DE	40.19	59	60.98
FL	62.61	72.75	75.54
GA	27.2	45.23	48.75
HI	21.71	21.71	21.71
IA	39.57	61.12	65.09
ID	53.05	53.05	60.09
IL	75.37	82.61	84.54
IN	40.11	66.72	73.54
KS	45.99	65.78	68.56
KY	50	69.82	68.13
LA	34.41	57.68	63.69
MA	77.89	79.32	85.03
MD	64.45	70.53	74.09
ME	59.56	62.48	67.7
MI	33.61	60.18	81.93
MN	62.66	64.99	73.2
MO	41.09	66.62	78.57
MS	24.17	47.39	42.7
MT	41.69	41.69	41.99
NC	32.77	45.63	51.68
ND	0	2.66	40.05
NE	35.65	50.92	75.55
NH	32.54	35.63	45.51
NJ	79.01	82.46	85.2
NM	43.6	61.59	71.06
NV	75.98	77.36	81.46
NY	84.04	89.31	93.03
OH	62.93	76.51	79.73
OK	39.47	66.47	68.38
OR	65.46	66.29	70.04
PA	85.02	88.49	88.91
RI	92.02	92.61	93.13
SC	26.29	46.02	39.14
SD	45.43	53.63	63.85
TN	44.02	65.56	65.62
TX	56.41	69.41	72.98
UT	56.34	57.47	73.15
VA	49.39	60.92	66.45
VT	59.33	61.84	59.33
WA	55.98	55.99	60.51
WI	71.05	74.76	83.46
WV	32.06	49.74	48.66
WY	20.78	21.23	34.93

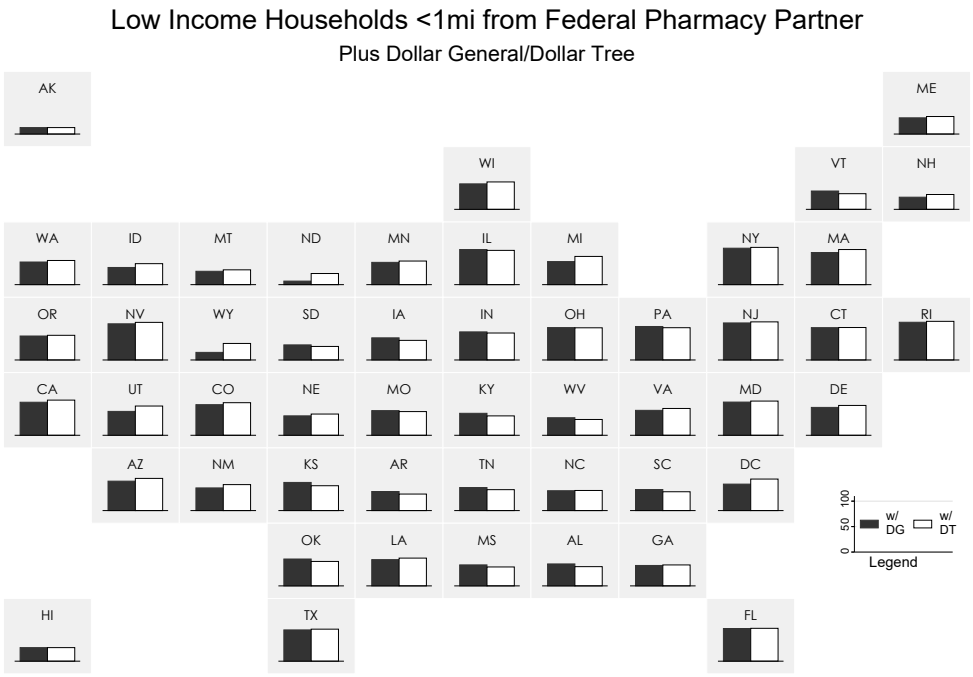
Notes: Share of Black population less than 1 mile from pharmacy partners, pharmacy partners plus Dollar General, and pharmacy partners plus Dollar Tree/Family Dollar. Data from RefUSA.

