ASPE ASSISTANT SECRETARY FOR PLANNING AND EVALUATION
OFFICE OF SCIENCE & DATA POLICY

ISSUE BRIEF
APRIL 2021

Factors influencing variation between states in efficiency of COVID-19 vaccine administration

KEY POINTS

- As of mid-February 2021, states and other jurisdictions have vaccinated 11-21% of their population against COVID-19, using different approaches for vaccine eligibility and vaccine distribution strategies.
- The percentage of vaccine doses received by states that have been administered to patients varies from 72% to nearly 100%, but this variation is unrelated to population size or the size of the population currently eligible to receive a vaccine in each state.
- States that have expanded eligibility to a larger proportion of their population have likely achieved lower coverage of the highest priority populations.
- While administration rates appear unrelated to prevalence of COVID-19 vaccine hesitancy, evaluating state-specific patterns of COVID-19 vaccine hesitancy could help inform any relationship to vaccine administration rates.

INTRODUCTION

In December 2020, the U.S. Food and Drug Administration (FDA) issued Emergency Use Authorizations (EUA) for the first two COVID-19 vaccines. The Pfizer-BioNTech COVID-19 vaccine received an EUA on December 11th and shipments of the vaccine began on December 13th; the Moderna vaccine received an EUA on December 18th and shipments of the vaccine began on December 20th. Since December, the federal government has delivered over 80 million doses of COVID-19 vaccines to states and other jurisdictions, with allocations proportional to the total population of the state aged 16 and over.[1] States have then embarked on a vaccination effort of unprecedented scale, with a need to prioritize which patients receive the vaccine first, and a challenge to ensure that vaccine doses are distributed equitably. To that end, the Advisory Committee on Immunization Practices (ACIP) developed a framework that divided population groups into phases (see Table 1), from which it has made recommendations for which phase should be vaccinated. The recommendations to date have been adopted by the Centers for Disease Control and Prevention (CDC).[2] However, these recommendations are not binding, and states can choose to follow these recommendations or develop their own. Additionally, the CDC recommendations did not specifically consider the timing or amount of vaccines received by each jurisdiction. States utilized the recommendations to develop their own sets of priority groups and phases, and rolled out

[1] The following states received a "Sovereign Nation Supplement" for American Indian/Alaskan Native populations that elected to receive vaccines through the state instead of the Indian Health Service: Alaska, Arizona, Minnesota, Nebraska, New Mexico, North Dakota, Oregon, Utah, Washington, Wisconsin.

[2] Dooling K, Marin M, Wallace M, et al. The Advisory Committee on Immunization Practices' Updated Interim Recommendation for Allocation of COVID-19 Vaccine — United States, December 2020. MMWR Morb Mortal Wkly Rep 2021;69:1657-1660. DOI: http://dx.doi.org/10.15585/mmwr.mm695152e2

each priority group in different ways. The goal of this brief is to summarize existing vaccine distribution strategies and approaches, as well as state characteristics, that may impact the efficiency with which doses delivered to states are administered to patients.

Table 1: Initial CDC Recommendations for Phased COVID-19 Vaccine Allocation[3]

Phase 1a	Healthcare personnel
	Long-term care facility residents
Phase 1b	Frontline essential workers • First responders • Corrections officers • Food and agricultural workers • U.S. Postal Service workers • Manufacturing workers • Grocery store workers • Public transit workers • Teachers and education support staff • Child care workers
	Persons aged ≥75 years
Phase 1c	Persons aged 65-74 years
	Persons aged 16-64 years with high-risk medical conditions • Cancer • Chronic kidney disease • Chronic obstructive pulmonary disease • Down Syndrome • Heart conditions • Immunocompromised • Obesity • Pregnancy • Sickle cell disease • Smoking • Type 2 diabetes
	Essential workers not recommended for vaccination in Phase 1b

