How have state-level policy responses influenced vaccination uptake of the COVID-19 pandemic in the United States

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Abstract

This study assesses the influence of state-level policies on COVID-19 vaccination rates in the US, focusing on California, New York, Texas, and Florida from 2020 to 2022. Initial findings show a positive correlation between policy intensity and vaccination rates, highlighting the effectiveness of early measures. However, in 2021, this trend reversed due to vaccine hesitancy and availability, indicating the complex nature of policy impact over time. The analysis also reveals that mandatory vaccination policies correlate with higher uptake. Overall, the research suggests that adaptable, equity-focused public health policies are crucial for successful vaccination campaigns in the face of evolving public health challenges.

Introduction

The COVID-19 pandemic, declared by the WHO in March 2020, profoundly impacted global health, economies, and daily lives. Initially, the absence of a vaccine presented a significant challenge, leading to widespread uncertainty and an urgent need for effective interventions. The breakthrough came with the FDA's emergency use authorization of the Pfizer-BioNTech vaccine in December 2020, followed by Moderna and Johnson & Johnson, marking a pivotal moment in the U.S.'s fight against the pandemic (U.S. Department of Health and Humanity Services).

Our study concentrates on the period from January 2020 to December 2022, a critical phase for the initial rollout and subsequent uptake of COVID-19 vaccines across the U.S. We specifically focus on California, New York, Texas, and Florida for our analysis (Figure1), chosen because they are the top four states by Gross Domestic Product (GDP), making them significant both economically and demographically.

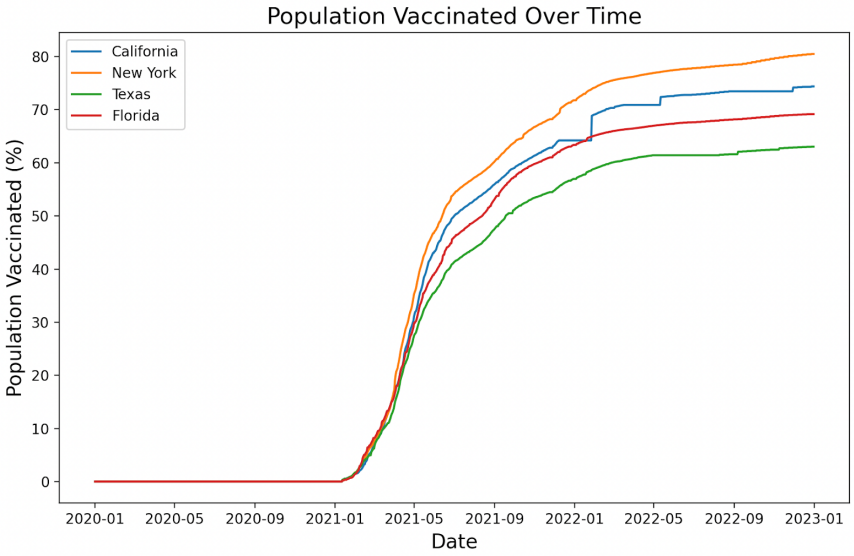

Figure1. Population Vaccinated Over January 2020 to December 2022

Our research question explores the impact of state-level policies on vaccination uptake during this pivotal time. Through the examination of policy interventions alongside vaccination rates in these states, our aim is to uncover insights regarding the dynamics of vaccine distribution and acceptance. This understanding will inform future public health policy and enhance pandemic response strategies without specifically focusing on the effectiveness of individual strategies.

Data

Our study uses data from the Oxford COVID-19 Government Response Tracker (OxCGRT), which tracks how governments worldwide have responded to the pandemic, focusing especially on vaccination policies from 2020 to 2022. This dataset helps us understand the different ways governments have tried to get people vaccinated, through methods like vaccine requirements or public health messages. (Table1)

We're looking specifically at how these vaccination policies have worked in the United States. By examining the OxCGRT data, we have a comprehensive view of the policy measures analyzed in our study, including vaccine prioritization, eligibility, financial support, and mandatory vaccination requirements as shown in the table below. (Table 2.1&2.2)

