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Assessment of Practices Affecting Racial and Ethnic COVID-19 Vaccination Equity in 10 Large US Cities

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ABSTRACT

Context: In the United States, COVID-19 vaccines have been unequally distributed between different racial and ethnic groups. Public reporting of race and ethnicity data for COVID-19 vaccination has the potential to help guide public health responses aimed at promoting vaccination equity. However, there is evidence that such data are not readily available.

Objectives: This study sought to assess gaps and discrepancies in COVID-19 vaccination reporting in 10 large US cities in July 2021.

Design, Setting, and Participants: For the 10 cities selected, we collected COVID-19 vaccination and population data using publicly available resources, such as state health department Web sites and the US Census Bureau American Community Survey. We examined vaccination plans and news sources to identify initial proposals and evidence of implementation of COVID-19 vaccination best practices.

Main Outcome Measure: We performed quantitative assessment of associations of the number of vaccination best practices implemented with COVID-19 racial and ethnic vaccination equity. We additionally assessed gaps and discrepancies in COVID-19 vaccination reporting between states.

Results: Our analysis did not show that COVID-19 vaccination inequity was associated with the number of vaccination best practices implemented. However, gaps and variation in reporting of racial and ethnic demographic vaccination data inhibited our ability to effectively assess whether vaccination programs were reaching minority populations.

Conclusions: Lack of consistent public reporting and transparency of COVID-19 vaccination data has likely hindered public health responses by impeding the ability to track the effectiveness of strategies that target vaccine equity.

KEY WORDS: COVID-19, health disparities, public data reporting, vaccination equity

In the United States, systemic racism resulted in significant disparities in COVID-19 infection, testing, disease, treatment, and vaccination. Black and/or Hispanic populations experience disproportionate risk of exposure[1] and infection,[2-4] lower testing rates,[1] higher hospitalization rates,[2,3,5,6] and death.[2] The Centers for Disease Control and Prevention (CDC) recognized discrimination and racism as factors that facilitated health inequities in minority populations during the pandemic.[7] The Kaiser Family Foundation found that Black and Hispanic people received fewer COVID-19 vaccines than their case count and total population in most states, while White and Asian people received more COVID-19 vaccines than their case count and total population in most states.[8,9]

Racial and ethnic disparities in vaccine uptake have been attributed to mistrust of the medical system by historically marginalized communities and subsequent vaccine hesitancy.[10] This mistrust further stems from systemic racism, which promotes educational, medical, and other inequities.[11,12] For example, health care clinics and vaccination sites tend to be located in more affluent and predominantly White areas, a structural trend that dates back to the Jim Crow era.[13] To combat these inequities, significant investment in vaccine equity efforts and strategies is required.

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Vaccination data transparency at the state and county levels is essential for addressing vaccine distribution gaps and tailoring outreach efforts to vulnerable groups. However, vaccination data are limited by the high percentage of missing racial and ethnic information.[14,15] As data related to racial groups become more granular,[16] the variability in how racial/ethnic data are collected and structured increases.

The primary objective of this cross-sectional study was to assess the gaps and discrepancies in how COVID-19 vaccination rates were reported by 10 of the largest cities in the United States. The secondary objective of this study was to examine vaccine distribution plans across all 10 cities and assess adoption and implementation of vaccine equity best practices that emerged during the pandemic between January 1 and June 30, 2021. All data were collected in July 2021, a critical time for the COVID-19 vaccine rollout because the vaccine was available to all US adults and vaccine mandates had not yet been implemented. With COVID-19 likely to become an endemic disease, there is an urgent need to better understand the role of vaccine equity programs in mitigating current and future disparities.

Methods

Data collection and measurement

City selection

Ten major US cities were chosen from a list of the 50 largest cities in the United States, based on US Census Bureau population estimates. Selected cities were sampled across a range of population sizes and were geographically heterogeneous. No 2 cities were selected from the same state. Notably, population size outliers included Atlanta, 39th largest, and Miami, 44th largest, due to their outsized role in southern states guiding COVID-19 response public discourse.[17,18]

Counties were utilized as a proxy for cities of interest in our analysis when necessary, such as during vaccination data collection. Counties were chosen on the basis of where the majority of the cities' population resided. For example, Chicago was mapped to Cook County and Houston was mapped to Harris County. Most of the selected cities mapped to a single county, except for New York City (NYC) and Atlanta:

City: County(-ies)
NYC: Bronx, Kings, New York, Queens, Richmond
Los Angeles: Los Angeles
Chicago: Cook
Houston: Harris
District of Columbia: District of Columbia
Miami: Dade
Philadelphia: Philadelphia
Atlanta: Fulton, DeKalb
Phoenix: Maricopa
Boston: Suffolk

Vaccination rates

To reliably quantify COVID-19 vaccination rates, publicly available data were obtained from official health department Web sites on July 19, 2021. When available, "at least one dose" and "fully vaccinated" data were recorded. Reflecting the status at time of data collection, "fully vaccinated" signifies individuals who received 2 doses of Pfizer or Moderna or 1 dose of Janssen.