METHODS

This brief focuses on COVID-19 vaccine administration rates, defined as the percentage of doses that have been administered to patients out of all doses received by the state. This metric describes the efficiency with which states administer the doses that they receive. In contrast, the term "vaccine coverage" used throughout this document refers to the percent of the population in a given state that has received a vaccine. Data on doses received by states and administered to patients in each state were obtained from CDC's COVID Data Tracker for all 50 states and the District of Columbia on February 22, 2021.[4] Vaccine administration data are reported from jurisdictions to the CDC and may lag based on the reporting schedule of a given jurisdiction. CDC notes that

[3] CDC. Vaccine Recommendations and Guidelines of the ACIP: COVID-19 ACIP Vaccine Recommendations. Accessed at https://www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/covid-19.html

[4] CDC. COVID Data Tracker: COVID-19 Vaccinations in the United States. Accessed at https://covid.cdc.gov/covid-data-tracker/#vaccinations

prior to February 15, 2021, the total doses delivered was determined assuming a total of five doses per vial of the Pfizer-BioNTech vaccine; however, if a sixth dose was administered from a single vial, this dose would be included in the vaccine administration data. Therefore, it is possible to have a vaccine administration rate greater than 100%, as states may have been able to administer a greater number of doses than were initially calculated based on the number of vials distributed. Vials received on or after February 15, 2021 are assumed to contain six doses per vial; this is reflected in the number of received doses in the CDC's vaccine data.[5]

Total state population was estimated using the 2019 American Community Survey 1-year estimates. The populations currently eligible to receive a vaccine according to each state's distribution plans were identified from state websites and media sources.[6,7,8] The term "eligible" is used throughout this document to refer to the populations who were currently able to receive a vaccination under their state's distribution plan as of mid-February 2021. Because states did not consistently use the same nomenclature for their phases as in the CDC framework, these data were used to identify the approximately equivalent priority groups (i.e., frontline essential workers) and CDC phase for each state (Table 1). In some states, the current phase varied by county; in these cases, the county with the broadest eligibility criteria was considered to represent the statewide phase. The number of currently eligible residents in each state was estimated using Ariadne Lab's Vaccine Allocation Planner for COVID-19,[9] which estimates the approximate number of unique individuals in each of the priority groups identified by CDC. This tool uses a probability-based model to estimate the likelihood of an individual to be in multiple priority groups. Estimates of the total population size in the currently eligible populations in each state, minus the estimated number of individuals with overlapping membership in multiple groups, were manually downloaded from this tool for further analysis.

Information regarding state systems for vaccine registration and scheduling were obtained from state websites and media sources.[10] Attitudes regarding COVID-19 vaccines and reasons for COVID-19 vaccine hesitancy were obtained from the U.S. Census Bureau's Household Pulse Survey, Week 24 (February 3-February 15).[11]

Association between variables of interest was assessed using simple linear regression, with statistical significance considered to be $p < 0.05$.

RESULTS

Vaccine Prioritization Strategies

According to the CDC recommendations, healthcare workers and long-term care facility residents should be in the first wave of vaccinations (Table 1). The majority of states followed this approach for their initial vaccine doses. In the second phase of COVID-19 vaccinations, CDC recommends expanding vaccine eligibility to frontline essential workers, defined as shown in Table 1, and adults over the age of 75. At this stage, defined as

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[5] CDC. COVID Data Tracker: COVID-19 Vaccinations in the United States. Accessed at https://covid.cdc.gov/covid-data-tracker/#vaccinations

[6] Kaiser Family Foundation. State COVID-19 Vaccine Priority Populations. Accessed at https://www.kff.org/other/state-indicator/state-covid-19-vaccine-priority-populations/

[7] The Washington Post. Vaccine Tracker. Accessed at https://www.washingtonpost.com/graphics/2020/health/covid-vaccine-states-distribution-doses/

[8] The Wall Street Journal. How to Get a COVID-19 Vaccine: a State-by-State Guide. Accessed at https://www.wsj.com/articles/how-to-get-a-covid-19-vaccine-a-state-by-state-guide-11611703769

[9] Ariadne Labs. Vaccine Allocation Planner for COVID-19. Accessed at https://covid19vaccineallocation.org/

