Title:

Preparedness for a Smallpox Outbreak: Comparing Metrics for Assessing Levels of Vaccination among Healthcare Workers by State

Abstract:

Objectives: By mid-2005, less than 17% of smallpox vaccine doses distributed to states for healthcare workers during the CDC vaccination campaign had been used. To understand how states responded to this campaign, vaccination patterns were studied. **Methods**: Metrics were calculated to compare the level of preparedness for a smallpox outbreak in terms of absolute numbers of healthcare workers vaccinated compared to the percentage of doses distributed to each state actually used, the rate of vaccination per capita population, and the percentage of healthcare workers vaccinated per hospital compared to the number CDC recommended. States were then ranked on each metric. **Results**: Results showed that rankings for comparisons of all four metrics were statistically significantly different ($p < .0001$). In addition, when ranks were assigned to quartiles, the states directly affected by the 9/11 attacks were in the lowest quartiles and states widely perceived to be at lower terror risk ranked in the top quartiles for preparedness. **Conclusions**: These results underscore the need to critically examine *how to define an appropriate level of vaccination preparedness* for a possible smallpox outbreak.

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Introduction

The threat of bioterrorism includes concern over the potential weaponization of smallpox. In response to this possible threat, the CDC *Advisory Committee on Immunization Practices* recommended that smallpox vaccination be administered to selected civilian volunteers[1,2]. In January 2003, the Smallpox Pre-Event Vaccination program for volunteer hospital-based and public health workers was initiated, with an initial goal of having 500,000 workers vaccinated[3,4]. When undertaken, it was described as the first phase of a larger campaign to vaccinate the entire US civilian population[2]. This has never occurred, however, and the program has not been further promoted beyond its initial phase. The Institute of Medicine, *Committee on Smallpox Vaccination Program Implementation*, has documented the scientific and policy challenges and controversies surrounding the initiation and implementation of the smallpox vaccination program[5].

The *Phase I* plan recommended that every US hospital vaccinate 50 to 100 health care workers to form a Smallpox Health Care Team[5(p27-32)]. These teams would include physicians, nurses, mid-level practitioners and ancillary staff such as housekeepers, security staff, and administrators[6]. The CDC asked all states and the District of Columbia to issue a pre-event smallpox vaccination plan by December 9, 2002 and estimate the number of vaccine doses needed [7]; It also provided states with a series of smallpox training opportunities to increase the knowledge and skills of public health and health care workers on vaccine distribution and smallpox diagnosis[8]. In addition, the CDC developed education materials, provided technical assistance, held regular conference calls with state public health officials, and worked on overall communication plans[5].

While it was anticipated that this phase would be implemented rapidly (over 30 days), in fact, only 39,579 individuals, or less that 17% of the distributed doses, have voluntarily accepted vaccination since the program's inception[9,10]. Many issues impeded the success of the program; logistical and economic issues hampered vaccination in some states. In other states, lengthy training sessions were required for all potential vaccines or prohibitive health inclusion criteria was mandated limiting the number of potential vaccinees. The General Accounting Office[11], in a report on the progress of the campaign, noted that states reported that they lacked guidance about what "smallpox preparedness" meant and about how to assess if they were sufficiently prepared. More importantly, however, healthcare worker acceptance and adoption of the program was very low. In fact, a number of studies looking at attitudes of health care workers toward the program revealed that most did not think the benefits of the vaccine outweighed the risks in an adult population, which might have a number of contraindicated conditions[12-17]. For example, Yih et al.[17] studied 1165 emergency room or ICU health care workers and found that only 32% of respondents would report to work after a patient with smallpox was admitted to their facility, if the respondent had not been vaccinated recently. Only 61%, however, reported they were willing to be vaccinated at the time of the survey. While other studies have found similar rates of intended vaccination[13-16],

actual vaccination rates are much lower. Benin et al.[12] found that only two of 141 surveyed physicians actually received vaccination when asked to do so.

Because of the reticence of health care workers to be vaccinated, the CDC has not attempted to vaccinate the public against smallpox. Nor to date has CDC issued a metric for assessing the numbers of healthcare workers who should be vaccinated in a state to provide a reasonable level of preparedness against a perpetrated smallpox outbreak.