Policy	**Coding of Measure**
V1 Vaccine Prioritization	0 - No plan 1 - A prioritized plan is in place 2 - Universal/general eligibility; No prioritization between group
V2 Vaccine Eligibility/Availability	0 - No categories are receiving vaccines 1 - Vaccines are available to some categories 2 - Vaccines are available to anyone over the age of 16 3 – vaccines are available to anyone over the age of 16 yrs PLUS one or both of 5-15 yrs and 0-4 yrs
V3-Vaccine Financial Support	0 - No availability 1 - full cost to the individual for all categories identified in V2 2 - full cost to the individual for some categories identified in V2, some subsidy for other categories 3 - partial funding by the government for all of the categories identified in V2 4 - partial funding by the government for some categories identified in V2, full funding for other categories 5 - all categories fully funded by the government
V4 Mandatory Vaccination	0 – no requirement to be vaccinated 1 – requirement to be vaccinated is in place for one or more groups

Table 1. Coding of Measures

States	V1	V2	V3	V4
California	2	3	5	0
	(0,1,2)	(0,1,2,3)	(0,5)	(0, 1)
Texas	2	2	5	0
	(0,1,2)	(0,1,2,3)	(0,5)	(0)
New York	2	3	5	0
	(0,1,2)	(0,1,2,3)	(0,5)	(0, 1)
Florida	2	3	5	0
	(0,1,2)	(0,1,2,3)	(0,5)	(0)

Table 2.1 Median Index of Vaccination Policy of Each States in 2021

States	V1	V2	V3	V4
California	2	3	5	1
	(0,1,2)	(0,1,2,3)	(0,5)	(0,1)
Texas	2	2	5	0
	(0,1,2)	(0,1,2,3)	(0,5)	(0,)
New York	2	3	5	1
	(0,1,2)	(0,1,2,3)	(0,5)	(0,1)
Florida	2	3	5	0
	(0,1,2)	(0,1,2,3)	(0,5)	(0)

Table 2.2 Median Index of Vaccination Policy of Each States from 2020-2022

Methodology

In our study, we aim to analyze the correlation between government policy intensity and changes in vaccination rates using Spearman's rho (ρ) and Kendall's tau (τ). These nonparametric statistical tools are selected for their effectiveness in identifying the strength and direction of associations between ranked variables, without assuming linearity or normal distribution. Previous research supports their suitability and advantages over traditional methods like

Pearson's correlation, particularly in datasets with non-normal distributions (Gilpin, 1993; Puth, Neuhäuser, & Ruxton, 2015; Xu, Hou, Hung, & Zou, 2013).

Both coefficients range from -1 (perfect negative correlation) to +1 (perfect positive correlation). Positive correlation indicates that both variables increase together, while negative correlation suggests an inverse relationship. Significance is determined through p-values, with a threshold commonly set at $p < 0.05$ to reject the null hypothesis, indicating statistically significant findings unlikely to occur by chance. This approach, supported by Biau, Jolles, and Porcher (2010), allows for the differentiation of significant results from those possibly arising from data variability, ensuring a robust analysis.

Our methodology involves ranking our two variables—policy intensity and vaccination changes—before calculating Spearman's rho and Kendall's tau. This approach will uncover the impact of government policies on vaccination uptake, offering insights into policy effectiveness in public health.

Result

The research paper delves into the impact of state-level policy responses on COVID-19 vaccination uptake in the United States, focusing on an analysis from 2020 to 2022 with specific insights into different time periods and policy roles. This comprehensive study provides a nuanced understanding of how public health policies influenced vaccination rates, highlighting the variations in policy effectiveness over time and across different strategies.

Our study faced limitations due to uniform government funding for vaccinations across all states, eliminating variability in financial support analysis. Additionally, the lack of mandatory vaccination policies in states like Florida and Texas hindered our ability to evaluate the effect of policy enforcement on vaccination rates.

