2020

Equitable Allocation of COVID-19 Vaccines: An Analysis of the Initial Allocation Plans of CDC's Jurisdictions with Implications for Disparate Impact Monitoring

Harald Schmidt
University of Pennsylvania

Rebecca Weintraub
Brigham and Women's Hospital; Harvard T.H. Chan School of Public Health

Michelle A. Williams
Harvard T.H. Chan School of Public Health, Harvard University

Alison Buttenheim
School of Nursing, University of Pennsylvania

Emily Sadecki
University of Pennsylvania

See next page for additional authors

Equitable allocation of Covid-19 vaccines: an analysis of the initial allocation plans of CDC's jurisdictions with implications for disparate impact monitoring

Harald Schmidt, PhD,[1]* Rebecca Weintraub, MD[2]* Michelle A. Williams, ScD[3] Alison Buttenheim,[4] Emily Sadecki, MD (cand.). MBE(cand.)[5] Helen Wu BA(cand.),[6] Aditi Doiphode (cand.),[6] Lawrence O. Gostin, JD[7#] Angela A. Shen, ScD, MPH[8#]

[1]Department of Medical Ethics and Health Policy, Center for Health Incentives and Behavioral Economics, Leonard Davis Institute of Health Economics, University of Pennsylvania
[2]Ariadne Labs, Brigham and Women's Hospital & Harvard T.H. Chan School of Public Health
[3]Harvard T.H. Chan School of Public Health, Harvard University, Boston, Massachusetts
[4]Department of Family and Community Health, School of Nursing; Center for Health Incentives and Behavioral Economics; Leonard Davis Institute of Health Economics, University of
[5]Department of Medical Ethics and Health Policy, University of Pennsylvania
[6]School of Arts and Sciences, University of Pennsylvania
[7]O'Neill Institute for National & Global Health Law, Georgetown University, Washington, DC
[8]Vaccine Education Center, Children's Hospital of Philadelphia
*Co-first-authors, #Co-senior-authors

- Abstract-

Major global and national vaccine allocation guidelines urge planners to allocate vaccines in ways that recognize, and ideally reduce, existing societal inequities within countries. However, allocation plans of the US will be determined individually by each of the CDC's 64 jurisdictions (states, the District of Columbia, five cities, and territories). We analyzed whether jurisdictions have incorporated novel approaches to reduce inequity, based on plans published by the CDC in early November 2020 (63 summaries [98% of all jurisdictions] and 47 full guidance documents [73% of all, including all 50 states]).

Eighteen states adopted a novel proposal to use a disadvantage index to allocate vaccines more equitably, for five types of equity goals: 1) to prioritize disadvantaged groups directly, 2) to define priority groups in phased systems, 3) to plan tailored outreach and communication, 4) to plan the location of dispensing sites and 5) to monitor uptake. Yet just over a third of all states, and only half of the 16 states with the largest shares of disadvantaged populations—where reducing inequity would be most urgent—pursue such goals.

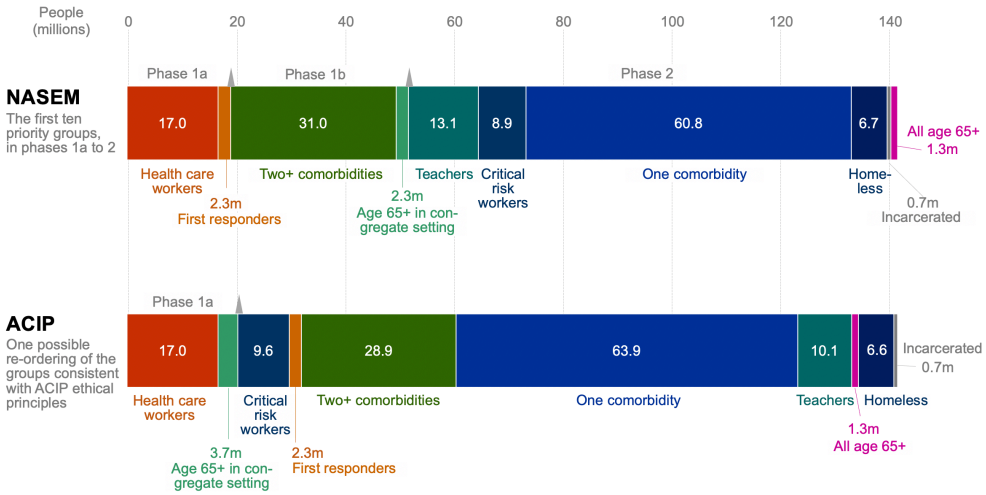
While allocation frameworks are still evolving, the plans we analyzed mark important historical and practical benchmarks, and could become firm policy when COVID-19 vaccines are authorized and delivered. Vaccine roll-out poses unprecedented logistical and practical challenges. To minimize the risk that ethics and social justice falls by the wayside in the busy months to come, planners at the federal, state and local levels should carefully consider on what grounds they decline to adopt equity measures that other planners deem important and feasible for defining priority populations, designing allocation quotas, and just as critical, enabling, and monitoring, uptake.

Introduction

When a Covind-19 vaccine becomes available, all nations will face scarcity for months, with greatest scarcity in lower-income countries. In the United States, recommendations from the Centers for Disease Control and Prevention's (CDC) Advisory Committee on Immunization Practice (ACIP) will formally guide which population groups should receive safe and effective Covid-19 vaccines. However, allocations will ultimately be determined by the CDC's 64 immunization grantees (comprising 50 states, the District of Columbia, 5 large cities, and 8 territories: referred to below collectively as jurisdictions). The CDC requested its jurisdictions to provide their plans by October 31, and it posted 63 summaries on November 8.[1] We analyzed these plans in short- and long-form to understand to what extent they reflected important commitments to allocate vaccines in ways that reduce inequities and promote social justice.

Covid-19 vaccine allocation relates to two main processes, providing available doses to jurisdictions according to their population or some other metric,[2] and then, within jurisdictions, to specific populations in meaningful sequence. Allocation frameworks seek to integrate a multitude of factors, such as saving the most lives and limiting the spread of infections, and are typically risk-based. Figure 1 shows how the ACIP's plan (including vote Dec 1, 2020 on phase 1a) compares to one proposed earlier by the National Academies of Science, Engineering and Medicine (NASEM),[3] a group tasked by the Centers of Disease Control and Prevention and the National Institutes of Health with assisting ACIP to develop equitable allocation guidance.

Figure 1: Priority groups under NASEM and ACIP frameworks
First144m people in the first 10 NASEM priority groups, accounting for overlap (note: ACIP framework still evolving, showing 1/multiple options. Depiction: Ariadne Labs)



Planning allocation across and within states presents unprecedented challenges and requires strong vaccine infrastructure, including human resources and data systems. In addition to a significant number of unknowns regarding the characteristics of vaccines, such as their longer-term effectiveness; capacity to prevent transmission as opposed to mainly preventing disease; and adverse-effect profiles, there are complex logistics centered around shipping and distribution; establishing handling and storage protocols; and ensuring administration and verification of follow-up second doses (where required) and overall vaccine coverage. Countless tradeoffs will likely need to be made among higher level aspirations regarding efficiency and equity, real-world logistical and pragmatic constraints, and established pathways in which federal, state and local health departments operate.[4] In the overall rush to control the pandemic, implementation can be as important as a vaccines' efficacy.[5] Even the most effective vaccines cannot curb SARS-CoV-2 unless a sizable portion of the population is immunized, estimated at over 90 percent. A central question is to what extent potentially frantic implementation will align—or stand in conflict—with commitments to mitigate existing societal inequities, particularly those affecting economically worse-off racial and ethnic minorities.

ACIP's overarching ethical values for allocating initial supplies of Covid-19 vaccines note that allocation strategies "should aim to both reduce existing disparities and to not create new disparities".[6] The latter statement echoes a similar one from an earlier publication of ACIP'S scientific and ethical principles, which explained that to "address the disproportionate burden of COVID-19 disease in some racial/ethnic minority groups […] strategies for implementation [should] reduce, rather than increase, health disparities in each phase of vaccine distribution".[7] This emphasis is also found in early academic commentary on the subject[8] and influential high-level policy advice by the NASEM,[3] as well as of the World Health Organization's WHO Strategic Advisory Group of Experts on immunization (SAGE).[9]

As figure 1 shows, to some extent, risk-based allocation frameworks such as the one proposed by NASEM or ACIP already address inequities by, for example, proposing to offer vaccines to people with multiple co-morbidities before otherwise healthy people. Due to the social determinants of health, economically worse-off populations are generally less healthy.[10-12] Therefore, a risk-based approach will allocate more vaccine sooner to economically worse-off populations. Likewise, since an implication of structural racism is that minorities face reduced economic mobility and account for larger shares of the economically worse-off,[13-15] such an

approach suggests that minority populations would be offered vaccines sooner. Similarly, offering vaccines to essential workers earlier can have this consequence, as minorities comprise a larger share of this workforce.[3,6]

Importantly, however, NASEM also recommended the use of an additional measure. Within each phase of allocation, and in "each population group, vaccine access should be prioritized for geographic areas identified through CDC's Social Vulnerability Index [SVI] or another more specific index."[2] An index such as SVI is tied to a geographic area, down to the level of neighborhoods, and captures their relative average advantage and disadvantage through a set of variables that go beyond income alone, and integrate, for example, educational attainment and housing quality[16] (and in the case of SVI also explicitly race and ethnicity).[17] Such indices can therefore capture population groups for whom the protection offered by vaccines is both more necessary and more valuable, as they are typically more dependent on regular income, less able to socially distance, and more likely to contract and spread the infection. In addition to public health and economic considerations, disadvantage indices matters ethically, and can promote restorative justice.[8,14,18] The NASEM notes that measures such as the SVI incorporate "the variables that the committee believes are most linked to the disproportionate impact of COVID-19 on people of color and other vulnerable populations." Concretely, the NASEM recommends setting aside 10% of federally available vaccines to be added to the allocations that worse-off groups would otherwise be offered, proportionate to population,[19] under its risk-based framework. Complementing this effort, jurisdictions should furthermore "ensure that special efforts are made to deliver vaccine to residents of high-vulnerability areas (defined as the 25 percent highest in the state)."[3] CDC staffers noted that the SVI could be integrated into Tiberius, a newly developed software system intended to assist states with vaccine allocation.[16] To ascertain the extent to which emerging allocation guidance incorporates statistical measures of disadvantage to reduce inequities, we therefore analyzed jurisdictions' initial frameworks.