Purpose

The purpose of this study was to compare metrics for assessing the level of preparedness to handle a smallpox outbreak based on the level of vaccination of healthcare workers in each state. We constructed metrics to approximate levels of preparedness, and used these to rank states to develop a "preparedness" rubric relative to the numbers of healthcare workers vaccinated. The metrics constructed were: 1) vaccines actually administered as a percentage of doses requested by each state; 2) numbers of health care workers vaccinated per capita population; and 3) health care workers vaccinated as a percentage of the estimated number the state would have needed to vaccinate to meet the CDC recommendation of vaccinating 50 to 100 health care workers for each hospital in a state. An additional goal was to use these rankings to develop quartiles of "preparedness" to understand how states differed in the "success" of their smallpox vaccination program. This approach moves beyond reporting the absolute numbers of persons vaccinated by state to rates that allow comparison across states of different size. It specifically attempts to address the critical issues of the size of the vaccinated health care workforce relative to the total population (vaccinations per capita population), the ability of states to vaccinate the numbers they anticipated needing vaccination, and the numbers actually vaccinated relative to the CDC recommendations.

Methods

Data were obtained on smallpox vaccination for each of the 50 states and the District of Columbia from a number of sources. Number of doses of vaccine requested by the states and distributed and the number of individuals vaccinated as of 6/30/05 were obtained from CDC records[9,10]. State population figures were obtained from the US Census 2003 estimated population[18]. Rates of vaccination for ER personnel were calculated by identifying the number of hospitals in each state[19] (obtained from www.hospitallink.com) and multiplying the number by 75 to approximate the number of healthcare workers needing vaccination if all hospitals in the state met the CDC recommendation of vaccinating 50 to 100 persons per hospital. This method, when summed, yielded an estimated 450,375 health care workers to be vaccinated in the United States. This figure is consistent with the CDC's estimate calling for a total of 440,000 to 500,000 health care workers to be vaccinated[2].

Although the CDC shipped vaccine directly to three cities (Los Angeles, New York City, Chicago), states and two territories (Puerto Rico and Palau), numbers vaccinated in all programs were aggregated to calculate the number of health care workers vaccinated by state. Data for territories are not reported here.

Standardizing the absolute numbers vaccinated into three different types of vaccination rates allows meaningful comparisons of the levels of smallpox vaccination among the states. Each also provides a slightly different perspective on level of smallpox vaccination preparedness by state.

Results

Table 1 includes all state level data and metrics calculated. Column 1 is state population. Column 2 shows the estimated recommended number of hospital personnel to be vaccinated to meet the CDC recommendations of 50-100 per hospital. Column 3 is the number of doses of smallpox vaccine requested by each state and distributed by the CDC as of June 30, 2005. The last four columns, described below, are absolute number vaccinated as of June 30, 2005 (column 4); the percentage of doses requested that were actually used (column 5); the per capita vaccination rate and (column 6); and the percentage of recommended number of hospital personnel actually vaccinated (column 7). Columns 4-7 also show how each state ranked against all other states on that metric.

Rankings for Absolute Numbers Vaccinated

In absolute numbers (Table 2), the five states that vaccinated the most health care workers were Texas (n=4632), Florida (n=4041), Tennessee (n=2429), Ohio (n=1921) and California (n=1854). In absolute numbers, the five states that vaccinated the fewest health care workers were Nevada (n=17), Rhode Island (n=36), Arizona (n=39), Maine (n=63) and Alaska (n=96). The states with the lowest absolute numbers of personnel vaccinated are some of the least populous states, making absolute numbers difficult to compare. When the data are standardized into metrics shown in columns 5-7 of Table 1, more meaningful comparisons are possible. For example, while Florida and Texas vaccinated the largest absolute numbers, neither state ranked in the top five based on percentage of vaccine doses actually used (Table 2), or per capita vaccination (Table 3). Florida was, however, in the top 5 when ranked by the percentage of recommended number vaccinated per hospital when aggregated for the state as a whole (Table 3).