Population data were obtained from the self-reported US Census Bureau American Community Survey's (ACS's) Annual County Resident Population Estimates by Age, Sex, Race, and Hispanic Origin table. Population data were used as a common denominator source to calculate vaccination rates due to significant variation in vaccination data reported by different cities. Because many state Web sites considered Hispanic as a race, rather than an ethnicity, non-Hispanic White, non-Hispanic Black, and non-Hispanic Asian population numbers were used.

Best practice selection and analysis

To assess each city's efforts to promote COVID-19 vaccine equity, 15 best practices were selected on the basis of the Duke Margolis Center for Health Policy's brief, "Prioritizing Equity in COVID-19 Vaccinations: Promising Practices From States to Reduce Racial and Ethnic Disparities."[19] The claims in this report are reflected in other well-known literature on vaccination equity best practices.[20-22] The strategies identified in this report (see Supplemental Digital Content Table S1, available at http://links.lww.com/JPHMP/B26) may help reduce systemic barriers to accessing health care, support community involvement to facilitate decision making, and increase data collection and reporting.

An analysis was conducted to determine whether each city proposed and implemented the 15 best practices during its initial COVID-19 vaccine distribution efforts. Each city's initial COVID-19 vaccination plan proposals (V 1.0) were obtained, except for Chicago and Philadelphia, for which only updated proposals were available in July 2021 (V 8.0 and 8.1, respectively).[23] To determine whether the best practice was initially proposed, key terms were searched in each city's documentation (see Supplemental

Digital Content Table S1, available at http://links.lww.com/JPHMP/B26).

If a key term was found in a city's COVID-19 Interim Plan and the best practice was described in surrounding text, a "Y" (Yes) was recorded in the initially proposed column. If a key term was not found, an "N" (No) was recorded (Table 2).

An online search was then conducted to determine whether the best practices were implemented by each city. Because of the quick rollout of these programs, the best representation of US resident experience was captured by local news outlets, scholarly journals, and local and state Web sites in each city. The search was limited to news stories published between January 1, 2021, and June 30, 2021. Only the first 8 results were considered. Each search term contained the city name and specific key terms (see Supplemental Digital Content Table S1, available at http://links.lww.com/JPHMP/B26).

Evidence of best practices implementation for each city was recorded depending on the results of a Google search containing the city name and key terms: "NA" (not available) for no related news sources, "N" for results that indicated the city did not implement the best practice, and "Y" for results that indicated the city did implement the best practice.

Statistical analysis

Linear regression was performed to assess the association of the number of implemented best practices with racial and ethnic vaccination rate difference in the selected cities. Linearity, homoscedasticity, independence, and normality were assumed. Residual plots did not show any distinct patterns, supporting the validity of these assumptions. Linear regression slope, P value (for analysis of statistically significant deviation of the slope from the null hypothesis of zero), and R^2 values were calculated. Data were analyzed in Excel (Microsoft, Redmond, Washington) and Sheets (Google, Mountain View, California). Statistical analysis and graphing were conducted using Prism 9.2.0 (GraphPad, San Diego, California). Statistical significance was determined by a threshold of $P < .05$.

RESULTS

City COVID-19 vaccination by race and ethnicity

COVID-19 vaccination reporting was profoundly heterogeneous across the United States throughout the vaccine rollout.[8] We found substantial discrepancies between health department Web sites in the categorization and reporting of race and ethnicity data for COVID-19 vaccinations, "at least one dose" versus "fully vaccinated" data, percentages versus raw numbers of vaccinated individuals, and frequency of Web site data updates (Table 1).

Not all health departments categorized Hispanic as an ethnicity, or in the same manner as the US Census Bureau. Los Angeles, Chicago, Houston, Philadelphia, Phoenix, and Boston all considered Hispanic as a value within the same demographic category as White, Black, and Asian. This differs from the US Census Bureau, which assigns individuals in both race and ethnicity categories. To mitigate the impact of the differences between health department reporting and the US Census Bureau ACS, all total population data and, when applicable, vaccination data were recorded as non-Hispanic White, non-Hispanic Black, and non-Hispanic Asian. When non-Hispanic demographic data were unavailable, White, Black, and Asian individuals were summed as a proxy for the non-Hispanic category. These derived cases are represented by black stripes on the bars of Figure 1F.