Methods

We obtained summaries of all jurisdictions' allocation plans published by November 8 on the CDC's dedicated website.[1] Where a document linked to full guidance, we included it in the analysis, and additionally obtained full plans by searching jurisdictions' health department

websites (Nov 7-14; archived copies available from the authors). Plans were analyzed using a seven-item extraction tool (see Appendix 1) conceptualized by HS, MAW and LG and refined in discussion with AS and RW, eliciting:

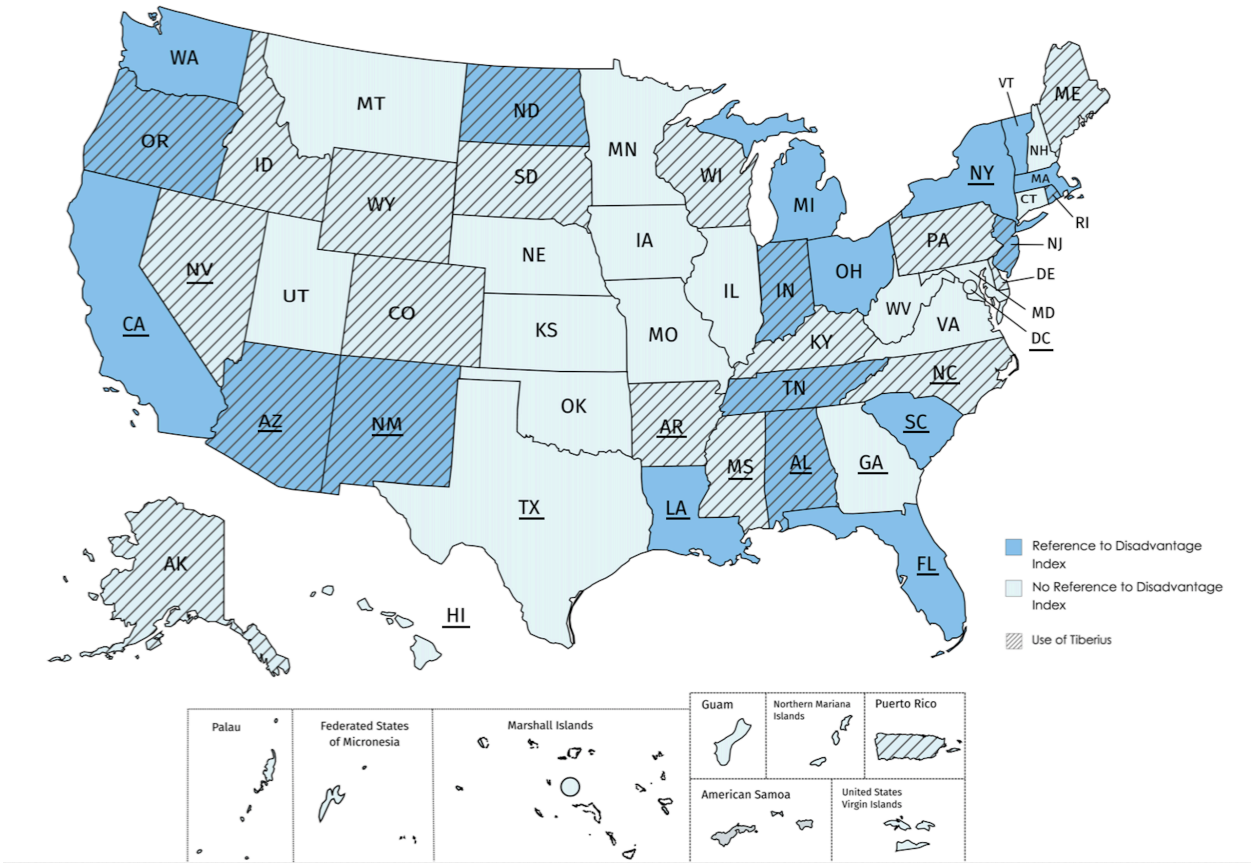
1. Whether jurisdictions intended to use an index of disadvantage for prioritization of worse-off population groups or other purposes;
2. Insofar as prioritization of worse-off is planned, what share of what population should be prioritized, and to what extent;
3. Whether plans envisaged the use of the newly developed Tiberius platform.

Two authors (AD and HW) each analyzed and tabulated half of all plans, and another (ES) verified all data entry. HS, ES, HW, and AD resolved any differences in data capture, which were marginal, given the simplicity of the extraction tool.

Results

We obtained a total of 63 summaries (98.4% of all jurisdictions) and 47 full guidance documents (73.4% of all jurisdictions, including all states). Table 1 and Figure 2 summarize the findings. Eighteen jurisdictions (all states, none are cities) refer to the SVI; California developed its own metric. A range of distinct uses of disadvantage measures emerged from the data, which we describe in more detail below. Twenty-four jurisdictions plan on using Tiberius (which may include prioritized allocations to worse-off areas, as captured by the SVI), including 15 that do not otherwise indicate that they intend to use SVI for other purposes that might benefit worse-off groups more.

Figure 2: Jurisdictions' use of statistical measures of disadvantage for prioritizing vaccine allocation, use of Tiberius allocation software system – geographical depiction



Note: In states shown in bold, more than 25% of the population are in the US' worse-off quartile, as measured on the SVI applied nationally. See Appendix 2.

Table 1: Jurisdictions' use of statistical measures of disadvantage for prioritizing vaccine allocation, use of Tiberius allocation software system

	Reference to Disadvantage Index			Use of Disadvantage Index for…					Use of Tiberius	
	Social Vulnerability Index (SVI)	Other	None	prioritizing worse-off using SVI	defining priority groups, possibly also prioritizing groups	planning outreach/ communication to ensure uptake (during scarcity or after)	planning dispensing sites	monitoring uptake	Yes	No
States (50)	18 (**AL**, **AZ**, **FL**, IN, **LA**, MA, MI, NJ, **NM**, **NY**, ND, OH, OR, RI, **SC**, TN, VT, WA)	1 (**CA**)	31 (**AR**, AK, CO, CT, DE, **GA**, **HI**, ID, IL, IA, KS, KY, MD, ME, MN, MO, **MS**, MT, NE, **NV**, NH, **NC**, OK, PA, SD, **TX**, UT, VA, WI, WV, WY)	7 (**CA**, IN, **LA**, MI, ND, OH, TN)	10 (**AL**, **FL**, MA, **NM**, **NY**, OR, RI, **SC**, VT, WA)	3 (**AZ**, VT, WA)	1 (NJ)	1 (OH)	23 (**AL**, AK, **AZ**, **AR**, CO, DE, ID, IN, KY, ME, **MS**, **NV**, NJ, **NM**, **NC**, ND, OR, PA, RI, SD, TN, WI, WY	27 (**CA**, CT, **FL**, **GA**, **HI**, IL, IA, KS, **LA**, MD, MA, MI, MN, MO, MT, NE, NH, **NY**, OH, OK, **SC**, **TX**, UT, VT, VA, WA, WV)
DC + Cities (6)	0	0	6 (**DC**, Chicago Houston, NYC, Philadelphia, San Antonio)	0	0	0	0	0	0	6 (**DC**, Chicago, San Antonio, Houston, NYC, Philadelphia)
Territories (7)	0	0	7 (Guam, Marshall Isl., Micronesia, N. Mariana Isl., Palau, Puerto Rico, US Virgin Isl.)	0	0	0	0	0	1 (Puerto Rico)	6 (Guam, Marshall Isl., Micronesia, N. Mariana Isl., Palau, US Virgin Islands)

Note: In states shown in bold, more than 25% of the population are in the US' worse-off quartile, as measured on the SVI applied nationally. See Appendix 2.

Among the 18 states that refer to the SVI, five different purposes can be distinguished (some jurisdictions indicate the intention to pursue more than a single goal; see Table 2 for an overview, and Appendix 1 for the full extracted data for further context).

In direct alignment with NASEM's recommendation, seven states indicate expressly that measures of disadvantage can help address social injustice in allocation planning (CA, IN, ND, NY, OH, VT, TN). The most specific articulation is found in Tennessee, which mirrors NASEM's approach at the state level and proposes to reserve 10% of its allocation for high SVI areas. Eighty-five percent would be allocated to counties by population, and 5% "equitably."

Ten states plan to use the SVI to identify priority populations (AL, FL, MA, NM, NY, OR, RI, SC, VT, WA). North Dakota contemplates using the SVI for a particular population group (to "ensure equity in the number of doses Tribal healthcare providers receive"), and NY notes the goal of identifying "which geographic areas of the state may derive a greater public health benefit to receiving early vaccine. This may include areas with higher historical burden of disease or areas that have the highest prevalence of COVID-19."

Four states (AZ, NJ, VT, WA) plan to use the SVI for purposes distinct from identifying priority groups, or determining the quantity of vaccines offered to a group. These states note the SVI's utility for promoting uptake, for example, planning locations of dispensing sites (NJ) or outreach or communication strategies (AZ, VT, WA).

Finally, Ohio intends to use the SVI "both a priori when deciding geographic distribution of vaccines, and post-hoc to ensure that state's goals to protect the most-at-risk and vulnerable Ohioans are upheld."