Vaccination Rates and Rankings as a Percentage of Doses Distributed

As shown in Table 2 (excerpted from Column 5 in Table 1), states varied by the percentage of doses of vaccine distributed than they actually used. Comparing the top five ranked states, Oklahoma used 53.7% of the doses received (376 out of 700 doses) followed by Iowa (49.2% or 492 out of 1000 doses), Nebraska (36.8% or 1470 out of 4000 doses), Minnesota (32.8% or 1476 out of 4500) and Alaska (32% or 96 out of 300 doses). In the five states ranked lowest, the percentage of vaccine used was only 1.1% in Nevada, 2.1% in the District of Columbia, 2.1% in Maine, 2.6% in Illinois and 3% in Rhode Island.

Vaccination Rates and Rankings Per Capita Population

There is also wide variation in vaccination rates per 100,000 population (Table 1, Column 6). These ranged from a high of 96.4 per 100,000 in South Dakota to only 0.7 per 100,000 population in Arizona. Table 3 summarizes smallpox vaccination rates per 100,000 population for the states with the highest and lowest rates. The four states with the highest rates are in the Midwest: Top-ranked South Dakota vaccinated 96.4 per 100,000; Nebraska and Wyoming vaccinated 84.5 and 82.6 per 100,000 respectively. North Dakota and Arkansas vaccinated 65.5 and 41.8 respectively. The lowest per capita vaccination is in Arizona, with only 0.7 per 100,000. The other states with the lowest per capita vaccination rates were Nevada (.8 per 100, 000), Georgia (2 per 100,000), Pennsylvania (2.5 per 100,000) and Massachusetts (2.9 per 100,000).

Vaccination Rates and Rankings Relative to CDC Recommendations Per Hospital

Using the estimated number of hospital personnel vaccinated as a percentage of the estimated number recommended by CDC for each state, the states achieved rates ranging from 23.5% in Connecticut to only 0.6% in Arizona (Table 1, Column 7). Table 3 illustrates the smallpox vaccination rate as a percentage of the estimated number of health care personnel that would have had to have been vaccinated in each state to meet the CDC recommendation of vaccinating 50-100 per hospital. Connecticut and Tennessee had the highest rates, each vaccinating 23.5% of the recommended number of health care workers per hospital. Florida ranked third, vaccinating 22.1% of their personnel. Nebraska vaccinated 20.9% and Wyoming vaccinated 18.4%. Among the states with the lowest rates in addition to Arizona, were Nevada (0.7%), Georgia (1.2%), Rhode Island (1.6%) and Maine and Massachusetts (each 1.9%).

Doses Requested by States Compared to CDC Recommendations Per Hospital

When comparing the number of doses requested by each state to the estimated number needed to vaccinate at the CDC recommended level per hospital (Table 1, Columns 1 and 3), there is also wide variation in the number of doses requested by the states. Some states (n=12) requested doses that fall within the range recommended by the CDC, based on the number of hospitals in the state. The majority of states, however, requested too many doses of vaccine (n=7) or too few doses (n=32) based on the number of hospitals in the state. To vaccinate 50-100 health care workers per hospital (the CDC target) California, for example, the most populous state with the largest number of hospitals, would have needed approximately 35,000 doses of vaccine, but only requested 19,300. Similarly, Minnesota, with a large number of hospitals, would have needed approximately 20,000 doses but only requested 4,500. Wisconsin would have needed 10,000 doses but only requested 2,500. In contrast, Florida, which has a large population but fewer hospitals per capita, requested 24,000 doses of vaccine when they would have only needed approximately 18,000 to meet the recommended target. The District of Columbia, which has few hospitals within the district limits, was estimated to need 1300 doses to meet the target but requested 5,000.

Smallpox Vaccination Rankings by Quartile

Table 4 summarizes how the states ranked by quartiles of preparedness for each metric. This analysis illustrates how little consistency was found in how states ranked. For example, some states fell into the first quartile in absolute number vaccinated but the third or fourth quartile of states on the other metrics. New York, in the first quartile on absolute numbers vaccinated, fell in the third quartile for percentage of doses used, the fourth quartile for vaccination rate per 100,000 population and the third quartile for percentage of recommended healthcare workers vaccinated. On the other hand, some states that ranked in the bottom quartiles on absolute number vaccinated ranked in the top quartiles on the other metrics. For example, Wyoming ranked in the third quartile for absolute number vaccinated but the second quartile on percentage of doses used, and the first quartile on per capita population and percentage of recommended health care workers vaccinated. Similarly, Vermont ranked in the bottom quartile for both absolute number and percentage of doses used, but the second quartile in per capita population and recommended healthcare workers vaccinated.