Vaccination data were further compromised in certain cities. For example, Florida stopped reporting demographic, by-county vaccination data on June 3, 2021. Florida transitioned to reporting weekly updated vaccination data only for the state. It was thus impossible to estimate vaccination rates across demographic subgroups for Miami. Furthermore, Florida labeled Asians as "Other" instead of an Asian demographic category. For Chicago, only fully vaccinated data were reported, instead of reporting "at least one dose" vaccination data. On the other hand, Boston only reported "at least one dose" vaccination data. Both Philadelphia and Boston reported vaccination data as percentages of the current population, instead of individual counts. In these cases, ACS total population data were used to obtain the counts of individuals presented in Table 1. These inconsistencies mirror those of other components of the often-fragmented US COVID-19 response, including public health guidelines, restrictions, and testing.[24,25]

Overall, Boston displayed the highest COVID-19 vaccination rate (at least one dose), followed by the District of Columbia and NYC, respectively (Table 1 and Figure 1A). Chicago displayed the lowest fully vaccinated rate, while Phoenix had the lowest "at least one dose" vaccination rate, likely because there were no data present for that category for Chicago (Table 1 and Figure 1A). Fully vaccinated rates trailed "at least one dose" vaccination rates by a nontrivial margin in many cities, except for Chicago and Boston, whose health department Web sites did not contain data on either "at least one dose" vaccination or fully vaccinated rates (Figure 1B). This suggests a

TABLE 1
COVID-19 Vaccination Data[a]

City	Vaccination Group		Demographic Group				
	Overall, at Least One Dose	Overall, Fully Vaccinated[b]	White[c]	Black[c]	Asian[c]	Hispanic[c]	Non-Hispanic[c]
New York City							
Population	8 336 817	8 336 817	2 681 976	1 825 848	1 228 598	2 423 588	5 913 229
Number vaccinated (%)	4 941 370 (59.3)	4 500 805 (54.0)	1 645 573 (61.4)	720 513 (39.5)	973 650 (79.2)	1 144 305 (47.2)	2 813 234 (47.6)
Los Angeles							
Population	10 039 107	10 039 107	2 615 947	798 279	1 485 197	4 881 970	5 157 137
Number vaccinated (%)	5 777 184 (57.5)	5 067 109 (50.5)	1 556 427 (59.5)	312 004 (39.1)	941 140 (63.4)	2 094 197 (42.9)	2 809 571 (54.5)
Chicago[d]							
Population	NA	5 150 233	2 162 156	1 184 247	398 201	1 319 283	3 830 950
Number vaccinated (%)	NA	1 337 039 (26.0)	1 484 186 (34.1)	314 698 (12.9)	256 484 (31.2)	425 460 (15.5)	2 055 368 (26.5)
Houston							
Population	4 713 325	4 713 325	1 353 078	886 956	335 133	2 061 019	2 652 306
Number vaccinated (%)	2 409 840 (51.1)	2 068 298 (43.9)	665 267 (49.2)	264 876 (29.9)	204 274 (61.0)	849 193 (41.2)	1 134 417 (42.8)
District of Columbia							
Population	705 749	705 749	264 400	313 290	30 541	79 477	626 272
Number vaccinated (%)	439 008 (62.2)	376 126 (53.3)	122 954 (46.5)	103 405 (33.0)	14 427 (47.2)	34 948 (44.0)	213 214 (34.0)
Miami							
Population	2 716 940	2 716 940	2 147 711	481 760	44 111	1 886 364	830 576
Number vaccinated (%)	1 570 846 (57.8)	1 212 839 (44.6)	1 078 738 (50.2)	98 061 (20.4)	NA	808 915 (42.9)	286 693 (34.5)
Philadelphia							
Population	1 584 064	1 584 064	543 890	642 162	120 932	241 425	1 342 639
Number vaccinated (%)	912 811 (57.6)	750 077 (47.4)	337 212 (62.0)	308 238 (48.0)	106 420 (88.0)	147 269 (61.0)	751 870 (56.0)
Atlanta							
Population	1 823 234	1 823 234	643 896	870 869	128 848	141 530	1 681 704
Number vaccinated (%)	905 398 (49.7)	807 536 (44.3)	380 234 (59.1)	289 313 (33.2)	80 037 (62.1)	52 768 (37.3)	720 241 (42.8)
Phoenix							
Population	4 485 414	4 485 414	2 446 089	250 899	194 895	1 408 855	3 076 559
Number vaccinated (%)	1 564 692 (34.9)	1 384 115 (30.9)	735 299 (30.1)	58 249 (23.2)	76 064 (39.0)	263 992 (18.7)	869 612 (28.3)
Boston							
Population	803 907	NA	363 231	161 449	73 381	187 460	616 447
Number vaccinated (%)	529 654 (65.9)	NA	230 410 (63.4)	79 305 (49.1)	55 262 (75.3)	99 747 (53.2)	364 977 (59.2)

Abbreviation: NA, not available.