[10] The Wall Street Journal. How to Get a COVID-19 Vaccine: a State-by-State Guide. Accessed at https://www.wsj.com/articles/how-to-get-a-covid-19-vaccine-a-state-by-state-guide-11611703769

[11] U.S. Census Bureau. Week 24 Household Pulse Survey: February 3 – February 15. Accessed at https://www.census.gov/data/tables/2021/demo/hhp/hhp24.html

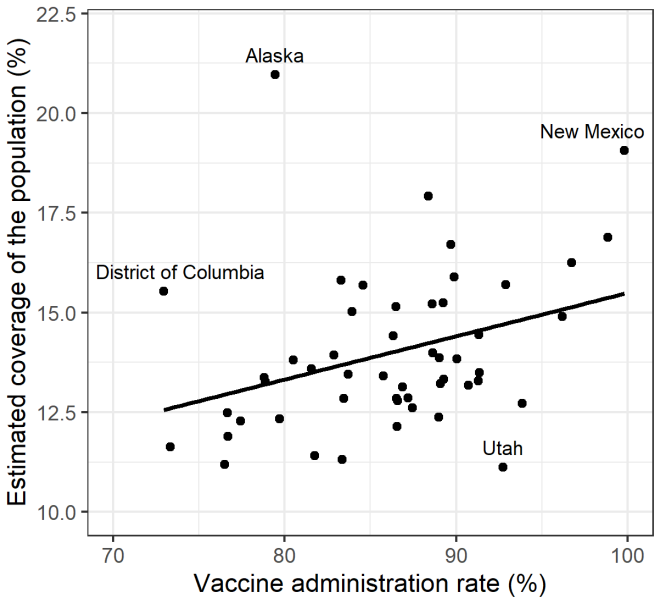
1b in the CDC recommendations, states began to significantly deviate. While some states have followed the definition of frontline essential workers provided by CDC,[12] other states have developed their own definition of frontline essential worker.

On January 12, 2021, then-Secretary of HHS Azar announced the recommendation to expand eligibility to include all adults over the age of 65 in phase 1b.[13] This expansion was intended to increase the number of vulnerable individuals eligible for vaccination, in response to rising death rates due to COVID-19 and early indicators that vaccine rollout was occurring too slowly. Many states have now done this, or have increased age-based eligibility stepwise by including an intermediate phase of adults aged 70 and over. However, other states have also included additional groups alongside essential workers and older adults in their currently eligible populations; for example, several states have included adults with comorbidities in their phase 1b. This patchwork of state policies has led to a significant state-to-state variation in vaccine eligibility. Using estimates from the Vaccine Allocation Planner for COVID-19,[14] the vaccine eligible population as of mid-February 2021 ranges from approximately 20% in Hawaii to over 60% in Missouri, Mississippi, and North Dakota.[15] These estimates assume that states have used the same definitions for each priority group as in the CDC recommendations; deviations from these recommendations may lead to under- or over-estimation of the number of people in each priority group.

Vaccine Administration Rates

As of February 22, 2021, the 50 states and D.C. had administered an average of 86.2% of their received vaccine doses. However, variability between states was considerable, with administration rates ranging from 72.9% (District of Columbia) to 99.8% (New Mexico). Similarly, the percent of the population having received at least one COVID-19 vaccine dose ranged from 11.1% (Utah) to 21.0% (Alaska). Since vaccines have been distributed to most states in proportion to state populations, population coverage is significantly related to the percent of doses that have been administered (Figure 1). One notable outlier is Alaska, which has launched a highly successful vaccination campaign.[16] Alaska's data on administration rates is not directly comparable to other states because it receives allocations monthly instead of weekly due to the unique challenges of

Figure 1: Vaccine coverage of the population versus vaccine administration rates.



Notes: The states with the highest and lowest values for each metric are labeled. Black line represents linear regression (slope = 1.04, R-squared = 0.11, p-value = 0.016).