Statistical Analysis of Rankings of Levels of Preparedness

To assess the comparability of the metrics calculated for gauging preparedness for a smallpox outbreak, we used the non-parametric Friedman test to assess the null hypothesis that there were no differences in the distributions of the ranks (assigned to each of the metrics calculated for all 50 states and the District of Columbia). The probability distribution of Q under the null hypothesis was approximated using a chi-square distribution with 50 degrees of freedom. Comparing the ranks of each state on absolute numbers vaccinated with the percent of doses distributed that were actually used, an indicator of state level response to the CDC vaccination mandate, there is a statistically significant difference (X^2=68.64 with p=0.0412). Comparing the rate vaccinated per 100,000 population with the percentage of CDC recommended hospital personnel to be vaccinated who were actually vaccinated for all hospitals in the state (X^2=88.76 with p=0.0006), two standardized indicators of preparedness, is also statistically significantly different. In addition, comparing the rankings for all four metrics (two indicators of state level response and two standardized indicators of preparedness), the results are statistically significant (X^2=122.36 with p<.0001).

Statistical analysis was also done to assess the quartile ranking for each state for the four metrics. Comparing the quartile rankings of each state on absolute numbers vaccinated with the percent of doses distributed that were actually used, there is a statistically significant difference (X^2=67.31 with p=0.0517). Comparing the quartile rankings for the rate vaccinated per 100,000 population with the percentage of CDC recommended hospital personnel to be vaccinated who were actually vaccinated, is also statistically significantly different (X^2=87.43 with p=0.0008).

Finally, comparing the quartile rankings on all four metrics, the results are also statistically significant (X^2=117.3 with p<.0001). In sum, each of the four metrics, as well as the quartile rankings, that might be used to assess state level of preparedness is

statistically different from the others. Thus the states varied in terms of how they ranked for preparedness depending on the metric selected.

Discussion

Metrics that might be used to assess the level of preparedness for having an adequate number of healthcare workers vaccinated in the event of a smallpox outbreak reflect the lack of clarity and absence of consistency in implementation of smallpox vaccination in the states. The absolute number of smallpox vaccinations, as well as the three vaccination metrics calculated, underscores the low level of acceptance of the vaccination program by both the states and health care workers themselves. The great variability in the rankings of states using each metric also shows that there are important regional differences in response to the CDC's recommendations for pre-event vaccination. We believe that it is important to study the political, socio-economic and cultural factors that influence vaccination decision-making if we are to understand the response to this vaccination campaign. Research is also needed on the types of communication strategies used by the states to persuade health care workers to be vaccinated.

The metrics calculated also highlight the importance of critically examining the way in which the "success" of a vaccination campaign is measured. Because the states had wide latitude in deciding how to define their own level of preparedness[5(p207-209)] in terms of numbers they needed to vaccinate, it is useful to examine how the percentage of doses of vaccine the states requested and received was actually used. In addition, states may have had different ideas on the number of hospitals in their states that would need to participate in the vaccination program thus the differences we found in the number of estimated healthcare workers for each state compared to the number of doses of vaccine actually requested. If we considered only the percentage of doses requested v. actually used, however, states that requested less vaccine than needed to meet the target level of vaccination recommended by the CDC could claim to have been more "successful" in implementing their vaccination campaign than states requesting more vaccine but actually using a smaller percentage.

For example, Oklahoma vaccinated 376 people with the 700 doses requested and received, using 53.7% of the doses requested. When looking at the number of hospitals in the state, however, Oklahoma would have needed an estimated 9,675 doses to meet the CDC recommendation of vaccinating 50-100 health care workers per hospital. From this perspective, Oklahoma only vaccinated 3.9% of the number of health care workers recommended by the CDC. Another disparity uncovered by this analysis is the unique differences in rankings when looking beyond the absolute number vaccinated. For instance, although Texas and Florida had the highest absolute numbers vaccinated, they did not vaccinate at the highest rates when calculated as a percentage of doses requested that were actually used, per capita vaccination, or the percentage of the CDC target that were actually vaccinated. Thus Texas, which had the highest absolute number vaccinated (4,632), ranked only 23rd on the percentage of requested doses actually used, 15th on per capita population, and 10th on the percentage of the CDC

target actually vaccinated. Florida, which vaccinated the second highest absolute number of people (4041), ranked 20th on the percentage of requested doses used, 12th in per capita vaccination, and 3rd in percentage of the CDC target actually vaccinated. From a preparedness perspective, there is lack of clarity as to which metric is most appropriate as an indicator of preparedness for a particular state.