Table 2: Central verbatim sections illuminating states' approach to drawing on statistical measures of disadvantage in allocating vaccines in situations of scarcity and non-scarcity (Note: regular font indicates that the text comes from the summary provided to CDC, italics that the text is found in the states' full guidance)	
Prioritize worse off using SVI	
CA	Identifying populations and communities that have been disproportionately impacted by COVID-19 and has developed a health equity metric to help guide continuing efforts to address disparities. *The equity metric is designed to reduce cases in the most disproportionately impacted communities, as defined by the census tracts in the lowest quartile of the Healthy Places Index within larger counties, and as defined by population and geography by the local health departments in smaller counties (where census tracts cannot be used).*
IN	*The CDC Social Vulnerability Index will be reviewed during the allocation process and applied if there is a limited vaccine during this phase. A document that identifies the SVI and estimated counts for comorbid conditions per county will assist in targeted allocation, distribution, and communication during this phase. Counties with higher SVIs may receive an increased allocation per population.*
LA	*In each population group, OPH will use CDC's Social Vulnerability Index (SVI) or another more specific index, as needed to prioritize for geographical areas for vaccine access.*
MI	MDHHS Division of Immunization will initially allocate COVID19 vaccine to hospitals and health systems and Local Health Departments (LHD) that can manage a large allocation of Vaccine A for administration to health care providers. Thereafter, allocations will be made to each of the health jurisdictions within Michigan for prioritization to community providers who have the ability to vaccinate the priority groups. Allocations are determined based on several factors including the social vulnerability index and population. *After initial allocations to hospitals, allocations will be made to each of the 45 health jurisdictions based on several factors including the social vulnerability index and population. LHDs will then use the relationships they have built with the community to allocate out additional amounts of vaccine to the providers in their community who are able to reach the vulnerable populations.*
ND	*The ND Advisory Committee on COVID-19 Vaccine Ethics may choose to utilize CDC's vulnerability index when allocating vaccine, which may ensure equity in the number of doses Tribal healthcare providers receive.*
OH	*In addition, vaccine administration will be assessed using the CDC's Social Vulnerability Index both a priori when deciding geographic distribution of vaccines and post-hoc to ensure that state's goals to protect the most-at-risk and vulnerable Ohioans are upheld.*
TN	*After careful review of the CDC Playbook and the National Academies' of Sciences, Engineering and Medicine's Framework for Equitable Allocation of COVID-19 Vaccine and discussion with the Stakeholder Group, TDH leadership, and the Unified Command Group, the following structure has been adopted for the allocation and prioritization of COVID-19 vaccines:* *Allocation:* • *Ten percent of the State's allocation of COVID-19 vaccines will be reserved by the State for use in targeted areas with high Social Vulnerability Index (SVI) values.* • *Five percent of the State's allocation of COVID-19 vaccines will be distributed equitably among all 95 counties.* • *Eighty-five percent of the State's allocation of COVID-19 vaccines will be distributed among all 95 counties based upon their populations.*
Define priority groups, possibly also prioritize	
AL	The Data Group will use all the available databases used for COVID-19 surveillance (including the Social Vulnerabilities Index), and CDC provided databases to identify, estimate the numbers, and where they are located.
FL	The Department's Office of Minority Health and Health Equity has been engaged in vaccination planning and existing networks and data will be utilized to inform these efforts. Social vulnerability indexes are available in GIS platforms and communities with health disparities have been identified
MA	…will identify and prioritize critical populations for vaccination following federal guidance . . *In addition, The Office of Population Health (OPH) manages the contract with Boston University School of Public Health (BUSPH) for Social Vulnerability Index (SVI) analysis and related mapping support. Within OPH, the Office of Health Equity (OHE) works to address social determinants so all Massachusetts residents can attain their full health potential. […]using the CDC's Social Vulnerability Index to assess the interaction of these forces [occupation, housing type, school enrollment, race/ethnicity, primary language, health care access, co-morbidities, socioeconomic factors] on the likelihood members of critical populations will accept, seek, and be able to access COVID-19 vaccine.* *Working with our collaborative Social Vulnerability Index (SVI) analytic and mapping partner, the Boston University School of Public Health, maintain superior ability to map these workforce resources at a granular level to inform planning.*
NM	NMDOH will also use numerous data sources, including the CDC's Social Vulnerability Index to identify populations at highest risk.

NY	*Once the vaccine is first approved for use, New York State will use up-to-date data to determine which geographic areas of the state may derive a greater public health benefit to receiving early vaccine. This may include areas with higher historical burden of disease or areas that have the highest prevalence of COVID-19. In addition, individual factors for hospitals and nursing homes will be considered including cases per facility in prior 14 days, and vulnerability index of population served. New York will also consider whether the vaccine can be used effectively as a potential outbreak interruption strategy and if so, what the criteria will be.*
OR	*Options for mapping population data (including Tiberius, Tableau and ArcGIS) are actively being explored in conjunction with mapping of CDC's Social Vulnerability Index (SVI) to identify overlap and potential areas of greatest need.*
RI	*The MV Workgroup will leverage a range of data sources to estimate numbers of critical populations …. Data sources consulted in the process of quantifying and locating members of critical populations include (though are not limited to):* - *Federal agency data to CMS; - CDC - Social Vulnerability Index*
SC	*DHEC is closely monitoring guidance put forth by the CDC's Advisory Committee on Immunization Practices (ACIP), the National Institutes of Health, and the National Academies of Sciences, Engineering, and Medicine (NASEM) regarding identified populations of focus for COVID-19 vaccination. Other resources include:* • *CDC's Social Vulnerability Index, which accounts for natural and human-caused disasters and disease outbreaks.*
VT	The Immunization Program will work closely with all COVID-19 vaccination providers and target settings to ensure equitable access to the COVID-19 vaccine. Vaccine allocation will be based on population data, with attention to critical populations. Vaccine administration data from the Immunization Registry will be monitored and reviewed by geographic location. Vaccine doses administered by enrolled sites will also be monitored and redistribution will be required. The Immunization Program is collaborating with the Health Operations Center's Health Equity and Community Engagement Team to ensure access for people who are disproportionately affected by COVID-19, including Black, Indigenous and people of color. GIS mapping and Social Vulnerability Indices will be employed to identify areas with limited access and direct distribution efforts.
WA	The use of social vulnerability indexes and maps will also inform how critical populations and sub-populations can be reached equitably and will inform allocation decisions under supply constraints. We will use tools such as Washington Tracking Network Information and CDC Social Vulnerability Index to identify Census tracts in Washington that have higher health inequities overall and to map other relevant social determinants of health, such as overcrowded housing, poverty, disability, or health insurance coverage.
Plan outreach/communication to ensure uptake (during scarcity or after)	
AZ	…allocate vaccine for higher-risk individuals, health care professionals, and other essential workers as recommended by VAPAC. There may be areas with limited providers, a high social vulnerability index (SVI), vaccine hesitancy or other factors that lead to lower vaccine uptake. In these areas, ADHS plans to work with local partners to develop targeted messaging and mobile POD vaccination strategies to encourage vaccination *…ADHS will utilize the SVI to identify communities that may need enhanced support before, during and after disasters.*
VT	The Immunization Program will work closely with all COVID-19 vaccination providers and target settings to ensure equitable access to the COVID-19 vaccine. Vaccine allocation will be based on population data, with attention to critical populations. Vaccine administration data from the Immunization Registry will be monitored and reviewed by geographic location. Vaccine doses administered by enrolled sites will also be monitored and redistribution will be required. The Immunization Program is collaborating with the Health Operations Center's Health Equity and Community Engagement Team to ensure access for people who are disproportionately affected by COVID-19, including Black, Indigenous and people of color. GIS mapping and Social Vulnerability Indices will be employed to identify areas with limited access and direct distribution efforts.
WA	*The use of social vulnerability indexes and maps will also inform how critical populations and sub-populations can be reached equitably and will inform allocation decisions under supply constraints. We will use tools such as Washington Tracking Network Information and CDC Social Vulnerability Index to identify Census tracts in Washington that have higher health inequities overall and to map other relevant social determinants of health, such as overcrowded housing, poverty, disability, or health insurance coverage.*
Plan dispensing sites	
NJ	*Social Vulnerability Index (SVI)[3] review to determine location of PODS [points of dispensing]*
Monitor uptake	
OH	*In addition, vaccine administration will be assessed using the CDC's Social Vulnerability Index both a priori when deciding geographic distribution of vaccines and post-hoc to ensure that state's goals to protect the most-at-risk and vulnerable Ohioans are upheld.*

Limitations and Discussion

Jurisdictions were asked to publish allocation plans under an extremely tight schedule with just 30 days between the official request and the deadline. While 63 provided summaries at the time of CDC's publication, and fuller allocations plans were available for all states, they were not available concurrently for 16 jurisdictions. Many aspects regarding implementation that affect these plans, such as cold-storage needs, are only now becoming concrete, as the Food and Drug Administration determines which vaccines to authorize.[5] In this sense, currently available plans offer only a snap-shot of evolving guidance. Moreover, using a statistical measure of disadvantage is not the only way of reducing disparities, and not every intended use might have been noted in the initial allocation plans. At the same time, the NASEM's recommendation that such a measure is called for to address Covid-19's unjust impact—and that it should be used in addition to a risk-based framework with specific phases and specific subpopulations—was patently clear. Likewise, every jurisdiction planner was likely aware of the vastly disparate Covid-19 impacts across racial and ethnic groups, in terms of unemployment, hospitalizations and deaths,[18,20] and the concurrent national reckoning with racial justice, which also prompted the NASEM's proposal. In this regard, the initial plans also represent an important historical benchmark, offering practical templates as well as a baseline measure of how pressing the need to reduce inequities and promote social justice is perceived to be, in relation to other important priorities.

Four main themes emerged from the findings: a) variation in the adoption of SVI and related measures, b) the degree of clarity about the likely impact of such measures on different dimensions of disparities, c) plans for the uptake of the Tiberius software, and d) the importance of disparate impact monitoring.