[a] *COVID-19 vaccination rate data obtained from publicly available health department Web sites of chosen large US cities of interest. Population data obtained from the US Census Bureau American Community Survey (ACS) Web site Annual County Resident Population Estimates by Age, Sex, Race, and Hispanic Origin table 2010-2019 and used as a standardizing measure across cities with heterogeneous vaccination reporting.*

[b] *Reflecting the status at the time of data collection, "fully vaccinated" signifies individuals who received 2 doses of Pfizer or Moderna or 1 dose of Janssen.*

[c] *Demographic group population and number vaccinated (%) are numbers with "at least one dose" of the COVID-19 vaccine.*

[d] *The exception is Chicago, which only had publicly available data for fully vaccinated, which is reproduced here.*

potentially significant role in the lack of adequate follow-up for second-dose appointments (Figure 1B). Rate of completion also varied by city, with Miami having the lowest completion rate and Phoenix having the highest completion rate.

Asian vaccination rates were higher than White vaccination rates in 8 of 10 cities (Table 1 and Figure 1C). The exceptions were Chicago, which had the lowest overall fully vaccinated rate, and Miami, which had no Asian demographic vaccination data available (Table 1 and Figure 1C). Black vaccination rates trailed White and Asian vaccination rates in all cities, many times by large margins (Table 1 and Figures 1C and 1E). In 6 of 10 cities, Hispanic