[12] This definition of essential workers was informed by the U.S. Department of Homeland Security's Cybersecurity and Infrastructure Security Agency's (CISA): https://www.cisa.gov/publication/guidance-essential-critical-infrastructure-workforce

[13] The New York Times. States Told to Vaccinate Everyone 65 and Over as Deaths Surge. Accessed at https://www.nytimes.com/2021/01/12/us/politics/vaccine-states.html

[14] Ariadne Labs. Vaccine Allocation Planner for COVID-19. Accessed at https://covid19vaccineallocation.org/

[15] These estimates do not account for variable definitions of "frontline essential workers." In states that have expanded eligibility to those over the age of 70, only estimates for ages 75+ are included in these total estimates.

[16] Bloomberg. Icy, Remote Alaska Has an Edge in Covid Vaccination. Accessed at https://www.bloomberg.com/news/articles/2021-02-09/why-alaska-is-winning-the-covid-vaccine-race

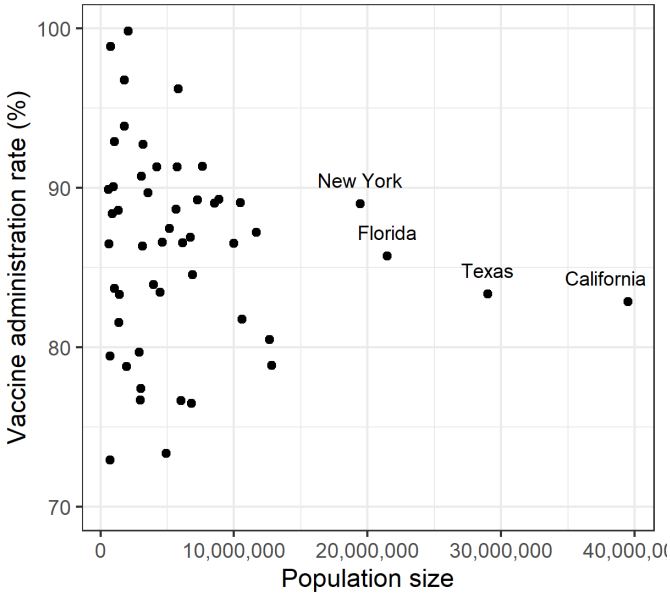
distributing vaccine in this remote state.[17] Estimates of vaccine coverage rates also do not account for individuals who are administered a vaccine in a different state than they live. Although vaccine coverage rates are a valuable metric to estimate the protected population, it is equally critical to understand factors that may influence the efficiency with which states are able to administer vaccine doses to patients. Therefore, this brief will focus on the efficiency of vaccine administration in terms of the proportion of received doses that have been administered to patients (vaccine administration rate).

Many hypotheses have emerged to explain differences in vaccine administration rates between states.[18,19] Potential predictors include state population size, size of the vaccine eligible population, centralization or decentralization of vaccine scheduling systems, vaccination site density, and local attitudes toward vaccines. The potential impact of each of these hypotheses on vaccine administration rates is discussed below.

State Population Size

Early observations of success in states such as West Virginia[20] and Alaska have raised questions of whether the logistics of vaccine rollout in more populous states may result in lower vaccine administration rate. However, when evaluating all states reporting data to the CDC, there is no statistically significant relationship between state population and administration rates (Figure 2). CDC-reported administration rates in the four most populous states, California, Texas, Florida, and New York, ranged from 82% to 89% and are similar to the average administration rate across all states.

Figure 2: Vaccine administration rate versus population size of each state.



Note: The four largest states are labeled.