A little over a third of states engaged directly with the novel proposal to utilize statistical measures of disadvantage to address social justice. Among the 16 states that have more than 25% of their population falling under the worst-off SVI quartile nationwide (see Appendix 2), half (n=8) plan on using the SVI: two with the goal of directly prioritizing worse-off groups (CA, LA), five to capture priority populations (and possibly prioritize further; AL, FL, NM, NY, SC), and one to draw on SVI for designing outreach/communication strategies once scarcity ends (AZ). Among the six jurisdictions with more than 30% worse-off (NM, DC, CA, NY, MS, TX), only two (CA, NY) plan on using the SVI, and four signal no such express intention at this point.

To reiterate, the use of a disadvantage index is not the only way in which equity could be addressed. We do not mean to suggest that the data presented here necessarily cast doubt on the commitments to equitable vaccine allocation of jurisdictions that currently do not indicate using such an index. But scrutiny of their efforts to explore—and more importantly implement and monitor—ways of allocating vaccines in ways that reduce inequities will likely increase. Note, for example, that even if all states were to set aside a 10% reserve of their allotted vaccines as additional amounts for those in the worst-off quartiles, under the NASEM framework, worse-off minorities would be offered vaccines below their population share until the beginning of phase 3, with the exception of the very first phase (see figure 1, Appendix 2, analogous simulation for the final ACIP framework ongoing).[2]

The extent to which a disadvantage index will directly shape social justice-based prioritization is essential to understand even if at this point it is somewhat unclear. However, the state of Tennessee stands out in its clarity regarding the planned increases in the numbers of courses reserved for worse-off groups. The state proposes to reserve 10% of its allocation for high SVI areas (in addition to what these areas would receive based on population), although it would still need to be specified what population segment would be offered the extra doses—given the direct alignment with the NASEM's overall recommendation, likely the state's worst-off quartile (alternatively, a more continuous approach could avoid inequities between, for example two census tracts that are marginally below and marginally above the 25% threshold). Tennessee also highlights the need to address intra-state variations by allocating 85% proportionate to population, but reserving a further 5% "equitably" (which, presumably, would be based on a measure like SVI, poverty measures, or another standard that operationalizes a sense of need).

An important use of the SVI relates to the expression among vaccine workers that "Vaccines don't save lives. Vaccinations save lives."[21] In the present context, this means that grouping worse-off populations in higher priority groups, or setting aside larger shares of vaccines alone, can be meaningless for reducing inequity if these steps are not matched with genuine efforts to ensure populations are also willing and able to accept vaccines. Outreach and effective communication are even more crucial if states make no additional efforts at prioritizing worse-off groups across phases or through larger allocated amounts. Yet, currently, only 4 states (AZ, NJ, VT, WA) describe that they plan to use the SVI for planning the location of dispensing sites, or communication and outreach efforts. None of the states with more than 30% of its population

falling under the nationally worst-off quartile plan such uses, and only one the 16 states with more than 25% worse-off does so (AZ; while the state recognizes the SVI's utility in this regard, it currently indicates no plans to use it for any other purpose).

Using a rigorous measure of disadvantage for promoting uptake is of great importance in view of the overall policy that jurisdictions will only receive new vaccine allocations once already received batches have been distributed.[22] While entirely reasonable in its motivation to minimize wastage, an unintended consequence of this policy could be that jurisdictions might prioritize regions where uptake is swift and virtually guaranteed, and conversely, might deprioritize locations with real or anticipated lower uptake.

Such an outcome would recreate the kind of dynamics that the NASEM sought to address with its proposal to use the SVI to mitigate the consequences of structural racism. Interpreting low vaccine uptake in, for example, communities with predominantly Black populations as expressing that these groups might simply not be interested in vaccines would be based on an overly simplistic understanding of autonomy. In planning outreach and communication activities, history matters. It is therefore crucial to be aware that rather than simply indicating a personal preference, vaccine hesitancy has different reasons that require different responses,[23] and can moreover be an entirely rational expression of lacking trust in the healthcare system and in government. Egregious historical ethical violations such as the Tuskegee study cast a long shadow in the collective memory of, particularly, Black communities, and ongoing experiences of structural racism in healthcare and beyond likewise undermine trust.[24-26] States with larger shares of worse-off communities of color and others not engaged with the healthcare system would therefore be well advised to explore similar uses of the SVI as intended by AZ, NJ, VT, and WA, particularly given that the incentive structures governing the deployment of new tranches of vaccines currently favor prioritizing allocations to geographic areas with the swiftest uptake.

On a practical note (with normative implications), approximately one-third (n=24) of jurisdictions indicate they plan to use the Tiberius Platform, including 15 that do not signal any other use of the SVI. This trend also matters normatively. Uniform adoption of a centralized platform to inform state plans can have advantages in, for example, consistent implementation of SVI-based prioritization, and transparency around the near-real-time data being used for decisions (e.g., re-distribution of doses at the local level). It might be puzzling why about two-

thirds of jurisdictions turn down the offer of a free platform with defined application. Anecdotal evidence suggests that novelty; concerns around the opacity of data integration; and about alignment of data representation with state-level data sets are part of the explanation. Improving transparency appears a desirable first step towards greater efficiency and operational effectiveness, and, possibly, more uniform use of adjusting allocations with disadvantage measures.

Finally—and directly related to the above points regarding variations in adopting SVI; questions about the impact that different types of adoptions will have; and use of Tiberius—planners in Ohio ought to be commended for expressly planning to use a disadvantage index not only for allocation purposes, but also for monitoring uptake. Such initiatives—for example, by assessing coverage rates by SVI deciles—can support disparate impact monitoring, a legal concept focused on determining whether policies negatively affect a protected group, even if they do not have that express intention, or directly use information about that group.[25-27] Ideally, given the salience of the goal of reducing inequities, the extent to which vaccines reach worse-off groups would be monitored at the federal level (and would appear to be feasible to implement, were a platform such as Tiberius more acceptable to jurisdictions). However, pragmatically, disparate impact monitoring is best conducted—and planned for, from the outset—at the state level, for it is here that vaccine redistributions, along with intensifications of outreach, communication or concentration of dispensing sites efforts, would need to be adjusted.

Conclusion

The nation faces an unprecedented logistical and social justice challenge in allocating vaccines under scarcity in the next half year or so. (At the global level, we anticipate scarcity for much longer periods of time, especially in low- and middle-income countries). Overall, the better-off white majority will be able to live and work socially distanced for a few months more with reasonable inconvenience. Unfortunately, the same cannot be said for the most disadvantaged communities, including, particularly, racial and ethnic minorities, who are a greater risk, and for whom a vaccine is far more important. Jurisdictions should explore to the fullest extent the potential of using statistical measures of disadvantage, alongside other options, to allocate vaccines equitably.[3,8]

The tasks at hand are urgent and complex. But we are also at a point where social justice must become central, rather than continue to be peripheral. There is still time for jurisdiction planners to play a direct role in changing the course of a troubling historical trajectory. Establishing allocation frameworks that increase the chances of more disadvantaged communities—and particularly those of color—to be offered a vaccine can help to reduce inequity, and can be one way of mitigating the consequences of past, and in many ways still ongoing,[20,24-27] wrongs.

References

1. Centers for Disease Control and Prevention (CDC) 2020. COVID-19 Vaccination Program Operational Guidance. Available at: https://www.cdc.gov/vaccines/covid-19/covid19-vaccination-guidance.html Accessed Nov 8, 2020. .
2. Schmidt HU, Ünver Williams, Michelle; Pathak, Parag; Sönmez, Tayfun; Gostin, Lawrence;. Rationing Safe and Effective COVID-19 Vaccines: Allocating to States Proportionate to Population May Undermine Commitments to Mitigating Health Disparities. *SSRN Working Paper.* 2020.
3. National Academies of Sciences Engineering aM. *A Framework for Equitable Allocation of Vaccine for the Novel Coronavirus.* Washington, DC:2020.
4. Rebecca L. Weintraub LS, Ami Karlage, Iman Ahmad, and Julie Rosenberg. COVID-19 Vaccine To Vaccination: Why Leaders Must Invest In Delivery Strategies Now. *Health Affairs.* 2020;0(0):10.1377/hlthaff.2020.01523.
5. A. David Paltiel JLS, Amy Zheng, and Rochelle P. Walensky. Clinical Outcomes Of A COVID-19 Vaccine: Implementation Over Efficacy. *Health Affairs.* 2020.
6. Nancy McClung MC, Kathy Kinlaw, Dayna Bowen Matthew, Megan Wallace, Beth P. Bell,Grace M. Lee, H. Keipp Talbot, José R. Romero, Sara E. Oliver, Kathleen Dooling,. The Advisory Committee on Immunization Practices' Ethical Principles for Allocating Initial Supplies of COVID-19 Vaccine — United States, 2020. *MMWR Morb Mortal Wkly Rep.* 2020;69:1782-1786.
7. Bell BP, Romero JR, Lee GM. Scientific and Ethical Principles Underlying Recommendations From the Advisory Committee on Immunization Practices for COVID-19 Vaccination Implementation. *JAMA.* 2020;324(20):2025-2026.
8. Schmidt H. Vaccine Rationing and the Urgency of Social Justice in the Covid-19 Response. *Hastings Cent Rep.* 2020;50(3):46-49.
9. World Health Organization. *WHO SAGE values framework for the allocation and prioritization of COVID-19 vaccination.* 14 September 2020 2020.
10. Berwick DM. The Moral Determinants of Health. *JAMA.* 2020.
11. Forde AT, Sims M, Muntner P, et al. Discrimination and Hypertension Risk Among African Americans in the Jackson Heart Study. *Hypertension.* 2020;(online first, July 1, 2020 https://doi.org/10.1161/HYPERTENSIONAHA.119.14492).
12. Dwyer-Lindgren L, Bertozzi-Villa A, Stubbs RW, et al. Inequalities in Life Expectancy Among US Counties, 1980 to 2014: Temporal Trends and Key Drivers. *JAMA Intern Med.* 2017;177(7):1003-1011.
13. Chetty R, Hendren N, Jones MR, Porter SR. Race and Economic Opportunity in the United States: an Intergenerational Perspective. *The Quarterly Journal of Economics.* 2019;135(2):711-783.
14. O'Brien R, Neman T, Seltzer N, Evans L, Venkataramani A. Structural racism, economic opportunity and racial health disparities: Evidence from U.S. counties. *SSM Popul Health.* 2020;11:100564.
15. Adair-Rohani H, Zukor K, Bonjour S, et al. Limited electricity access in health facilities of sub-Saharan Africa: a systematic review of data on electricity access, sources, and reliability. *Global health, science and practice.* 2013;1(2):249-261.
16. Schmidt H, Pathak P, Sönmez T, Ünver MU. Covid-19: how to prioritize worse-off populations in allocating safe and effective vaccines. *BMJ.* 2020;371:m3795.
17. Schmidt H, Gostin LO, Williams MA. Is It Lawful and Ethical to Prioritize Racial Minorities for COVID-19 Vaccines? *JAMA.* 2020;324(20):2023-2024.
18. Khazanchi R, Evans CT, Marcelin JR. Racism, Not Race, Drives Inequity Across the COVID-19 Continuum. *JAMA Network Open.* 2020;3(9):e2019933-e2019933.