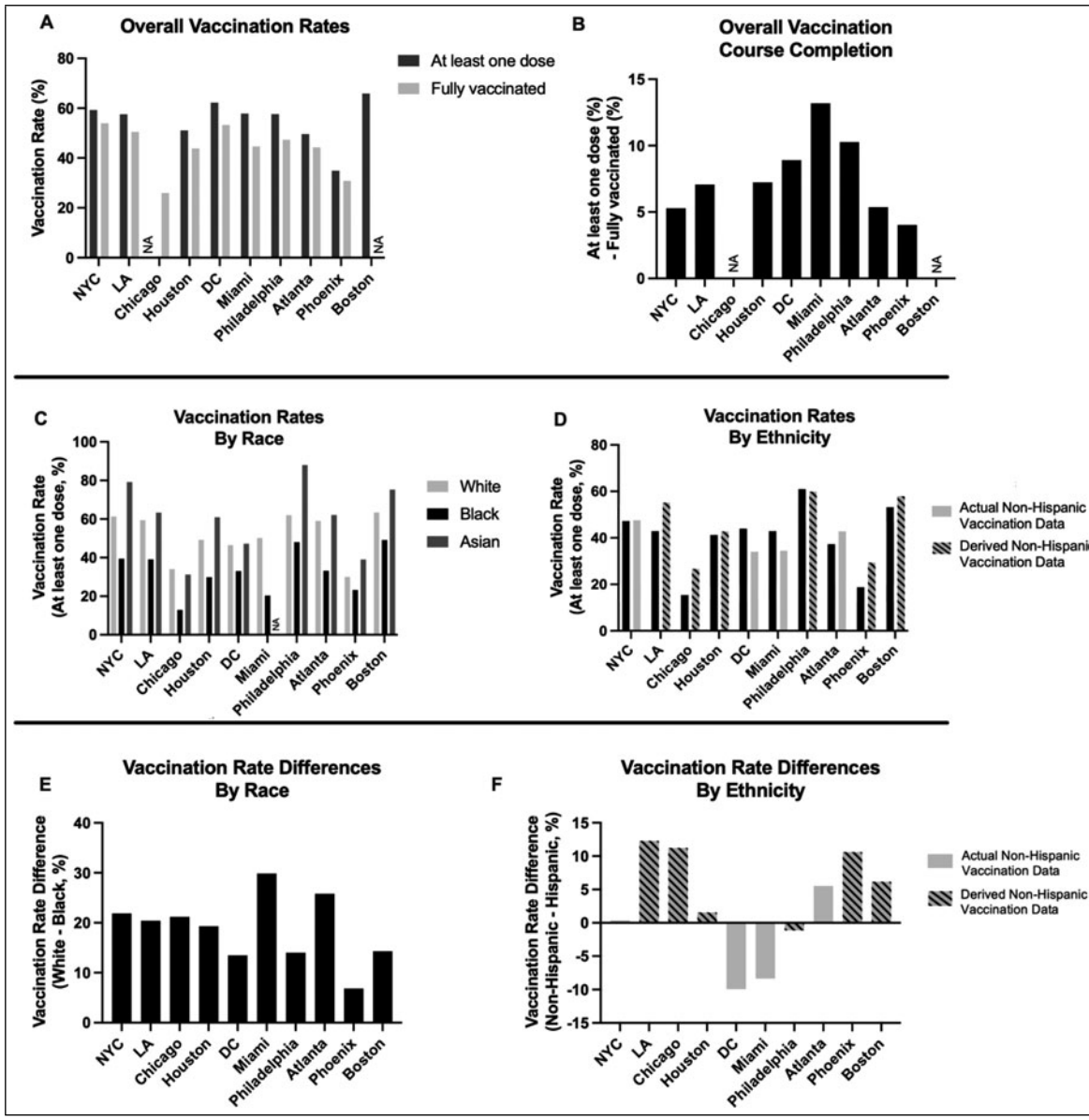

FIGURE 1 COVID-19 Vaccination Equity by Race and Ethnicity in 10 Large US Cities
(A) COVID-19 vaccination data from 10 large US cities by both "at least one dose" and "fully vaccinated," as outlined in many health department Web sites. Raw data of numbers of vaccinated individuals were gathered on July 19, 2021, and standardized to the city demographic populations reported by the American Community Survey 2019 1-year estimates. Reflecting the status at time of data collection, "fully vaccinated" signifies individuals who received 2 doses of Pfizer or Moderna or 1 dose of Janssen. "NA" (not available) designates instances in which there was no publicly available data for that category at the time of search. (B) Differences in COVID-19 vaccination rates between "at least one dose" and completed immunization regimens. (C) COVID-19 vaccination rates in cities by racial demographic group. White, Black, and Asian vaccination rates are represented here, as these were the demographic groups for which there were data available in most cases. (D) COVID-19 vaccination rates in cities by ethnic demographic group. (E) Vaccination rate differences between White and Black individuals, calculated by subtracting the 2 respective percentages. (F) Vaccination rate differences between non-Hispanic and Hispanic demographic groups.

vaccination rates trailed non-Hispanic vaccination rates (Table 1 and Figure 1D) but by smaller margins. There was marked variation between cities, with some showing higher Hispanic vaccination rates than non-Hispanic vaccination rates, such as District of Columbia and Miami (Figure 1F). It is important to consider that this graph is comparing Hispanic vaccination rates with the entire non-Hispanic population vaccination rate. Disparities would likely be much greater if Hispanic rates were compared with, for example, the non-Hispanic White population. However, these comparisons could not be completed because of the paucity of sufficient ethnicity and race data.

Analysis of city "best practice" implementation

Adoption and implementation of COVID-19 vaccination equity best practices across the 10 US cities of interest were examined. Most best practice fulfillments, defined as those that were initially proposed and subsequently implemented in a city, emphasized community involvement, such as partnering with community-based organizations to host vaccination clinics (#8), partnering with community leaders on public health messaging efforts (#9), and establishing mobile or pop-up COVID-19 vaccination clinics (#10) (Table 2). NYC had the greatest number of best practice fulfillments, revealing its comprehensive initial COVID-19 vaccination plan and initial focus on targeting vaccine equity (Table 3). All 10 US cities initially proposed and implemented vaccine education initiatives to help combat vaccine hesitancy and misinformation (Figure 2A).

Between January 2021 and July 2021, each city updated its original COVID-19 vaccination plan to better address vaccination inequities. On average, cities ultimately implemented 6.3 vaccination equity best practices that were not initially included in vaccination plans (Table 3 and Figure 2B). This finding suggests that although cities may not have thoroughly addressed vaccination equity in their initial COVID-19 vaccination plans, they were able to learn from others and adapt.

However, some cities did not adjust their initial COVID-19 vaccination proposals, as indicated by a large number of unaddressed best practices. NYC and Philadelphia, cities that have higher COVID-19 vaccination rates than others, leveraged every best practice analyzed (Figures 1A and 2B and Table 3). Chicago, District of Columbia, and Atlanta had the greatest number of unaddressed best practices, notably, at 3 per city (Tables 2 and 3). The best practices that were least likely to be implemented were zip code prioritizations (#3), government mandated paid leave (#7), and removal of proof of residency requirements (#13) for COVID-19 vaccination (Table 2 and Figure 2A). Overall, only an average of 1.6 best practices were unaddressed among the 10 cities of interest (Table 3), evidence of awareness of vaccination equity strategies and desire to implement them.