It is also interesting to note that the three states directly affected by the terrorist attacks of 9/11 (New York, Pennsylvania and Virginia) rank in the bottom quartiles among all states for smallpox vaccination preparedness for most metrics calculated. New York ranked 37th in percentage of doses actually used, 40th in per capita vaccination and 33rd in the percentage of CDC recommended vaccinations..Comparing these metrics respectively for the other affected states, Pennsylvania ranked 46th, 48th and 45th (vaccinating 308) and Virginia ranked 39th, 32nd and 19th (vaccinating 914). New Jersey, which suffered significant casualty during 9/11 and vaccinated 671 ranked 36th in the percentage of doses actually used, 39th in per capita vaccination, and 23rd in the percentage of CDC recommendations. In contrast, the states widely believed to be at less risk of a terrorist attack, e.g., those in the Midwest with low population density, consistently rank in the top quartile of preparedness for all of the metrics calculated. For example, Nebraska had the best overall rankings for the metrics used in this analysis, vaccinating 1470 individuals and ranking 3rd in percentage of doses distributed, 2nd in per capita population and 4th in number of estimated healthcare workers. We do not have data to explain this phenomenon, but believe that understanding why some states (e.g., Nebraska, North Dakota, South Dakota, Wyoming) were more successful than others in vaccinating the CDC recommended numbers of health care workers warrants further study.

Conclusion

Overall, the levels of smallpox vaccination in the states raise many questions about the development and implementation of a national plan for vaccination of emergency response teams to handle an infectious disease outbreak. While smallpox has received considerable attention, the likelihood of outbreaks of other infectious diseases including SARS and Avian flu underscore the need to understand state level response to CDC recommendations for handling an outbreak before it has spread widely. The IOM notes that the CDC's rapid implementation of the smallpox vaccination program did not allow time to finalize or test many components of the campaign. The rate of vaccination rose gradually after the campaign was launched in January of 2003 but dropped precipitously by the summer of 2004. While many explanations have been given for the failure of the campaign to reach target levels, including the fact that it was launched without evidence of an impending crisis, the issue of state level response needs greater attention. Research is needed on how the states interact with federal officials, particularly the CDC, to implement programs in the face of information that is always incomplete, and in recognition of the fact that the capacity for rapid response is a key element in preparedness under all circumstances.

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Tables

Table 1. Smallpox Vaccination Metrics Calculated as a) Percentage of Distributed Doses Actually Used, b) Vaccinations Per Capita Population and c) Percentage of Recommended Number Vaccinated for all Hospitals in the State *