19. Schmidt H, Ünver, Utku, Williams, Michelle; Pathak, Parag; Sönmez, Tayfun; Gostin, Lawrence;. What Prioritizing Worse-Off Minority Groups for COVID-19 Vaccines Means Quantitatively: Practical, Legal and Ethical Implications *SSRN Working Paper.* 2020.
20. Yearby R, Mohapatra, Seema,. Law, Structural Racism, and the COVID-19 Pandemic. *Journal of Law and the Biosciences (2020, Forthcoming), Saint Louis U Legal Studies Research Paper No 2020-08, Indiana University Robert H McKinney School of Law Research Paper No 2020- SSRN Working paper available at: https://papersssrncom/sol3/paperscfm?abstract_id=3612824.* 2020.
21. Orenstein W. Vaccines don't save lives. Vaccinations save lives. *Hum Vaccin Immunother.* 2019;15(12):2786-2789.
22. Centers for Disease Control and Prevention (CDC). *COVID-19 Vaccination Program Interim Playbook for COVID-19 Vaccination Program Jurisdiction Operations Interim Operational Guidace, Version 2.0.* Centers for Disease Control and Prevention (CDC),; October 29, 2020 2020.
23. Buttenheim A. SARS-CoV-2 Vaccine Acceptance: We May Need to Choose Our Battles. *Annals of Internal Medicine.*0(0):null.
24. St Fleur N. Two Black university leaders urged their campuses to join a Covid-19 vaccine trial. The backlash was swift. *STATNesws.* October 12, 2020, 2020.
25. Kakani P, Chandra A, Mullainathan S, Obermeyer Z. Allocation of COVID-19 Relief Funding to Disproportionately Black Counties. *JAMA.* 2020;324(10):1000-1003.
26. Navathe A, Schmidt, Harald. Why a Hospital Might Shun a Black Patient - The way medical professionals are paid keeps structural racism alive. It's unethical and it must change. *New York Times.* Oct 6, 2020, 2020.
27. Foster S, Cannon, Yael, Bloche, Gregg. Health Justice Is Racial Justice: A Legal Action Agenda For Health Disparities,. In. *Health Affairs Blog*2020.

Appendix 1

Complete data extraction tool: References to the use of statistical measures of disadvantage, and the Tiberius platform, in the CDC's jurisdictions initial allocation frameworks (based on a) summaries of all jurisdictions' allocation plans published by November 8 on the CDC's dedicated website,[1] and b) full versions, which were either obtained website links within the short version, or obtained through additional searches on jurisdictions' health department websites (Nov 7-14; archived copies available from the authors).							
	1	1a	1b	2	2a	3	3a
#=not mentioned Green fonts: full version	Refers to disadvantage index? (SVI, ADI, other: STATE WHICH)	Use Index for: - identifying - prioritizing -[other=note]	Verbatim text	Magnitude and mechanisms for any prioritization are (eg 10% of state allocation for worse off)	Verbatim text	Plans on using Tiberius? (yes,no)	Verbatim text
Alabama	SVI	Define priority groups, possibly also prioritizing	The Data Group will use all the available databases used for COVID-19 surveillance (including the Social Vulnerabilities Index), and CDC provided databases to identify, estimate the numbers, and where they are located.	No	#	Yes	ADPH will also utilize the Health and Human Services' (HHS) Operation Warp Speed (OWS) Tiberius web microplanning tool to assist with allocations during all phases. ADPH will use Tiberius to identify the number and location of COVID-19 critical populations down to the county level, including maps. ADPH has created a

							Data Group to analyze and verify the data in Tiberius.
Alaska	#	#	#	No	#	Yes	Critical infrastructure data are being gathered from various entities through Alaska's critical infrastructure workforce. These data will improve the utility of Tiberius. Data sources include (but are not limited to) the following: Alaska Department of Labor and Workforce Development, Alaska Division of Insurance, Alaska Division of Healthcare Facilities (i.e., healthcare licensing), Alaska Native Tribal Health Consortium, Alaska Pharmacists

							Association, Chronic Disease and Health Promotion, Epidemiology, Public Health Nursing, and Alaska State Hospital and Nursing Home Association (ASHNHA). The Alaska Immunization Program will use Tiberius to assist with microplanning to ensure there is equitable access to COVID-19 vaccination services throughout all areas within the state.
Arizona	SVI	Plan outreach/ communication to ensure uptake (during scarcity or after)	During the initial phase of the vaccination campaign, ADHS and the local allocators will utilize federal, state, and local data sources to estimate critical populations and allocate vaccine for higher-risk	No	#	Yes	ADHS may also leverage staffing offered by CDC to support Tiberius, VTrckS, VAMS, and other systems used to manage the vaccine response.

			individuals, health care professionals, and other essential workers as recommended by VAPAC There may be areas with limited providers, a high social vulnerability index (SVI), vaccine hesitancy or other factors that lead to lower vaccine uptake. In these areas, ADHS plans to work with local partners to develop targeted messaging and mobile POD vaccination strategies to encourage vaccination. In addition, the Department worked with partners at Arizona State University (ASU) to identify priority areas with individuals at high risk for COVID-19 complications using two different assessments of risk - one utilizing Hospital				

			Discharge histories and 20 diagnosis codes that are well documented in the scientific literature as associated with elevated risk of poor COVID outcomes. The second approach was conducted using a COVID vulnerability index developed by ASU. It looks at many factors, such things as poverty, ethnicity, that has been shown to be statistically associated with elevated COVID death, diagnosis, or hospitalization . This analysis identified 31 high risk Primary Care Areas (PCAs) that contain an estimated 54% of all persons in Arizona who would be at elevated risk of poorer COVID19 outcomes. These areas have been prioritized throughout				

			the response for targeted communications, social media listening, increased testing and vaccine resources ADHS will utilize the SVI to identify communities that may need enhanced support before, during and after disasters.				
Arkansas	#	#	The ADH will leverage the Federal data platform known as Tiberius and work closely with the Arkansas State Data Center at the University of Arkansas at Little Rock to update Arkansas population data by county and zip code to continually assess vaccination rollout efforts. This data will allow us to overlay critical populations with health care providers using geo-mapping	No	#	Yes	The ADH will leverage the Federal data platform known as Tiberius and work closely with the Arkansas State Data Center at the University of Arkansas at Little Rock to update Arkansas population data by county and zip code to continually assess vaccination rollout efforts. This data will allow us to overlay critical

							populations with health care providers using geo-mapping.
California	CA Health Equity Metric	Prioritize worse off using SVI	Additionally, California is identifying populations and communities that have been disproportionately impacted by COVID-19 and has developed a health equity metric to help guide continuing efforts to address disparities. The equity metric is designed to reduce cases in the most disproportionately impacted communities, as defined by the census tracts in the lowest quartile of the Healthy Places Index within larger counties, and as defined by population and geography by the local health departments in smaller counties (where census tracts cannot be used).	No	#	No	#

Chicago	#	#	#	No	#	No	#
Colorado	#	#	#	No	#	Yes	The GIS Unit is already involved in mapping critical populations and has the expertise to assist with spatial analyses to identify where additional focus may be needed to recruit providers for vaccination efforts. Colorado would also be interested in comparing the population estimates in the CDC's Tiberius mapping application to ensure we are using the best available data to inform provider recruitment.