There was only one occasion in which a best practice was initially proposed yet not implemented (Table 3). Miami emphasized vaccination equity in its initial proposal, but our search yielded negative responses, especially among the Black community. For instance, several local news outlets mentioned that affluent, White individuals were more likely to receive the vaccine at events that were meant to target marginalized communities, representative of the systemic disparities within the state. This corroborates Miami's low Black vaccination rates in comparison with the White population (Figure 1D). Each of the 10 US cities stated equity as a major consideration (#3) in its initial COVID-19 vaccination plans, and Miami was the only city that failed to implement it (Table 2 and Figure 2A). Finally, the number of COVID-19 vaccination best practices implemented by a city was not associated with racial and ethnic vaccination rate differences (Figures 2C and 2D).

Discussion

Racial and ethnic inequity in COVID-19 vaccine uptake presents a significant public health issue and continues to be of increasing concern due to the rise in COVID-19 cases and deaths spurred by variants. Our data demonstrate trends of higher vaccination rates among Asian individuals, and lower vaccination rates among Black and Hispanic individuals in 10 large US cities. This aligns with prior work on vaccination intent and hesitancy showing higher rates of vaccine hesitancy among Black participants than among Asian and White participants.[26,27]

We show substantial variation in vaccination equity across 10 of the largest cities in the United States. In addition, we found that most of the selected US cities implemented additional COVID-19 vaccination best practices that were not proposed in their initial vaccination plans, indicating that, over time, cities learned and adopted these strategies to promote a more equitable distribution of vaccines. Vaccination best practices included measures such as effective public health messaging and vaccine education, partnerships with the community leaders and organizations, and linguistically accessible health documentation and providers. However, we did not find a significant association between implementation of COVID-19 vaccination best practices in cities and measures of vaccination equity.

In this study, we observed quite significant gaps and discrepancies in the public reporting of racial and ethnic COVID-19 vaccination data. Such inconsistencies prevented us from being able to determine the existence and significance of associations of socioeconomic and political factors and best practice implementation with COVID-19 vaccination equity. Furthermore, these data gaps may significantly impair effective implementation of public health strategies aimed at reducing vaccination inequities and disparities.

This study is limited because of its investigation of a relatively small number of US cities. Future work

TABLE 2
COVID-19 Vaccination Equity Best Practices[a]

	Best Practice Number	#1		#2		#3		#4		#5		#6		#7	
	Date and Version of COVID-19 Vaccination Distribution Proposals	Reporting of Race and Ethnicity Data on COVID-19 Vaccinations by County		COVID-19 Vaccination Equity as a Stated Consideration		Zip Code Prioritizations for COVID-19 Vaccine Rollout		Available Transportation Options to COVID-19 Vaccination Sites		Linguistically and Culturally Accessible COVID-19 Vaccination Providers		Translation of COVID-19 Vaccine Information		Mandated Paid Leave for COVID-19 Vaccinations for Public Jobs	
		P	I	P	I	P	I	P	I	P	I	P	I	P	I
New York City	Oct 2020 V 1.0	Y	Y	Y	Y	N	Y	N	Y	N	Y	Y	Y	N	Y
Los Angeles	Oct 16, 2020 V 1.0	Y	Y	Y	Y	N	Y	N	Y	N	Y	Y	Y	N	Y
Chicago	Jun 20, 2021 V 8.1	Y	Y	Y	Y	N	N	N	N	N	Y	N	Y	N	Y
Houston	Oct 16, 2020 V 1.0	N	Y	Y	Y	N	Y	N	Y	N	Y	N	Y	N	N
District of Columbia	Nov 27, 2020 V 1.0	Y	Y	Y	Y	N	Y	N	Y	N	N	Y	Y	N	N
Miami	Oct 16, 2020 V 1.0	N	Y	Y	N	N	N	N	Y	N	Y	N	Y	N	N
Philadelphia	Mar 31, 2021 V 8.0	N	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	N	Y
Atlanta	Oct 15, 2020 V 1.0	N	Y	Y	Y	N	N	N	Y	N	Y	N	Y	N	N
Phoenix	Oct 2020 V 1.0	Y	Y	Y	Y	N	N	N	Y	N	Y	N	Y	N	NA
Boston	Oct 16, 2020 V 1.0	N	Y	Y	Y	N	NA	N	Y	N	Y	Y	Y	N	Y

(*continues*)

TABLE 2
COVID-19 Vaccination Equity Best Practices[a] (*Continued*)