Size of eligible population based on state's distribution plan

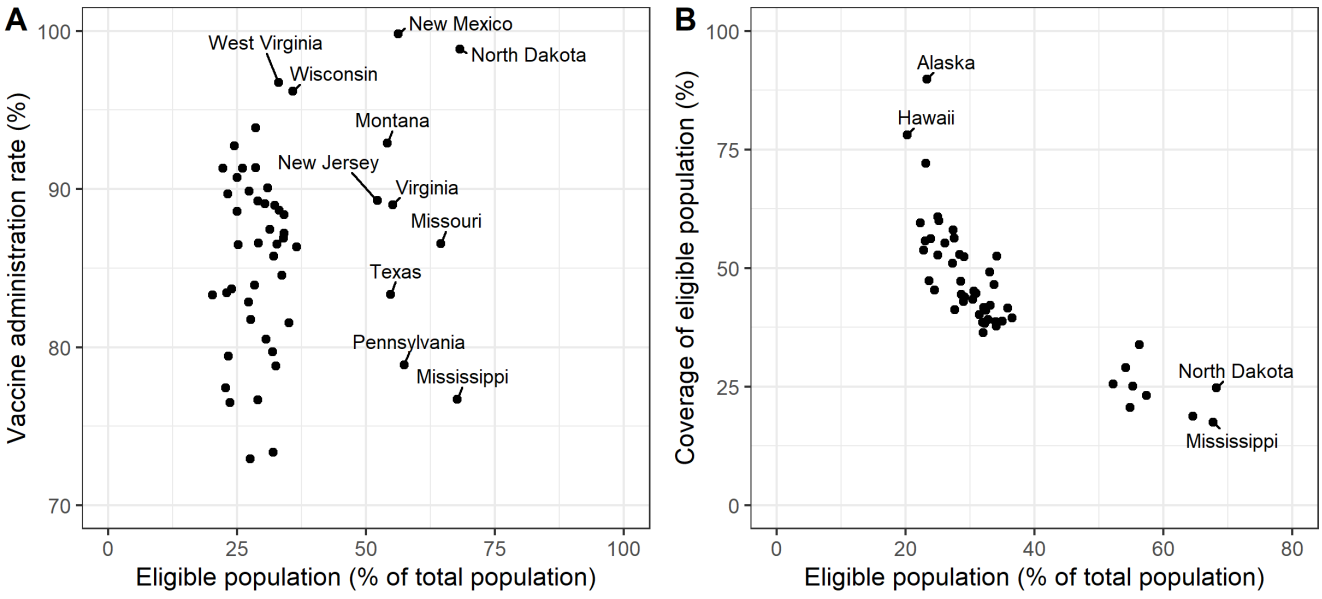
As described above, states vary considerably in the populations that are currently eligible to be vaccinated. In early phases of the rollout, some advocated for expanded eligibility to increase overall uptake and to prevent waste of doses. At present, there are nine states in which over half of the population is estimated to be eligible, due to the inclusion of adults with high-risk health conditions in their current phases (Figure 3A). Although two of the states (New Mexico and North Dakota) with the highest administration rates also have higher than average proportions of their population currently eligible, other states with a smaller eligible population have been similarly successful. Overall, there is

[17] Alaska also receives a "Sovereign Nation Supplement" for American Indian/Alaskan Native populations that elected to receive vaccines through the state instead of the Indian Health Service. See footnote 1 for a full list of states receiving this supplement.
[18] The Brookings Institution. The COVID-19 vaccine: What can states learn from each other? Accessed at https://www.brookings.edu/blog/fixgov/2021/02/19/the-covid-19-vaccine-what-can-states-learn-from-each-other/
[19] The Pew Charitable Trusts. These States Found the Secret to COVID-19 Vaccination Success. Accessed at https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2021/02/02/these-states-found-the-secret-to-covid-19-vaccination-success
[20] NPR. Why West Virginia's Winning the Race to Get COVID-19 Vaccine Into Arms. Accessed at https://www.npr.org/sections/health-shots/2021/01/07/954409347/why-west-virginias-winning-the-race-to-get-covid-19-vaccine-into-arms#

no relationship between the size of the eligible population and the efficiency with which doses are being administered. Therefore, it seems likely that expanding eligibility groups alone will not achieve higher administration rates.