STATE and District of Columbia	Col 1 Estimated 2003 State Population	Col 2 Estimated number of Hospital Personnel in state to be vaccinated to meet CDC per hospital target	Col 3 # Smallpox Vaccination Doses Requested and Distributed (as of 6/30/05)	Col 4 #Health care workers Vaccinated (as of 6/30/05)	Col 5 % of doses distributed actually used (Col 4/Col 3 X 100)	Col 6 Vaccination rate per capita (per 100,000 population) (Col 4 / Col 1 X 100,000)	Col 7 % of CDC target actually vaccinated (aggregated for all hospitals in state) (Col 4 / Col 2 X 100)
Alabama	4,500,752	9,750	10,000	503 Rank: 25	5.0% Rank: 43	11.2 Rank: 35	5.2% Rank: 35 (tie)
Alaska	648,818	1,950	300	96 Rank: 47	32.0% Rank: 5	14.8 Rank: 24	4.9% Rank: 38
Arizona	5,580,811	6,525	500	39 Rank: 49	7.8% Rank: 40	.7 Rank: 51	.6% Rank: 51
Arkansas	2,725,714	6,375	11,000	1,138 Rank: 11	10.3% Rank: 35 (tie)	41.8 Rank: 5	17.9% Rank: 6
California	35,484,453	35,100	19,300	1,854 Rank: 5	9.6% Rank: 38	5.2 Rank: 41	5.3% Rank: 34
Colorado	4,550,688	6,150	1,800	224 Rank: 37	12.4% Rank: 31	4.9 Rank: 42	3.6% Rank: 41
Connecticut	3,483,372	3,000	6,500	704 Rank: 22	10.8% Rank: 34	20.2 Rank: 17	23.5% Rank: 1 (tie)
Delaware	817,491	825	700	109 Rank: 45	15.6% Rank: 22	13.3 Rank: 30	13.2% Rank: 10 (tie)
District of Columbia	563,384	1,350	5,000	105 Rank: 46	2.1% Rank: 49 (tie)	18.6 Rank: 18	7.8% Rank: 26
Florida	17,019,068	18,300	24,000	4,041 Rank: 2	16.8% Rank: 20	23.7 Rank: 12	22.1% Rank: 3
Georgia	8,684,715	14,025	900	175 Rank: 41	19.4% Rank: 16	2.0 Rank: 49	1.2% Rank: 49
Hawaii	1,257,608	2,100	4,500	181 Rank: 40	4.0% Rank: 45	14.4 Rank: 26	8.6% Rank: 24
Idaho	1,366,332	3,600	1,000	200 Rank: 38	20.0% Rank: 15	14.6 Rank: 25	5.6% Rank: 31 (tie)
Illinois	12,653,544	17,475	14,200	376 Rank: 31 (tie)	3.0% Rank: 48	3.0 Rank: 46	2.2% Rank: 44

Indiana	6,195,643	9,975	2,900	765 Rank: 17	26.4% Rank: 10	12.3 Rank: 33	7.7% Rank: 27
Iowa	2,944,062	9,450	1,000	492 Rank: 26	49.2% Rank: 2	16.7 Rank: 20	5.2% Rank: 35 (tie)
Kansas	2,723,507	10,275	3,000	448 Rank: 27	14.9% Rank: 24	16.4 Rank: 21	4.4% Rank: 39
Kentucky	4,117,827	9,300	4,200	848 Rank: 16	20.2% Rank: 14	20.6 Rank: 16	9.1% Rank: 22 (tie)
Louisiana	4,496,334	11,850	10,000	1,107 Rank: 12	11.1% Rank: 32	24.6 Rank: 10	9.3% Rank: 21
Maine	1,305,728	3,375	3,000	63 Rank: 48	2.1% Rank: 49 (tie)	4.8 Rank: 43	1.9% Rank: 46 (tie)
Maryland	5,508,909	6,225	6,000	752 Rank: 19	12.5% Rank: 29 (tie)	13.7 Rank: 29	12.1% Rank: 15
Massachusetts	6,433,422	9,675	1,500	188 Rank: 39	12.5% Rank: 29 (tie)	2.9 Rank: 47	1.9% Rank: 46 (tie)
Michigan	10,079,985	9,375	6,700	925 Rank: 14	13.8% Rank: 27	9.2 Rank: 37	9.9% Rank: 20
Minnesota	5,059,375	20,700	4,500	1,476 Rank: 6	32.8% Rank: 4	29.2 Rank: 8	7.1% Rank: 29 (tie)
Mississippi	2,881,281	8,100	5,600	403 Rank: 30	7.2% Rank: 41	14.0 Rank: 27	5.0% Rank: 37
Missouri	5,704,484	9,825	5,000	1,253 Rank: 9	25.1% Rank: 11	22.0 Rank: 13	12.8% Rank: 13
Montana	917,621	4,125	1,000	144 Rank: 42	14.4% Rank: 25	15.7 Rank: 22	3.5% Rank: 42
Nebraska	1,739,291	7,050	4,000	1,470 Rank: 7	36.8% Rank: 3	84.5 Rank: 2	20.9% Rank: 4
Nevada	2,241,154	2,400	1,500	17 Rank: 51	1.1% Rank: 51	.8 Rank: 50	.7% Rank: 50
New Hampshire	1,287,687	2,550	3,000	331 Rank: 33	11.0% Rank: 33	25.7 Rank: 9	13.0% Rank: 12
New Jersey	8,638,396	7,350	6,500	671 Rank: 23	10.3% Rank: 35 (tie)	7.8 Rank: 39	9.1% Rank: 22 (tie)
New Mexico	1,874,614	4,275	5,000	238 Rank: 36	4.8% Rank: 44	12.7 Rank: 3	5.6% Rank: 31 (tie)
New York	19,190,115	21,375	11,500	1,167 Rank: 10	10.1% Rank: 37	6.1 Rank: 40	5.5% Rank: 33
North Carolina	8,407,248	10,650	7,500	1,312 Rank: 8	17.5% Rank: 18	15.6 Rank: 23	12.3% Rank: 14
North Dakota	633,837	3,675	2,000	415 Rank: 28	20.8% Rank: 13	65.5 Rank: 4	11.3% Rank: 17
Ohio	11,435,798	16,050	6,500	1,921 Rank: 4	29.6% Rank: 7	16.8 Rank: 19	12.0% Rank: 16
Oklahoma	3,511,532	9,675	700	376 Rank: 31 (tie)	53.7% Rank: 1	10.7 Rank: 36	3.9% Rank: 40
Oregon	3,559,596	4,875	400	115 Rank: 44	28.8% Rank: 9	3.2 Rank: 45	2.4% Rank: 43
Pennsylvania	12,365,455	14,550	10,000	308	3.1%	2.5	2.1%

