Distance to Vaccine Sites is Associated with Lower COVID-19 Vaccine Uptake

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COVID-19 remains a leading cause of death in the United States despite wide availability of vaccines. Even in light of the rapidly spreading Omicron variant, vaccination has stalled, with only 62% of Americans fully vaccinated, and only around 20% having received a booster shot.¹

In recent attempts to boost vaccine uptake, some states are returning to mass vaccination sites.² Although a mass-vaccination approach was useful early in vaccine distribution,³ it also increases travel distance to vaccination sites. Given that distance is a potent barrier to other health-related behaviors—such as when distance to fresh food⁴ and gyms⁵ curbs healthy eating and exercise—there is reason to believe that distance could similarly inhibit vaccine uptake.

Yet, people largely overlook the impact of distance: When participants in our pilot survey ($N = 199$) listed barriers to COVID-19 vaccination, only 6% mentioned distance. Reducing distance may thus be an important-yet-underutilized lever to improve vaccination rates—one that has not been tested directly in any prior research.

To test distance effects, we analyzed the detailed geospatial COVID-19 data available for California. Specifically, we related zip-code level vaccine uptake rates (as of January 4, 2022) to COVID-19 vaccination site location, accounting for a range of key demographic and attitude-related influences.

Method

We examined vaccination rates in 1,472 zip codes and 3,531 vaccine sites. Multilevel linear regression models predicted vaccine uptake from: mean travel distance to the 10 nearest vaccine sites, vaccine hesitancy, partisanship, population density, urban/rural status, median

family income, and percent seniors. All data, code, and additional details are available online: https://osf.io/brmy4/?view_only=eb9624efbaa04fd396a9a6084ba4a21e.

Results

Longer distance correlated with lower vaccine uptake, $r(1462) = -0.44$. Supporting a unique role of friction, a sizable effect of distance on vaccine uptake persisted in the full multilevel model controlling for spatial dependence as well as demographic and attitudinal covariates (see table 1). To explore the robustness of this conclusion, we used a multiverse approach⁶ (testing all combinations of 16 distance/travel time measures and covariates), with a significant distance effect persisting across 85% of models (856 of 1,008). Similarly, when looking only at models that included all 7 covariates, a significant distance effect emerged in 75% of the models (12 out of 16). The magnitude of the distance effect in the full model was sizable—comparable to that of partisanship and nearly two-thirds that of vaccine hesitancy ($\beta_{\text{distance}} = -.19$, $\beta_{\text{partisanship}} = -.20$, $\beta_{\text{hesitancy}} = -.31$). In real terms, being 0.25 miles vs. 5 miles from a vaccine site was associated with a 9% lower vaccination rate (75% vs. 66%).

To probe the possibility of reverse causality (high demand attracting more vaccine sites), we examined the distance-vaccination association only for retail locations (e.g., CVS), which were largely set pre-pandemic. Yet distance effects similarly persisted in these analyses ($\beta_{\text{distance}} = -.20$).

Table 1

Regression Results Predicting Vaccine Uptake from Travel Distance Without Covariates and Full Model with Covariates.

<< INSERT TABLE 1 HERE >>

Figure 1

COVID-19 Vaccine Uptake as a Function of Travel Distance to Vaccination Sites, from the Full Model with Covariates.

<< INSERT FIGURE 1 HERE >>

Discussion

Distance is a neglected yet meaningful determinant of vaccine uptake. To the best of our knowledge, this is the first large-scale demonstration that distance reduces vaccine uptake. The effect was extremely robust, holding across a wide range of distance measures and after accounting for potent covariates such as vaccine hesitancy, partisanship, and rural/urban location.

Our results are encouraging. Reducing distance provides a powerful, non-coercive lever for increasing COVID-19 vaccination. Careful thinking about distance is critical to increasing booster shot uptake and combating the emergence of highly infectious variants such as Omicron. Finally, these results cast doubt on recent policy efforts to deploy mass vaccination sites,² suggesting instead more localized approaches.

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References

1. Our World In Data. Coronavirus (COVID-19) Vaccinations. *Our World in Data*. Published March 5, 2020. Accessed November 2, 2021. <https://ourworldindata.org/covid-vaccinations>
2. Patel V. Some states are opening mass vaccination sites amid the Omicron surge. <https://www.nytimes.com/live/2022/01/09/world/omicron-covid-vaccine-tests#some-states-are-opening-mass-vaccination-sites-amid-the-omicron-surge-in-the-us>. Published January 9, 2022. Accessed January 12, 2022.
3. Goralnick E, Kaufmann C, Gawande AA. Mass-Vaccination Sites—An Essential Innovation to Curb the COVID-19 Pandemic. *N Engl J Med*. 2021;384(18): e67. doi: 10.1056/NEJMp2102535
4. Morland K, Diez Roux AV, Wing S. Supermarkets, Other Food Stores, and Obesity: The Atherosclerosis Risk in Communities Study. *Am J Prev Med*. 2006;30(4):333-339. doi:10.1016/j.amepre.2005.11.003
5. Bachman R. How Close Do You Need to Be to Your Gym? *Wall Street Journal*. <https://www.wsj.com/articles/how-close-do-you-need-to-be-to-your-gym-1490111186>. Published March 21, 2017. Accessed January 12, 2022.
6. Steegen S, Tuerlinckx F, Gelman A, Vanpaemel W. Increasing Transparency Through a Multiverse Analysis. *Perspect Psychol Sci*. 2016;11(5):702-712. doi:10.1177/1745691616658637

Table

Table 1

Regression Results Predicting Vaccine Uptake from Travel Distance Without Covariates and Full Model with Covariates.