Connecticut	#	#	Several data sources are being used to identify populations in Connecticut at high risk for COVID-19, and DPH will utilize mapping tools to provide visual representation of target populations when the data is finalized. After applying recommendations and with visual data, DPH will coordinate with these target groups, coordinate vaccinators, and identify for COVID-19 vaccine administration setting for Phases 1-A, 1-B, and 2.	No	#	No	#
Delaware	#	#	#	No	#	Yes	The Immunization Program will use the Health and Human Services (HHS) operating system called "Tiberius" to allow the Vaccine Planning Group to obtain vaccine

							data for Delaware and target critical populations and work groups to ensure the vaccine allocated to Delaware is being used effectively.
District of Columbia	#	#	The estimate of Critical Workforce and Populations for Phase 1 of COVID-19 Vaccine Distribution was created using available information from DC government agencies, local community partners, CDC's Behavioral Risk Factor Surveillance System (BRFSS) for the District, and DC's Health and Medical Coalition Healthcare Workforce Survey.	No	#	No	#
Florida	SVI	Define priority groups, possibly also prioritizing	The Department's Office of Minority Health and Health Equity has been engaged in vaccination	No	#	No	#

			planning and existing networks and data will be utilized to inform these efforts. Social vulnerability indexes are available in GIS platforms and communities with health disparities have been identified. Florida has a well-integrated public health and emergency management system that allows the state to identify at-risk populations and personnel across multiple disciplines, provide robust geographic information system (GIS) mapping capabilities, and communicate with persons from various disciplines through an integrated emergency management structure. The Department's Office of Minority Health and Health Equity has been				

			engaged in vaccination planning and existing networks and data will be utilized to inform these efforts. Social vulnerability indexes are available in GIS platforms and communities with health disparities have been identified.				
Georgia	#	#	DPH Immunization Program will utilize a combination of existing national, state-wide, and local data sources; engagement of community-based organizations, academic institutions, and state agencies; mapping, modeling, and forecasting; and surveillance data to identify critical and priority populations. Information collected on critical populations will be compiled into a Critical	No	#	No	#

			Populations database maintained by DPH.				
Guam	#	#	#	No	#	No	#
Hawaii	#	#	#	No	#	No	#
Houston	#	#	#	No	#	No	#
Idaho	#	#	DHW's Immunization and Preparedness Programs are working together to develop plans and gather input and data from state, local, and tribal government agencies to identify, estimate numbers of, and locate critical populations.	No	#	Yes	The Immunization Program plans to use the Department of Health and Human Services' Operation Warp Speed Tiberius Platform ("Tiberius") to aid in COVID-19 vaccine distribution planning, tracking, modeling, and analysis to support a successful vaccination campaign. In addition,

							the immunization programis developing a tool for calculating vaccine dose allocations to assist with ensuring equitable distribution of vaccine for priority populations
Illinois	#	#	#	No	#	No	#
Indiana	SVI	Prioritize worse off using SVI	Data Advisory Group: Explored creative data resources and compiled Indiana-specific data for critical populations. The CDC Social Vulnerability Index will be reviewed during the allocation process and applied if there is a limited vaccine during this phase. A document that identifies the SVI and estimated counts for	No	#	Yes	The IDOH will use Tiberius as a visualization tool for allocations, vaccine administration data monitoring, and transparency Estimates of the identified critical populations and critical infrastructure workforce are based on accurate information from population

			comorbid conditions per county will assist in targeted allocation, distribution, and communication during this phase. Counties with higher SVIs may receive an increased allocation per population.				representative organizations, industry leaders, and public open-source data. IDOH will also leverage the federal HHS data management system, Tiberius. These accurate estimates are leveraged to minimize potential waste of vaccine, constituent products, and ancillary supplies.
Iowa	#	#	#	No	#	No	#
Kansas	#	#	Critical populations and infrastructure will be identified and estimated through use of the most recent Behavioral Risk Factor Surveillance System (BRFSS) data,	No	#	No	#

			American Community Survey (ACS) data, and ESRI Community Analyst data. Critical populations to be gathered through these data sets include: racial and ethnic minority groups; individuals 65 years and older; individuals with disabilities; individuals that are underinsured or uninsured; individuals living in congregate settings; and individuals attending colleges or universities. Kansas has defined critical infrastructure workforce personnel to include healthcare personnel and other essential workers as included in the Cybersecurity and Infrastructure Security Agency (CISA) 4.0 guidance				

Kentucky	#	#	#	No	#	Yes	KDPH will utilize the following systems to share information and manage the COVID-19 vaccination campaign (where applicable): … Tiberius (see doc for full list)
Louisiana	SVI	Prioritize worse off using SVI	In each population group, OPH will use CDC's Social Vulnerability Index (SVI) or another more specific index, as needed to prioritize for geographical areas for vaccine access.	Yes	The Louisiana COVID-19 Allocation Tool apportions vaccine by percentages based on the Advisory Committee on Immunization Practices (ACIP) guidance for priority groups	No	#
Maine	#	#	Maine reviewed multiple data sets to identify and determine approximate numbers of critical populations. Data collected and evaluated originated from the following resources: Data and Dashboards Team,	No	#	Yes	Maine CDC will use tool such as the IIS and Tiberius to monitor vaccine inventory, distribution, and administration. Maine will utilize the Tiberius Platforms

			Vaccine Planning Unit, U.S. CDC., Priority 1 Assessment Hospital Survey and Annual Surveys facilitated by the Maine Immunization Program (MIP), nursing home and long-term care facilities information from the Maine Division of Licensing and Regulatory Services, and Census data.				to assist in vaccine planning, distribution and allocation efforts. This will allow us to plan provider-level orders across a range of distribution scenarios. Tiberius provides flexible and data-backed applications that enable users to make data-driven decisions.
Marshall Islands	#	#	#	No	#	No	#
Maryland	#	#	MDH will work with other state/local agencies, and previously identified partners to develop estimates for groups identified by the state (core planning group and technical advisory group) and CDC's Advisory Committee on Immunization	No	#	No	#

			Practices (ACIP) as priority for vaccination during this phase				
Massachusetts	SVI	Define priority groups, possibly also prioritizing	Using a variety of existing data sets, along with CDC COVID-19 guidance on the three phases of vaccine availability, recommendations from the National Academies of Sciences, Engineering, and Medicine, and the final prioritization of the Advisory Committee on Immunization Practices, MDPH will identify and prioritize critical populations for vaccination following federal guidance. In addition, MDPH will refer to emerging evidence of historic and COVID-19-specific vaccine hesitancy and under-immunization risk. Once critical	No	#	No	#

			populations are enumerated and mapped, MDPH will determine parameters and data sets to inform the prioritization model including projections, and requisite mapping, for the distribution of the vaccine by phase (and subsets of populations within in each phase), and by priority group and location The Office of Population Health (OPH) manages the contract with Boston University School of Public Health (BUSPH) for Social Vulnerability Index (SVI) analysis and related mapping support. Within OPH, the Office of Health Equity (OHE) works to address social determinants so all Massachusetts residents can attain their full health potential.				

			MDPH will engage the services of a vendor to provide analytical capacity and will be charged with utilizing U.S. Census (and reliable intercensal estimates of populations conducted by the University of Massachusetts Donahue Institute) to characterize communities at the city/town level— with reference to current trends in COVID-19 infections—at the subpopulation level (occupation, housing type, school enrollment, race/ethnicity, primary language, health care access, co-morbidities, socioeconomic factors), and perform analysis using the CDC's Social Vulnerability Index to assess the interaction of these forces on the likelihood				

			members of critical populations will accept, seek, and be able to access COVID-19 vaccine. Working with our collaborative Social Vulnerability Index (SVI) analytic and mapping partner, the Boston University School of Public Health, maintain superior ability to map these workforce resources at a granular level to inform planning.				
Michigan	SVI	Prioritize worse off using SVI	Thereafter, allocations will be made to each of the health jurisdictions within Michigan for prioritization to community providers who have the ability to vaccinate the priority groups. Allocations are determined based on several factors including the social vulnerability index and population.	No	#	No	#

			After initial allocations to hospitals, allocations will be made to each of the 45 health jurisdictions based on several factors including the social vulnerability index and population. LHDs will then use the relationships they have built with the community to allocate out additional amounts of vaccine to the providers in their community who are able to reach the vulnerable populations.				
Micronesia	#	#	#	No	#	No	#
Minnesota	#	#	#	No	#	No	#
Mississippi	#	#	#	No	#	Yes	To improve vaccination among critical population groups, MSDH has and will work to

							ensure that these groups have access to vaccination services. MSDH will work internally using mapping tools provided by NORC, CMS and Operation Warp Speed (OWS) Tiberius to create visual maps of these populations, including places of employment for the critical infrastructure workforce category, to assist in COVID-19 vaccination clinic planning. In addition, MSDH will use Tiberius to inform this effort to ensure maximum administration distribution and/or low vaccination coverage rates to ensure

							maximum administration distribution is available to all populations identified in each phase MSDH will monitor baseline data against coverage and distribution data throughout the effort through OWS Tiberius to identify any gaps in coverage and distribution. MSDH will use Tiberius, the U.S. Department of Health & Human Services (HHS) Operation Warp Speed Protect (OWS) ecosystem of data sharing platforms that connects data sources for analysis

							and modeling. Tiberius will assist MSDH in analyzing coverage level across the state. This information will inform next steps and further provider recruitment and enrollment, throughout the effort.
Missouri	#	#	DHSS obtained estimated numbers of priority groups for COVID-19 vaccination using data from the Bureau of Labor and Statistics, DHSS, CDC mapping tools, Missouri Economic Research and Information Center (MERIC), and Missouri Department of Economic Development. DHSS sent county-level tier sheets to each Local Public Health Agency (LPHA) for completion, with 14% of LPHAs not	No	#	No	#

			returning tier sheets. Many of the produced sheets had missing or apparent inaccurate data. Members of the planning team have reached out to those who did not return the document or had missing data. State-level data are included below. The maps in Appendix D will consist of locations of priority groups by county.				
N. Mariana Islands	#	#	#	No	#	No	#
Montana	#	#	Determination for critical populations for mass vaccination is comes from CDC guidance, Montana data, Montana University resources, and other DPHHS information.	No	#	No	#
Nebraska	#	#	Nebraska DHHS will use the American Community Survey (ACS)	No	#	No	#

			to arrive at population estimates by county of vulnerable populations stratified by age group, gender, race, and ethnicity. The ACS will be further leveraged to arrive at estimates for individuals incarcerated/ detained in correctional facilities, individuals experiencing homelessness/ living in shelters, college/university enrollment, people living in other congregate settings such as treatment facilities and military barracks, and people with disabilities.				
Nevada	#	#	#	N/A	#	Yes	Limited Doses Received in Tiberius
New Hampshire	#	#	#	N/A	#	No	#
New Jersey	SVI	Plan dispensing sites	Social Vulnerability Index (SVI)[3] review to determine location of PODS sites	#	#	Yes	New Jersey will receive a **Tiberius Analytic Support** subject matter expert to optimize