				Rank: 34	Rank: 46	Rank: 48	Rank: 45
Rhode Island	1,076,164	2,250	1,200	36 Rank: 50	3.0% Rank: 47	3.3 Rank: 44	1.6% Rank: 48
South Carolina	4,147,152	5,925	7,800	998 Rank: 13	12.8% Rank: 28	24.1 Rank: 11	16.8% Rank: 8
South Dakota	764,309	4,200	4,300	737 Rank: 20	17.1% Rank: 19	96.4 Rank: 1	17.5% Rank: 7
Tennessee	5,841,748	10,350	10,000	2,429 Rank: 3	24.3% Rank: 12	41.6 Rank: 6	23.5% Rank: 1 (tie)
Texas	22,118,509	35,025	30,000	4,632 Rank: 1	15.4% Rank: 23	20.9 Rank: 15	13.2% Rank: 10 (tie)
Utah	2,351,467	3,525	1,500	288 Rank: 35	19.2% Rank: 17	12.2 Rank: 34	8.2% Rank: 25
Vermont	619,107	1,200	2,000	130 Rank: 43	6.5% Rank: 42	21.0 Rank: 14	10.8% Rank: 18
Virginia	7,386,330	9,150	10,000	914 Rank: 15	9.1% Rank: 39	12.4 Rank: 32	10.0% Rank: 19
Washington	6,131,445	7,500	4,000	554 Rank: 24	13.9% Rank: 26	9.0 Rank: 38	7.4% Rank: 28
West Virginia	1,810,354	4,950	2,500	734 Rank: 21	29.4% Rank: 8	40.5 Rank: 7	14.8% Rank: 9
Wisconsin	5,472,299	10,800	2,500	763 Rank: 18	30.5% Rank: 6	13.9 Rank: 28	7.1% Rank: 29 (tie)
Wyoming	501,242	2,250	2,600	414 Rank: 29	15.9% Rank: 21	82.6 Rank: 3	18.4% Rank: 5
TOTALS	**290,809,777**	**450,375**	**291,100**	**39,579**	**16.4%**	**20.0**	**9.0%**

*Number of hospitals in each state (www.hospitallink.com) multiplied by 75
Column 4 compared to Column 5 rankings: χ^2=68.64 with p=0.0412
Column 6 compared to Column 7 rankings: X^2=88.76 with p=0.0006
Columns 4,5,6 and 7 compared: X^2=122.36 with p<.0001

Table 2. States with the Highest and Lowest Level of Preparedness Calculated as Absolute Number Vaccinated and Percentage of Distributed Vaccine Doses Actually Used

Highest Levels	**Absolute # Vaccinated**
Texas	4,632
Florida	4,041
Tennessee	2,429
Ohio	1,921
California	1,854
Lowest Levels	
Nevada	17
Rhode Island	36
Arizona	39
Maine	63
Alaska	96
Highest Levels	**% of Distributed Doses Actually Used**
Oklahoma	53.7%
Iowa	49.2%
Nebraska	36.8%
Minnesota	32.8%
Alaska	32.0%
Lowest Levels	
Nevada	1.1%
District of Columbia	2.1%
Maine	2.1%
Illinois	2.6%
Rhode Island	3.0%