Furthermore, by expanding eligibility to a larger swath of the general population, coverage of the highest priority groups is likely diluted (Figure 3B), and may compound the existing challenge of accessibility for vulnerable populations including the elderly, lower income, and minority populations. For example, 67.7% of the population is currently eligible to be administered a vaccine in Mississippi, but the state has not received enough vaccine to cover this population. Based on the current number of administered doses, only 17.6% of Mississippians in any currently eligible priority group are expected to have received one dose (7.2% with two doses). In contrast, in states that have restricted vaccine eligibility to smaller populations, generally including phase 1a, phase 1b, and adults over the age of 65, the coverage of these specific populations is much higher. A recent analysis of state-level vaccine coverage among adults over age 65 also found that Mississippi had a smaller increase in vaccine coverage of older adults (10% increase) during the month of February than other reporting states.[21] This may reflect the impact of competition for limited vaccine appointments when a large percentage of the population is eligible to be vaccinated. Thus, the impact of these distribution strategies on vaccination rates in vulnerable populations should be the focus of future work.

Figure 3: Vaccine administration rate (A) or estimated coverage of eligible population (B) versus the percent of the total population that is currently eligible to receive a vaccine.



Notes: States with an administration rate over 95% or an eligible population over 50% are labeled in (A). The two states with the highest coverage of their prioritized populations and the two states with the largest eligible population are labeled in (B). Linear regression on the data shown in (B) was statistically significant (slope = -0.93, R-squared = 0.66, p-value = 4.4e-13).

[21] The Kaiser Family Foundation. Vaccinating Older Adults in the US Against COVID-19: A Work in Progress. Accessed at https://www.kff.org/coronavirus-covid-19/issue-brief/vaccinating-older-adults-in-the-us-against-covid-19-a-work-in-progress/

Vaccine scheduling and registration approaches

States have differed significantly in the ways in which the general public must sign up to receive vaccine doses. Some states developed centralized systems for residents to register and ultimately schedule vaccination appointments in locations near them. Other states provide lists of vaccination sites or county websites, which in many cases provide multiple options for vaccination sites at hospitals, pharmacies, or health departments. The majority of states have taken a decentralized approach to vaccine registration and scheduling, but this strategy has received criticism due to the burden it places on residents to identify and navigate many scheduling platforms.[22] In addition, state approaches have varied in accessibility. Some states allowed residents to register either online or by phone, while others did not offer any phone-based registration. Some had no state-wide hotline at all. Notably, two of the states with the highest administration rates have centralized registration systems for state-run vaccination sites (West Virginia and New Mexico), but others with high administration rates, including North Dakota and Wisconsin, do not. West Virginia's centralized vaccine system, which allows all residents to preregister for a vaccine regardless of their prioritization phase, has been lauded as a model.[23] However, other states with centralized systems range in vaccine administration rates from 72% (District of Columbia) to 89% (Connecticut). Therefore, it seems that approaches for vaccine scheduling or registration alone cannot explain the observed variation in administration rates.

Vaccination site density and types

A recent analysis hypothesized that the number of vaccination sites may impact administration rates.[24] Although many states do not provide complete lists of vaccination sites in their states, researchers identified the number of vaccination sites in 39 states; however, they found no relationship between administration rates and vaccination sites per capita. This analysis did not account for the geographic distribution of vaccination sites within the state, which may impact administration rates if vaccination sites are clustered in urban areas or too spread apart in rural areas. At this time, there is no comprehensive database of vaccination sites in the U.S., but future work should evaluate this question.

Additionally, states have used different approaches in the types of vaccination sites available to its residents. West Virginia was the only state to opt out of a federal partnership with CVS and Walgreens, and instead used small, independent pharmacies who had established relationships with residents throughout the state.[25] This difference has been cited as a reason for West Virginia's success, particularly in vaccinating residents of long-term care facilities.[26] More populous states have opened multiple mass vaccination sites at fairgrounds, amusement parks, and stadiums. Health departments, retail pharmacies, and hospitals or clinics also make up a significant number of vaccination sites. It is possible that the types of sites being used, or the distribution of vaccine doses between site types, may further influence administration rates. However, these data are not available at this time.