	#8		#9		#10		#11		#12		#13		#14		#15	
	Partnership With Community Organizations for COVID-19 Vaccination Clinics		Partnerships With Community Leadership for COVID-19 Public Health Messaging		Establish Mobile or Pop-Up COVID-19 Vaccination Clinics		Walk Up COVID-19 Vaccination Sites (Without Appointment)		Repurposing of Preexisting COVID-19 Testing Infrastructure for Vaccinations		Remove Requirements for Proof of Residency for COVID-19 Vaccination		COVID-19 Vaccine Education Outreach Efforts		Public/ Private Partnerships for COVID-19 Vaccination	
	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I
New York City	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y
Los Angeles	Y	Y	Y	Y	Y	Y	N	Y	N	Y	N	N	Y	Y	Y	Y
Chicago	Y	Y	N	Y	Y	Y	N	Y	N	Y	N	N	Y	Y	Y	Y
Houston	N	Y	Y	Y	Y	Y	N	Y	N	Y	N	N	Y	Y	Y	NA
District of Columbia	Y	Y	Y	Y	Y	Y	N	Y	Y	NA	N	N	Y	Y	Y	Y
Miami	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y
Philadelphia	Y	Y	Y	Y	Y	Y	N	Y	N	Y	N	Y	Y	Y	Y	Y
Atlanta	Y	Y	Y	Y	Y	Y	N	Y	N	Y	N	N	Y	Y	Y	NA
Phoenix	Y	Y	Y	Y	N	Y	N	Y	N	Y	N	N	Y	Y	Y	Y
Boston	Y	Y	Y	Y	Y	Y	N	Y	N	Y	N	Y	Y	Y	N	Y

Abbreviations: I, evidence of implementation; N, No; NA, not available; P, initially proposed; Y, Yes.

[a] Binary analysis of initial proposition and evident implementation of 15 best practices for COVID-19 vaccination in 10 large US cities. Dates and versions of available COVID-19 Vaccination Plans for each city's state were recorded. "Y" (Yes) corresponds with the corroboration of the best practice. "N" (No) corresponds with the contradiction of the best practice. "NA" (not available) corresponds with the absence of credible news sources that support or deny the best practice's implementation.

TABLE 3
Implementation of COVID-19 Vaccination Equity Best Practices[a]

	Number of Fulfillments (Y → Y)	Number of Adjustments (N → Y)	Number of Unaddressed (N → N)	Number of Maladjustments (Y → N)	Number of Total Best Practices Implemented
New York City	9	6	0	0	15
Los Angeles	8	6	1	0	14
Chicago	6	6	3	0	12
Houston	4	8	2	0	12
District of Columbia	8	3	3	0	11
Miami	5	7	2	1	12
Philadelphia	8	7	0	0	15
Atlanta	5	6	3	0	11
Phoenix	6	6	2	0	12
Boston	6	8	0	0	14

Abbreviations: N, No; Y, Yes.

[a] *Analysis of the transition from initially proposing to implementing best practices in 10 large US cities.*