Table 8: Vaccine Access—Hispanic Population

State	<1 mile pharmacy	<1 mile pharmacy plus DG	<1 mile pharmacy plus DT
AK	15.72	15.72	15.72
AL	22.72	40.03	32.39
AR	10.65	35.34	28.59
AZ	59.54	62.15	64.04
CA	67.22	68.43	71.09
CO	61.99	63.59	66.34
CT	44.88	49	48.99
DC	63.99	63.99	73.04
DE	35.53	44.95	48.58
FL	52.56	60.93	59.62
GA	24.05	38.49	36.72
HI	24.27	24.27	24.27
IA	27.36	42.72	37.47
ID	35.99	35.99	43.4
IL	59.5	66.92	64.04
IN	29.62	48.57	42.41
KS	40.97	54.72	48.1
KY	28.78	44.76	38.88
LA	31.53	49.66	50.29
MA	52.73	54.14	58.55
MD	53.94	58.54	59.61
ME	31.15	34.47	36.94
MI	29.05	42.58	48.34
MN	39.77	43.32	45.76
MO	31.26	47.97	43.53
MS	19.23	36.8	31.39
MT	30.5	30.5	33.27
NC	26.64	37.6	37.35
ND	0	5.18	29.43
NE	26.76	44.69	42.88
NH	11.57	17.83	21.88
NJ	63.84	66.25	68.18
NM	34.37	47.2	51.12
NV	63.5	65.46	66.94
NY	64.36	68.92	69.88
OH	46.58	57.87	53.75
OK	30.7	53.01	44.89
OR	47.86	50.26	51.95
PA	51.56	58.32	54.65
RI	61.12	62.96	65.06
SC	26.17	42.23	35.01
SD	22.56	35.46	30.69
TN	28.14	43.9	36.87
TX	52.64	62.21	60.78
UT	40.51	41.96	52.06
VA	46.78	53.21	55.1
VT	32.35	38.38	33.21
WA	44.52	44.64	47.48
WI	35.75	41.6	44.23
WV	17.96	31.97	27.25
WY	14.16	15.52	31.17

Notes: Share of Hispanic population less than 1 mile from pharmacy partners, pharmacy partners plus Dollar General, and pharmacy partners plus Dollar Tree/Family Dollar. Data from RefUSA.

Figure 3: Percentage of Low-Income Households with Federal Pharmacy Partner at <1mi



Notes: State-by-state data on the share of households earning less than $35K per year that are located less than a mile from a federal pharmacy partner or dollar store. The black bars represents the current pharmacy partners plus Dollar General while the white bars represent the current pharmacy partners plus Dollar Tree.

Table 9: Vaccine Access—Alternative Partners and Distance

State	<1 mile pharmacy	<1 mile pharmacy plus state	<1 mile pharmacy plus DG	<5 miles pharmacy	<5 miles pharmacy plus state	<5 miles pharmacy plus DG
AK	13.79	37.97	37.97	39.41	58.66	58.66
AL	26.79	36.36	51.98	69.6	76.98	93.58
AR	9.12	32.04	48.43	50.24	73.89	87.63
CT	64.68	73.21	75.54	97.33	98.01	98.72
GA	25.21	32.81	47.56	77.91	84.29	95.97
IL	66.15	71.27	77.89	89.33	90.7	96.38
KS	39.9	50.12	62.27	73.46	83.9	90.47
MD	64.53	72.11	76.02	92.97	94.41	97.34
ME	32.45	33.56	35.75	62.3	65.12	73.89
MO	31.21	58.61	65.48	73.94	85.49	92.37
MS	23.14	39.16	50.86	58.56	68.81	87.16
ND	0	50.81	51.4	14.64	72.6	74.11
NJ	75.75	79.4	82.08	98.71	99.12	99.73
NV	75.25	78.24	80.22	91.74	92.31	93.16
OH	55.62	67.24	75.3	90.22	92.29	97.29
OK	30.52	43.29	62.87	72.36	78.41	92.85
PA	64.49	70.31	74.69	90.59	92.86	97.76
SC	27.38	32.87	47.58	76.56	79.02	94.13
WA	48.27	56.07	56.18	83.96	88.75	88.85
WV	22.45	23.1	37.63	68.4	70.11	87.03

Notes: Share of low-income households less than 1 mile/5 miles from pharmacy partners, pharmacy partners plus state vaccine sites, and pharmacy partners plus state vaccine sites plus Dollar General.Data from RefUSA and state vaccine sites.