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[22] The Washington Post. Coronavirus vaccine has arrived, but frustrated Americans are struggling to sign up. Accessed at https://www.washingtonpost.com/health/2021/01/02/coronavirus-vaccine-has-arrived-frustrated-americans-are-struggling-sign-up/

[23] The Brookings Institution. COVID-19 vaccinations: Why are some states and localities so much more successful? Accessed at https://www.brookings.edu/blog/fixgov/2021/01/25/covid-19-vaccinations-why-are-some-states-and-localities-so-much-more-successful/

[24] The Brookings Institution. The COVID-19 vaccine: What can states learn from each other? Accessed at https://www.brookings.edu/blog/fixgov/2021/02/19/the-covid-19-vaccine-what-can-states-learn-from-each-other/

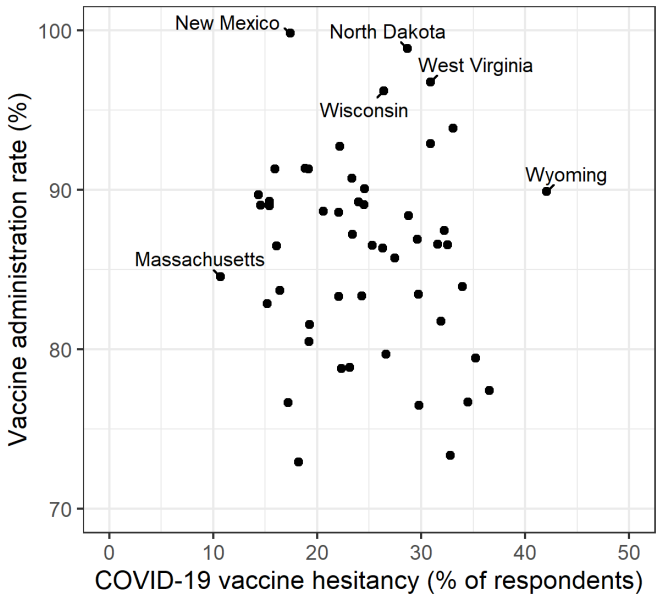
[25] NPR. Why West Virginia's Winning the Race to Get COVID-19 Vaccine Into Arms. Accessed at https://www.npr.org/sections/health-shots/2021/01/07/954409347/why-west-virginias-winning-the-race-to-get-covid-19-vaccine-into-arms#

[26] NPR. Why West Virginia's Winning the Race to Get COVID-19 Vaccine Into Arms. Accessed at https://www.npr.org/sections/health-shots/2021/01/07/954409347/why-west-virginias-winning-the-race-to-get-covid-19-vaccine-into-arms#

Attitudes toward COVID-19 vaccines and vaccine hesitancy

Finally, it is possible that underlying differences in vaccine attitudes, trust, and hesitancy might contribute to the observed variation in administration rates between states. The U.S. Census Bureau's Household Pulse Survey[27] provides estimates of general COVID-19 vaccine hesitancy in each state. When evaluating those respondents who indicate that they probably will not or definitely will not get a COVID-19 vaccine, there is considerable variation between states. However, there was no observed relationship between overall hesitancy to receive a COVID-19 vaccine and a state's administration rates. Remarkably, even some states with high rates of COVID-19 vaccine hesitancy have high administration rates (Figure 4). This is encouraging given that a recent survey found that knowing someone who has been vaccinated for COVID-19 is correlated with vaccine enthusiasm[28] – thus, simply achieving higher coverage of the population may help to encourage hesitant individuals to be vaccinated. It will be important to continue monitoring this relationship as vaccine coverage of the population increases – given that the average vaccine coverage is less than 20%, vaccine hesitancy may not currently impact vaccine administration rates, but may begin to do so in the future.

Figure 4: Vaccine administration rate versus COVID-19 vaccine hesitancy as measured in the Household Pulse Survey.



Notes: COVID-19 vaccine hesitancy is defined in this plot as the percentage of respondents in each state who indicated that they probably will not receive the COVID-19 vaccine.