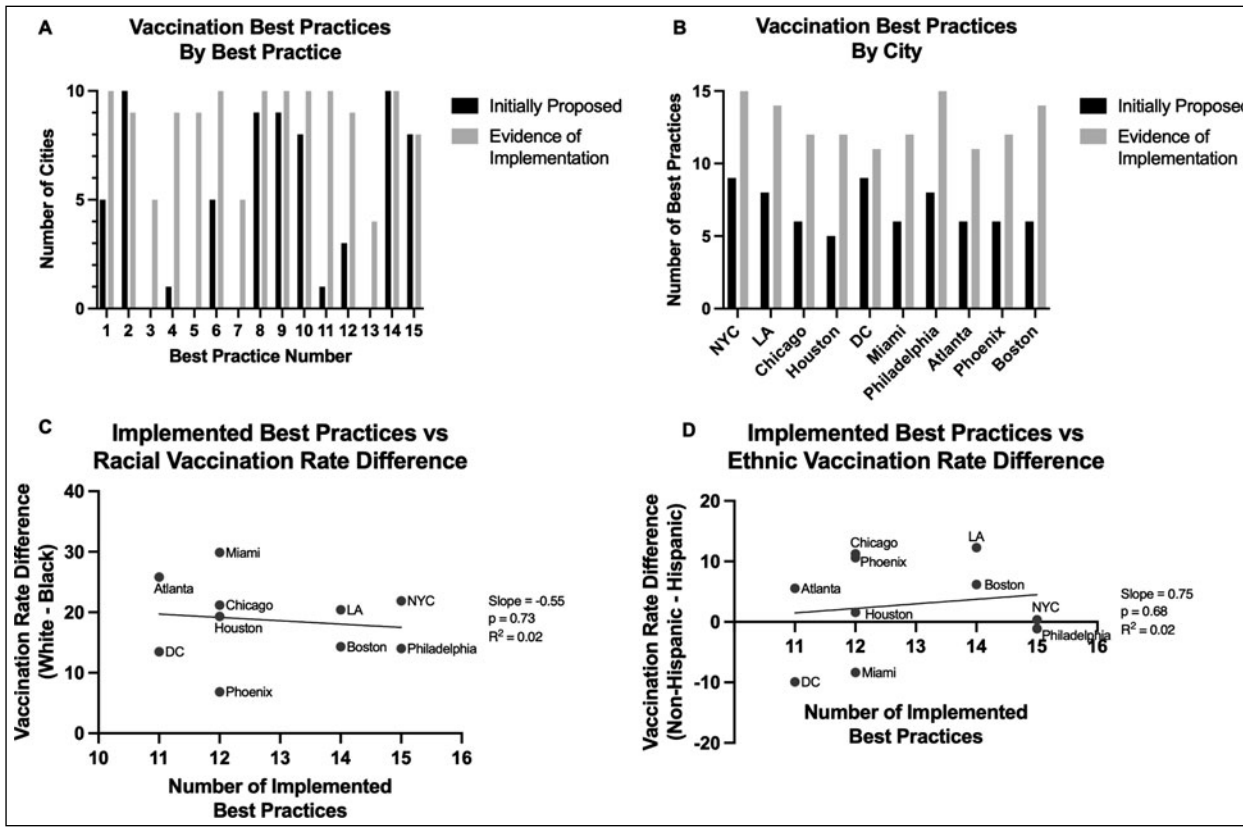

FIGURE 2 Analysis of COVID-19 Vaccination Equity Best Practice Proposals and Implementations
(A) Number of cities that initially proposed and evidently implemented each of the 15 best practices. Best practice numbers correspond to the best practices listed in the "Methods" section and shown in Table 2. (B) Number of best practices initially proposed and evidently implemented in all 10 cities. (C) Linear regression of number of implemented vaccination equity best practices prediction of vaccination rate differences between White and Black individuals. (D) Linear regression of number of implemented vaccination equity best practices prediction of vaccination rate differences between non-Hispanic and Hispanic individuals.

should address a wider array of cities, as well as other US locales, including smaller, rural areas. Poor data quality additionally limited our ability to investigate the factors associated with race- and ethnicity-based COVID-19 vaccination equity. Utilization of the 2019 Census Bureau ACS for population could impact our analyses, due to population and demographic changes between 2019 and 2021. Furthermore, we cannot account for people who received a vaccine in a different county from where they reside.

Our work solely addresses information that was publicly available online. While this is an important distribution channel for US residents, a more complete picture of COVID-19 vaccination inequities and disparities could be obtained through direct contact and primary data collection from public health officials and other involved stakeholders. We are not aware of any evidence that public media reporting accurately represents cities' implementations of vaccination plans. It is likely that much reporting lacks significant granularity concerning vaccination plan implementation. Finally, the binary nature of the vaccination best practice analysis likely does not reflect the spectrum of ways in which vaccination equity strategies were implemented. Better data on such details would allow for a deeper interrogation of the effectiveness of the COVID-19 vaccination best practices analyzed in this study.

Heterogeneity in COVID-19 responses has been one of the defining characteristics over the course of the pandemic in the United States, resulting in marked fragmentation and discordance.[28] Lack of vaccination data collection, public reporting, and transparency has likely hindered public health responses by impeding the ability of public health officials to track whether and how certain strategies made a difference. For example, variation in reporting inhibited our ability to effectively assess whether vaccination equity programs were reaching Hispanic communities. These deficiencies in vaccination data may explain why many cities did not initially propose some COVID-19 vaccination equity best practices and why most cities did not end up implementing all best practices.

Improved standardization of vaccination data is likely necessary to promote racial and ethnic COVID-19 vaccination equity. This could include ensuring common definitions of racial and ethnic groups across US cities, inclusion of all common racial and ethnic groups, and continuity of public vaccination data reporting over time. A federally operated centralized database synthesizing vaccination data from cities and states across the United States could further improve data standardization. We further suggest that more extensive characterization and reporting of vaccination equity strategies rolled out in US cities are necessary to enable formal analysis of the impact of such strategies. Assigning these roles of monitoring and reporting to specific public health officials may be an effective way to facilitate this objective. Generally, our findings indicate that a more unified structure in public health response may be necessary to effectively promote racial and ethnic COVID-19 vaccination equity and prompt many avenues of future investigation to address this pertinent issue.

Implications for Policy & Practice

- Lack of vaccination data collection, public reporting, and transparency has likely hindered public health responses by impeding the ability of public health officials to track whether and how certain strategies made a difference.
- Variation in reporting inhibited our ability to effectively assess whether vaccination equity programs were reaching Hispanic communities. These deficiencies in vaccination data may explain why many cities did not initially propose some COVID-19 vaccination equity best practices and why most cities did not end up implementing all best practices.
- Our findings suggest that a more unified structure in public health response may be necessary to effectively promote racial and ethnic COVID-19 vaccination equity.

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