Table 3. States with the Highest and Lowest Levels of Preparedness Calculated as Vaccination Rates Per Capita Population and by Percentage of CDC Recommended Number Of Hospital Personnel to be Vaccinated

Highest Levels	**Rate Per 100,000**
South Dakota	96.4
Nebraska	84.5
Wyoming	82.6
North Dakota	65.5
Arkansas	41.8
Lowest Levels	
Arizona	.7
Nevada	.8
Georgia	2.0
Pennsylvania	2.5
Massachusetts	2.9
Highest Levels	**% of Recommended Number of Healthcare Workers Vaccinated Actually Vaccinated**
Connecticut	23.5%
Tennessee	23.5%
Florida	22.1%
Nebraska	20.9%
Wyoming	18.4%
Lowest Levels	
Arizona	.6%
Nevada	.7%
Georgia	1.2%
Rhode Island	1.6%
Massachusetts (tie with Maine)	1.9%

Table 4. States' Rankings in Quartiles by Preparedness Metric

Top Quartile	Second Quartile	Third Quartile	Bottom Quartile
Absolute Number of Persons Vaccinated			
Texas	Michigan	Kansas	Hawaii
Florida	Virginia	North Dakota	Georgia
Tennessee	Kentucky	Wyoming	Montana
Ohio	Indiana	Mississippi	Vermont
California	Wisconsin	Illinois	Oregon
Minnesota	Maryland	Oklahoma	Delaware
Nebraska	South Dakota	New Hampshire	District of Columbia
North Carolina	West Virginia	Pennsylvania	Alaska
Missouri	Connecticut	Utah	Maine
New York	New Jersey	New Mexico	Arizona
Arkansas	Washington	Colorado	Rhode Island
Louisiana	Alabama	Idaho	Nevada
South Carolina	Iowa	Massachusetts	
Percent of Vaccine Doses Distributed Actually Used			
Oklahoma	Kentucky	Michigan	Arizona
Iowa	Idaho	South Carolina	Mississippi
Nebraska	Georgia	Maryland	Vermont
Minnesota	Utah	Massachusetts	Alabama
Alaska	North Carolina	Colorado	New Mexico
Wisconsin	South Dakota	Louisiana	Hawaii
Ohio	Florida	New Hampshire	Pennsylvania
West Virginia	Wyoming	Connecticut	Rhode Island
Oregon	Delaware	Arkansas	Illinois
Indiana	Texas	New Jersey	Maine
Missouri	Kansas	New York	District of Columbia
Tennessee	Montana	California	Nevada
North Dakota	Washington	Virginia	
Rate of Vaccination Per 100,000 Population			
South Dakota	Vermont	Mississippi	New York
Nebraska	Texas	Wisconsin	California
Wyoming	Kentucky	Maryland	Colorado
North Dakota	Connecticut	Delaware	Maine
Arkansas	District of Columbia	New Mexico	Rhode Island
Tennessee	Ohio	Virginia	Oregon
West Virginia	Iowa	Indiana	Illinois
Minnesota	Kansas	Utah	Massachusetts
New Hampshire	Montana	Alabama	Pennsylvania
Louisiana	North Carolina	Oklahoma	Georgia
South Carolina	Alaska	Michigan	Nevada
Florida	Idaho	Washington	Arizona
Missouri	Hawaii	New Jersey	
Percentage of CDC Recommended Health Care Workers to be Vaccinated Who Were Actually Vaccinated			
Connecticut	North Carolina	Indiana	Oklahoma
Tennessee	Maryland	Washington	Colorado
Florida	Ohio	Minnesota	Montana
Nebraska	North Dakota	Wisconsin	Oregon
Wyoming	Vermont	Idaho	Illinois
Arkansas	Virginia	New Mexico	Pennsylvania
South Dakota	Michigan	New York	Maine
South Carolina	Louisiana	California	Massachusetts
West Virginia	Kentucky	Alabama	Rhode Island
Texas	N. Jersey	Iowa	Georgia
Delaware	Hawaii	Mississippi	Nevada
New Hampshire	Utah	Alaska	Arizona
Missouri	District of Columbia	Kansas	