Additionally, the Household Pulse Survey includes a number of questions that may reflect an individual's hesitancy to be vaccinated. These include concerns about side effects, vaccine efficacy, perceived need of vaccination, dislike of vaccinations, doctor recommendations, a desire to wait and see or belief that others need the vaccine first, concerns about cost, lack of trust in COVID-19 vaccines or the government in general. Respondents could select multiple reasons for hesitancy to receive a COVID-19 vaccine. None of these hesitancy factors were robustly related to administration rates; however, these surveys do suggest that hesitancy may play a role in administration rates in specific states. The District of Columbia, which at the time of this data collection had the lowest administration rate in the country, is a marked outlier in the percentage of respondents who are hesitant because they do not know if a vaccine will work (31.6% compared to the national mean of 20.8%) and because their doctor has not recommended it (17.3% compared to the national mean of 6.6%). The landscape of COVID-19 vaccine hesitancy may differ from state to state due to differing cultural backgrounds, education, or other factors. Vaccine hesitancy may also vary by more localized geographic areas within states, which would mask overall state trends. Therefore, evaluating the elements of COVID-19 vaccine hesitancy in specific states may be necessary to fully understand state-to-state differences in vaccine hesitancy and any potential influence this may have on vaccine administration rates.

[27] This analysis used data from the U.S. Census Bureau's Household Pulse Survey Week 24 (February 3-15): https://www.census.gov/data/tables/2021/demo/hhp/hhp24.html

[28] Kaiser Family Foundation. KFF COVID-19 Vaccine Monitor: January 2021. Accessed at https://www.kff.org/report-section/kff-covid-19-vaccine-monitor-january-2021-vaccine-hesitancy/

DATA LIMITATIONS

The analysis in this brief is subject to several data limitations. As noted in the Methods, reported vaccine administration rates may lag behind actual administration rates due to differing reporting schedules between jurisdictions. Additionally, the use of the sixth dose in vials of the Pfizer-BioNTech COVID-19 vaccine may artificially inflate historical vaccine administration data. If some states used these extra doses more than others, this might result in inaccurate comparisons of vaccine administration rates; however, data on the use of these extra doses by jurisdiction is not currently available.

Estimates of the population that is currently eligible to be vaccinated in each state may be impacted by variable definitions of each category, particularly each state's definition of essential workers. Additionally, in some states, counties can decide when to expand eligibility to the next priority group independent of statewide decision-making. County-level estimates of each priority group are not currently available; therefore, estimates of the currently eligible population may be less accurate in states with county-level variation in vaccine distribution strategies.

Finally, this issue brief does not address challenges states may have experienced in anticipating the quantity of vaccine to be delivered. Early on, a number of states reported having to cancel vaccine appointments due to receiving fewer vaccine doses than expected.[29] This may have had negative effects on vaccine administration rates by hindering planning efforts, decreasing public confidence in the vaccine scheduling system, or by causing states to hold back doses to ensure sufficient supply for already-vaccinated individuals to receive their second dose. The impact of these challenges on vaccine administration rates should be evaluated in future work.

CONCLUSION

With COVID-19 vaccines in limited supply, ensuring effective and timely administration of vaccines is essential to maximize the number of people protected. As of mid-February 2021, coverage of state populations ranged from 11% to 21% with administration rates ranging from 72% to nearly 100%. Although various factors have been hypothesized to drive the observed variation in administration rates, no clear patterns emerged when evaluating data from all 50 states and the District of Columbia. Importantly, expanding eligibility criteria to a larger proportion of the population was not significantly related to higher administration rates, and as long as vaccine supply is limited, is associated with lower coverage of the highest priority populations. Finally, while general COVID-19 vaccine hesitancy was not related to administration rates, it is possible that states are experiencing different hesitancy-related factors or localized differences in COVID-19 vaccine hesitancy that may contribute to their overall vaccine administration rates. Future work should evaluate the impact of outreach strategies from successful states, including use of social media and community partners, on combating vaccine hesitancy and increasing rates of vaccination.

[29] AP News. States report vaccine shortages and cancel appointments. Accessed at https://apnews.com/article/coronavirus-vaccine-update-f1b8967b6a077d89d21134f4eac069f6

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