							New Jersey's use of data monitoring available through federal systems. Mapping will provide visualization of vaccine coverage for the state by provider type, vaccine type, and population type.
New Mexico	SVI	Define priority groups, possibly also prioritizing	NMDOH will also use numerous data sources, including the CDC's Social Vulnerability Index to identify populations at highest risk.	N/A	#	Yes	NMDOH is interested in using the Operation Warp Speed (OWS) Tiberius platform for the critical population identification. We do, however, want to ensure that more detailed, and potentially more accurate, New Mexico data is used.
New York	Unspecified if SVI	Define priority groups, possibly also prioritizing	In addition, individual factors for hospitals and nursing homes will be considered including cases	N/A	#	No	#

			per facility in prior 14 days, and vulnerability index of population served. New York will also consider whether the vaccine can be used effectively as a potential outbreak interruption strategy and if so, what the criteria will be.				
New York City	#	#	#	N/A	#	No	#
North Carolina	#	#	#	N/A	#	Yes	Ordering will be allocated at the state level during the Implement ation Phase. It is anticipated that during Phase 1, a limited supply of vaccine will be available. Using existing interoperab le uploads of vaccine orders into the CDC's Vaccine Order Tracking System (VTrckS) and Tiberius; a seamless, secure, and access-

							controlled collaboration across all government agencies and teams relevant to the Operation Warp Speed (OWS) COVID-19 vaccine effort, including federal agencies and state health departments, will be used to estimate vaccine allocation. The Tiberius platform integrates data concerning COVID-19 vaccine clinical trial operations, manufacturing, allocation, ordering, distribution, inventory, and population-level administration to provide OWS with a real-time understanding of the effort. Tiberius allows users

							to better understand and support exploring and analyzing key COVID-19 metrics and forecasts from multiple governmen t and academic modeling groups to support bespoke federal governmen t workflows.
North Dakota	SVI	Prioritize worse off using SVI	The ND Advisory Committee on COVID-19 Vaccine Ethics may choose to utilize CDC's vulnerability index when allocating vaccine, which may ensure equity in the number of doses Tribal healthcare providers receive.	N/A	#	Yes	North Dakota intends to use the federal Tiberius platform, which will provide data from a variety of sources to inform allocation decision making and monitor the impact of allocations.
Ohio	SVI	Prioritize worse off using SVI Monitor uptake	In addition, vaccine administration will be assessed using the CDC's Social Vulnerability Index both a priori when deciding geographic distribution of	N/A	#	No	#

			vaccines and post-hoc to ensure that state's goals to protect the most-at-risk and vulnerable Ohioans are upheld.				
Oregon	SVI	Define priority groups, possibly also prioritizing	Options for mapping population data (including Tiberius, Tableau and ArcGIS) are actively being explored in conjunction with mapping of CDC's Social Vulnerability Index (SVI) to identify overlap and potential areas of greatest need.	N/A	#	Yes	Options for mapping population data (including Tiberius, Tableau and ArcGIS) are actively being explored in conjunction with mapping of CDC's Social Vulnerability Index (SVI) to identify overlap and potential areas of greatest need.
Oklahoma	#	#	#	N/A	#	No	#
Palau	#	#	#	Yes	Targeting population groups for vaccine 1st batch (2nd batch: 2 weeks later, same operations for 2nd dose) Governmental decision makers and mission essential	No	#

					personnel: 150 MOH and private clinics personnel: 550 First Responder and critical governmen t personnel: 340 Children 3-18 years old with high risk condition: 150 Adults 19-64 years old with high risk condition: Adults 65 and older: 1300		
Pennsylvania	#	#	#	N/A	#	Yes	It's anticipated DOH will rely heavily on the CDC's Tiberius software in order to identify relevant data.
Philadelphia	#	#	Prioritization of different critical populations was established using a formal risk assessment tool. PDPH is employing both primary	N/A	#	No	#

			and secondary data collection methods to define and estimate numbers of persons in each of the critical population groups.				
Puerto Rico	#	#	#	N/A	#	Yes	The PR Immunization Program will employ the HHS Tiberius Analytic Support software to produce vaccination reports and generate a dashboard capability if applicable.
Rhode Island	SVI	Define priority groups, possibly also prioritizing	The MV Workgroup will leverage a range of data sources to estimate numbers of critical populations throughout Rhode Island. As new guidance and evidence identifies additional population groups at increased risk of susceptibility or of severe illness, the MV Workgroup will work to identify their numbers and	N/A	#	Yes	Rhode Island will seek to leverage its existing COVID-19 information collection and sharing processes to the maximum extent possible to support the COVID-19 vaccination campaign. Available information collection processes include (though are not limited to):

			locations. The COVID-19 Vaccine Subcommittee will further support this effort by facilitating engagement with key stakeholders and providing subject- matter expertise and guidance. Data sources consulted in the process of quantifying and locating members of critical populations include (though are not limited to): - Federal agency data to CMS - CDC - Social Vulnerability Index				Monitoring RICAIR, PrepMod, OSMOSSIS, VAERS, Tiberius, VaccineFinder
San Antonio	#	#	#	N/A	#	No	#
South Carolina	SVI	Define priority groups, possibly also prioritizing	CDC COVID-19 Vaccination Plan Template Section 4A: Describe how your jurisdiction plans to: 1)	N/A	#	No	#

			identify, 2) estimate numbers of, and 3) locate (e.g., via mapping) critical populations. DHEC is closely monitoring guidance put forth by the CDC's Advisory Committee on Immunization Practices (ACIP), the National Institutes of Health, and the National Academies of Sciences, Engineering, and Medicine (NASEM) regarding identified populations of focus for COVID-19 vaccination. Other resources include: CDC's Social Vulnerability Index, which accounts for natural and human-caused disasters and disease outbreaks.				
South Dakota	#	#	SDDOH will incorporate a variety of data sources from both state and federal data repositories to determine the	N/A	#	Yes	SDDOH will monitor progress of COVID-19 vaccination program to include

			number of individuals with each critical population				provider enrollment, access to vaccine, dose administered through SDIIS, vaccine ordering and distribution, as well as data reporting to CDC. SDDOH will use multiple platforms such as SDIIS, Tiberius, Qualtrics, VtrackS, among others.
Tennessee	SVI	Prioritize worse off using SVI	After careful review of the CDC Playbook and the National Academies' of Sciences, Engineering and Medicine's Framework for Equitable Allocation of COVID-19 Vaccine and discussion with the Stakeholder Group, TDH leadership, and the Unified Command Group, the following structure has been adopted for the allocation and	10% allocated to worse off groups	10% of the State's allocation of COVID-19 vaccines will be reserved by the State for use in targeted areas with high vulnerability to morbidity and mortality from the virus	Yes	TDH plans to utilize state and national data sources, CDC's Tiberius application, and Geographic Information System (GIS) mapping to locate and map identified critical populations in Tennessee, including health care personnel and other essential workers, residents

			prioritization of COVID-19 vaccines: Allocation: Ten percent of the State's allocation of COVID-19 vaccines will be reserved by the State for use in targeted areas with high Social Vulnerability Index (SVI) values. Five percent of the State's allocation of COVID-19 vaccines will be distributed equitably among all 95 counties. Eighty-five percent of the State's allocation of COVID-19 vaccines will be distributed among all 95 counties based upon their populations.				and staff of congregate care facilities, individuals with underlying medical conditions, or of age, disability, racial, and ethnic minority groups or other vulnerable populations, that place them at higher risk for severe COVID-19 illness and death.
Texas	#	#	#	N/A	#	No	#
United States Virgin Islands	#	#	VIDOH will use a two-prong strategy for identifying, estimating, and locating critical populations of the 106,405 people living in USVI. This will involve reviewing existing data	N/A	#	No	#

			sources for identifying and estimating critical populations, then validating data of critical populations with stakeholder engagement. This process will also ensure effective communicatio n and outreach over the entire course of the vaccine operation.				
Utah	#	#	The UIP will utilize several different data sources to identify, estimate, and locate the critical populations of Utah residents, such as (but not limited to) the Behavioral Risk Factor Surveillance Survey, Long Term Care Report, and US Census data. The UIP has also created surveys that will gather more local and hospital/clinic data. This data will help the UIP and PW determine which	N/A	#	No	#

			populations will receive the vaccine first and will help estimate how many vaccines these populations will need.				
Vermont	SVI	Define priority groups, possibly also prioritizing Plan outreach/ communication to ensure uptake (during scarcity or after)	The Immunization Program will work closely with all COVID-19 vaccination providers and target settings to ensure equitable access to the COVID-19 vaccine. Vaccine allocation will be based on population data, with attention to critical populations. Vaccine administration data from the Immunization Registry will be monitored and reviewed by geographic location. Vaccine doses administered by enrolled sites will also be monitored and redistribution will be required. The Immunization Program is collaborating with the Health	N/A	#	No	#

			Operations Center's Health Equity and Community Engagement Team to ensure access for people who are disproportionately affected by COVID-19, including Black, Indigenous and people of color. GIS mapping and Social Vulnerability Indices will be employed to identify areas with limited access and direct distribution efforts.				
Virginia	#	#	#	N/A	#	No	#
Washington	SVI	Define priority groups, possibly also prioritizing Plan outreach/ communication to ensure uptake (during scarcity or after)	The use of social vulnerability indexes and maps will also inform how critical populations and sub-populations can be reached equitably and will inform allocation decisions under supply constraints. We will use tools such as Washington Tracking Network Information	N/A	#	No	#