	Without Covariates				Full Model			
<i>Predictors</i>	<i>b</i>	<i>SE</i>	β	<i>p</i>	<i>b</i>	<i>SE</i>	β	<i>p</i>
Intercept	0.69	0.02	-.25	<.001	0.89	0.06	-.07	<.001
Mean time (log transformed)	-0.03	0.00	-.21	<.001	-0.03	0.01	-.19	<.001
Partisanship: % Trump vote in 2020					-0.32	0.04	-.20	<.001
Population density					0.00	0.00	-.02	.969
HHS estimated vaccine hesitancy					-2.70	0.41	-.31	<.001
% Urban					0.00	0.02	.00	.427
% Seniors					0.54	0.06	.20	<.001
Median household income					0.00	0.00	.30	<.001

Figure 1

COVID-19 Vaccine Uptake as a Function of Travel Distance to Vaccination Sites

(log-transformed) from the Full Model with Covariates.

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Supplement

Datasets

Our analyses used the following data sources.

COVID-19 Vaccination Rates Our main outcome was COVID-19 vaccination data provided by the California Health and Human Services Agency, as of January 4, 2022. This dataset provides weekly zip-code level vaccination rates for the state of California. Our analysis excluded zip codes that do not represent geographical units. Namely, 182 zip codes classified as a PO Box and 19 zip codes classified as “unique” (these are usually zip codes that represent a central mailing location for large organizations).¹

Vaccine Site Location GISCorps’ COVID-19 vaccination provider geolocation data² is a crowdsourced dataset created in collaboration with leading health providers (CVS Health, Walgreens) as well as state and local authorities. It includes exact geolocation (longitude and latitude) for 37,890 vaccination sites across the United States (3,531 vaccination sites in California).²

Vaccine Hesitancy Vaccine hesitancy, using the Health and Human Services’ estimates, are derived from the Census Bureau’s Household Pulse Survey, which measures willingness to get vaccinated for COVID-19.³

Voting Patterns Precinct-level voting results from California are hosted on the Harvard Dataverse.⁴ Precinct-level results were converted to census-block level using the precinct-to-census-block conversion file provided by the California Statewide Database.⁵ Block level voting data were then aggregated to the census tract level and converted to zip code using HUD-USPS crosswalk files (see “Data processing” below).⁶

Population density, urban/rural status, median family income, and share of seniors

We used zip-code level census data for population density (number of residents per square mile), urban/rural status, median family income, and share of seniors, obtained using the “zipcodeR” package.

Data processing

All analyses were conducted on zip-code level data. When data were provided in geographical units other than zipcode, they were converted to zip codes using HUD-USPS crosswalk files, which designate the overlap between zip codes and other geographies.

There is not a one-to-one mapping between zip codes and census units. For example, most zip codes span multiple census tracts, and census tracts often span multiple zip codes. For census-tract data, zip-code level statistics were calculated as the weighted sum (for count variables) or weighted mean (for continuous or binary variables) of their constituent census tracts. Note that for binary variables, this process converts binary variables into continuous ones. For example, census tracts are designated as either urban or rural, but a zip code can consist of a mixture of urban and rural tracts (although 67% of CA zip codes in our analyses were classified as over 90% urban or rural).

For data provided at the county level, if a zip code spanned more than one county, zip code level metrics were calculated using the weighted mean of the statistic for all relevant counties, based on the % of addresses in a zip code that fall within each county.

Analytic approach

A multiverse approach tested whether distance friction suppresses vaccine uptake across a range of model specifications. We ran 1,008 multilevel regression models (with zip codes nested within counties) predicting vaccine uptake from every possible combination of 16

distance measures, as well as a set of up to 7 covariates: vaccine hesitancy, share of 2020 Trump voters, population density, urban/rural status, median family income, and percent seniors.

Specifically, the distance measures involved testing across 8 alternative distance measures, each fit using raw and log distance (16 distance variables):

- 1) Number of vaccine sites within a [1/5/10/20] mile aerial radius.
- 2) [median / mean] [travel distance / travel time] between each zip code's population-weighted centroid and 10 nearest vaccine sites.

References

1. California Department of Public Health. COVID-19 Vaccine Progress Dashboard Data by ZIP Code. Updated January 4, 2021. Accessed January 7, 2021. <https://data.chhs.ca.gov/dataset/covid-19-vaccine-progress-dashboard-data-by-zip-code>
2. GISCorps. Covid-19 Vaccination Provider Locations in the United States. Covid-19 Vaccination Provider Locations in the United States. Published October 25, 2021. Accessed November 26, 2021. <https://coronavirus-resources.esri.com/datasets/GISCorps::covid-19-vaccination-provider-locations-in-the-united-states/about>
3. HHS. Vaccine Hesitancy for COVID-19: County and local estimates. Published 2021. Accessed November 26, 2021. <https://data.cdc.gov/Vaccinations/Vaccine-Hesitancy-for-COVID-19-County-and-local-es/q9mh-h2tw>
4. Voting and Election Science Team. 2020 Precinct-Level Election Results. Harvard Dataverse. Published 2021. Accessed November 26, 2021. <https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/K7760H&version=27.0>
5. California Statewide Database. 2020 General Election Geographic Data. Published 2020. Accessed October 15, 2021. https://statewidedatabase.org/d10/g20_geo_conv.html
6. HUD. HUD USPS Zip Code Crosswalk Files. Published 2021. Accessed November 26, 2021. https://www.huduser.gov/portal/datasets/usps_crosswalk.html