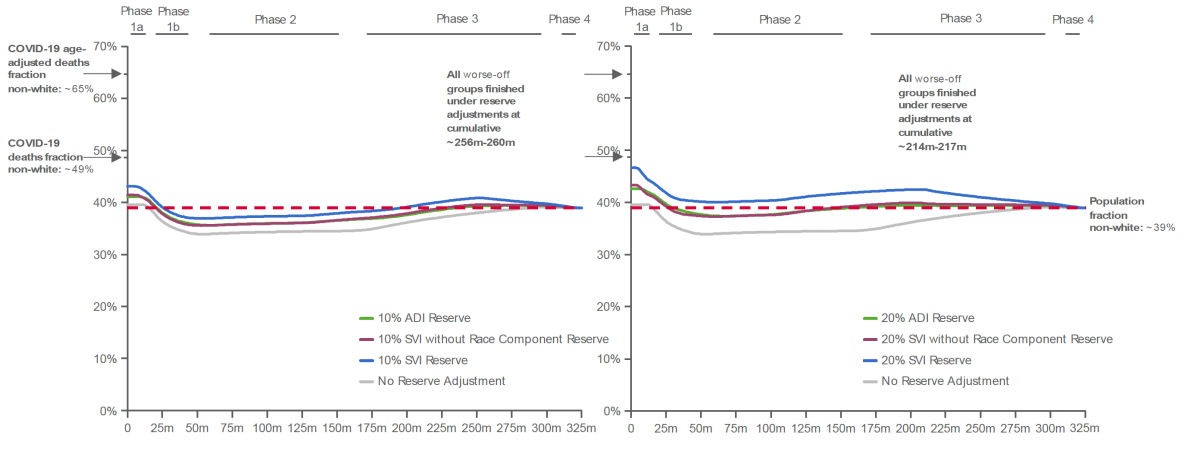
			and CDC Social Vulnerability Index to identify Census tracts in Washington that have higher health inequities overall and to map other relevant social determinants of health, such as overcrowded housing, poverty, disability, or health insurance coverage.				
West Virginia	#	#	#	N/A	#	No	#
Wisconsin	#	#	a tool will be developed to take the main principles into consideration, as well as other relevant data (e.g., county population, percentage of a particular subgroup, vaccinator ability to store that particular vaccine).	N/A	#	Yes	DPH will data from a number of sources, including the Wisconsin provider registration system, the WIR, the CDC program used for vaccine distribution , VTrckS, and the federal database Tiberius to produce reports for internal and external use.
Wyoming	#	#	#	N/A	#	Yes	The Immunization Unit will utilize a variety of

							tools to determine allocation amounts and locations in early and limited supply scenarios. Tools will include the use of Tiberius and data collected through the Provider Profiles for enrolled providers. Allocations will first be prioritized for hospitals, PHNOs, CHDs, and Eastern Shoshone Tribal Health to ensure access for critical populations, including healthcare workers and others identified by CDC, ACIP and in consideration of recommendations from the Wyoming Medical Ethics Committee.

Appendix 2 – Data on quantifying shares of worse-off populations and the impact of statistical measures of disadvantage to adjust allocations

At the time the NASEM recommended setting aside a 10% national reserve to be allocated to worse-off populations as captured under SVI, it was unclear what quantitative impact this would have in terms of the numbers of doses offered to these communities. To quantify this, we simulated using SVI along a modified version of the index that reduced legal challenges, and another index that likewise reduces this risk (the Area Deprivation Index, ADI).[1] The figure below shows on the left-hand side the consequences of setting aside 10% at the state-level (the more realistic approach, see the example of Tennessee, noted in the manuscript) of the amount allocated to states based on population and adding this in addition to the share that a states' worse-off quartile as captured on the respective index would receive. The right-hand side shows the consequences of doubling this amount to 20%, which can also give a rough[2] idea of what a combined 10% reserve at the national level, and at the state level would mean.
The share of the worse-off quartile among minority populations that would be offered vaccines under the unadjusted NASEM framework in shown in the gray line. In the initial phase, all indices would offer worse-off minorities vaccines above their population share, even though in the case of the unadjusted NASEM framework the margin is slim, and considerably higher on the different indices. Around half-way through phase 1, using only the state-level 10% reserve (left-hand side illustration), on all scenarios the share of offered vaccines drops below the population share, while increasing the reserve size to 20% leads to offers that are consistently above the population share. Note also the shares of covid-related deaths (crude and age-adjusted) of all minority populations collectively, that are shown for context on the vertical axis. Further, note that the standardized assumptions made here set aside logistical complexities of implementation, that likely make it harder, rather than easier to reach worse-off groups.

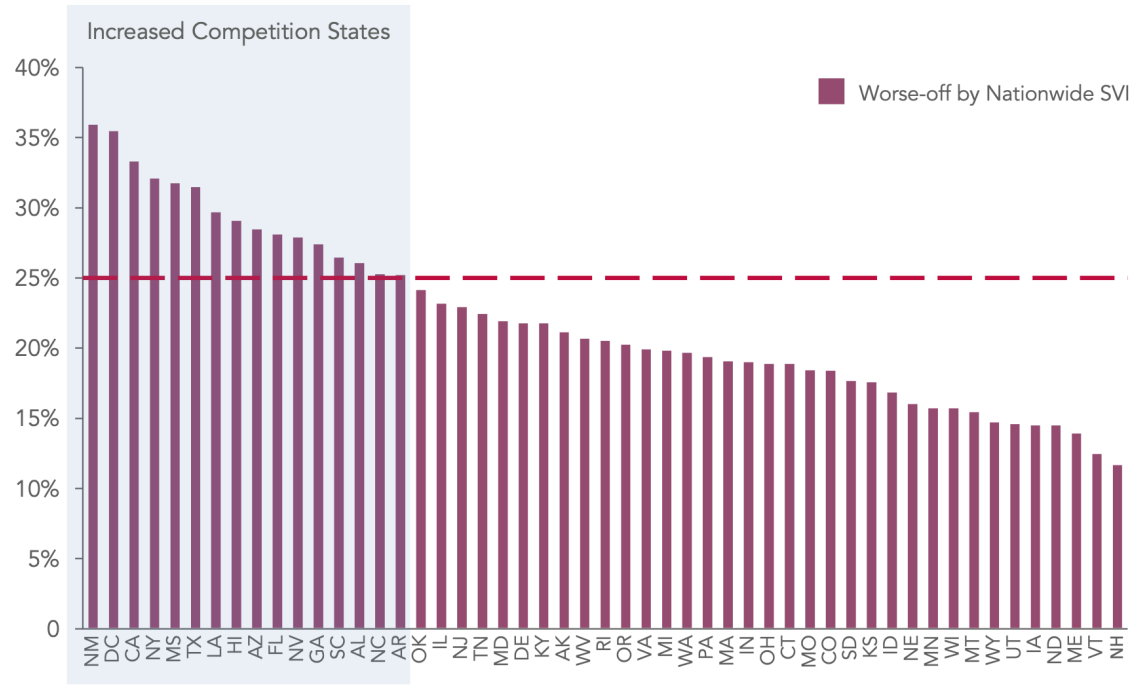
Figure 1: Proportion of vaccine doses offered to minorities (i.e. all Hispanic, Black, Asian, Indigenous, mixed-race groups), after and before reserve adjustments for worse-off groups, by cumulative number of vaccine doses offered



Notes: COVID-19 death fraction and age-adjusted death fraction is as of 09/15/2020. Death rates and age-adjusted death rates may be inaccurate in the presence of multi-racial groups and racial groups outside Indigenous, Asian, Black, Latino, white, and Pacific Islander. Non-white includes all racial groups excluding non-Hispanic, white. Phase labels at top of figure represent estimates of approximate NASEM phase populations. All worse-off groups are finished to be served at the end of 323m cumulative vaccines when there are no reserve adjustments.
Sources: National Academies of Sciences, Engineering, and Medicine Framework for Equitable Allocation of Vaccine for the Novel Coronavirus, American Community Survey (ACS) 5-Year, and APM Research Lab, Color of Coronavirus.

The US's states do not have equal shares of worse-off populations. Figure 1 shows what share of each state's population falls into the nation's worse-off quartile, varying from 36% (NM) to 12% (NH).[3] In 16 'Increased Competition' states, the worse-off group accounts for more than 25% of its population: allocating vaccine proportionate to population would increase scarcity for these populations.

Figure 1: Share of each state's population falling under the worse-off quartile nationally (SVI)



Notes: Using individualized SVI estimation approach based on the ACS PUMS data set. CDC's census-tract approach and our approach has correlation 0.924 for worse-off population shares of states.

Sources: National Academies of Sciences, Engineering, and Medicine Framework for Equitable Allocation of Vaccine for the Novel Coronavirus and American Community Survey (ACS) 5-Year.

[1] Schmidt, Harald and Unver, Utku and Williams, Michelle A. and Pathak, Parag A. and Sonmez, Tayfun Oguz and Gostin, Lawrence O., What Prioritizing Worse-Off Minority Groups for COVID-19 Vaccines Means Quantitatively: Practical, Legal and Ethical Implications (October 27, 2020). Available at SSRN: http://dx.doi.org/10.2139/ssrn.3716686

2 In a subsequent study, we addressed the question of whether a 10% national reserve, or a 10% state-level reserve would be more beneficial, finding the former superior, but the latter still preferable over no adjustment, see: Schmidt, Harald and Pathak, Parag A. and Williams, Michelle A. and Sonmez, Tayfun Oguz and Unver, Utku and Gostin, Lawrence O., Rationing safe and effective Covid-19 vaccines: allocating to states proportionate to population may undermine commitments to mitigating health disparities (November 12, 2020). Available at SSRN: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3729069

[3] Schmidt, Harald and Pathak, Parag A. and Williams, Michelle A. and Sonmez, Tayfun Oguz and Unver, Utku and Gostin, Lawrence O., Rationing safe and effective Covid-19 vaccines: allocating to states proportionate to population may undermine commitments to mitigating health disparities (November 12, 2020). Available at SSRN: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3729069