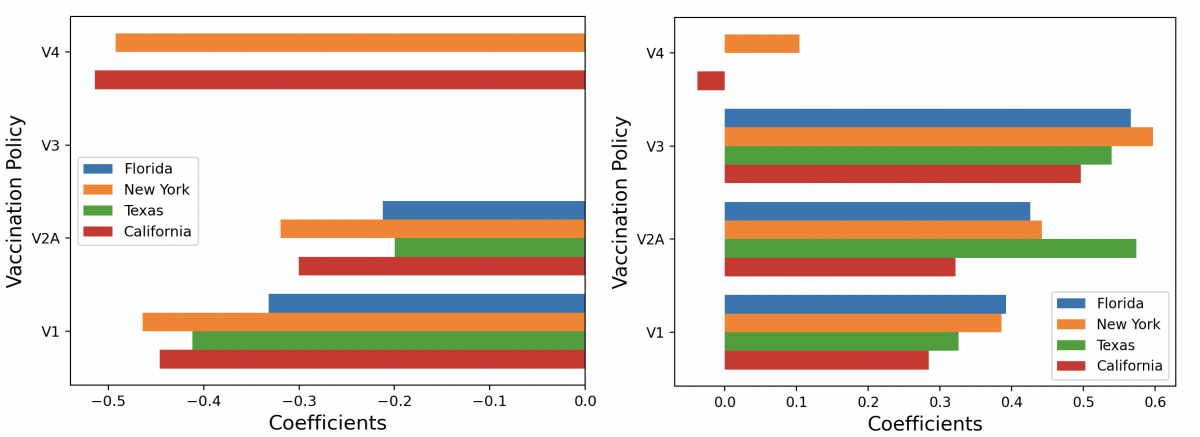

Figure2. Comparison of Spearman's rho Correlation Coefficients

(Left 2021, Right 2020-2022)

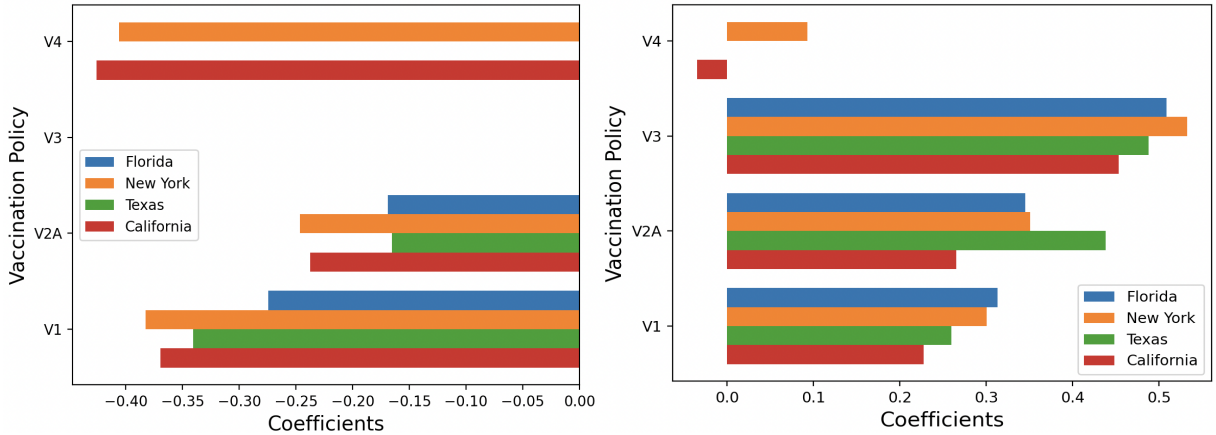

Figure3. Comparison of Kendall's tau Correlation Coefficients

(Left 2021, Right 2020-2022)

Positive and Negative Correlation Across Different Time Periods

Positive Correlation (2020-2022): The study uncovered a consistent positive correlation between the intensity of vaccination policies and the rise in vaccination rates in states such as Florida, New York, Texas, and California from 2020 to 2022. This positive correlation emphasizes the significance of early and sustained policy measures. Initiatives like public health campaigns, infrastructure for vaccine distribution, and planning played a pivotal role in priming

populations for higher vaccine uptake. The anticipation and readiness for vaccine availability, fostered by intensive policy measures, likely enhanced public trust and receptiveness to vaccination.

Negative Correlation (2021): In contrast, 2021 witnessed a negative correlation between policy intensity and vaccination rate changes across the studied states. This period, marked by increased vaccine availability and the onset of vaccine hesitancy, suggests a diminished impact of policy intensity on vaccination rates. The findings indicate that the direct relationship between policy intensity and vaccination uptake becomes more complex as the public's urgency toward vaccination diminishes. This shift highlights the challenges in navigating vaccine hesitancy and the importance of addressing diverse concerns within the population. It underscores the necessity for policies that are adaptable and sensitive to the changing public health context and sentiments.

State Specific Insights: The variation in correlation coefficients across states highlights the impact of localized policy responses and demographic factors on vaccination uptake. For instance, the stronger positive correlations in states like Florida and New York over the overall period suggest more effective policy measures or higher public receptivity to vaccination campaigns. Conversely, the unique negative correlation observed in California in 2021 for certain vaccine metrics points to specific challenges that may have been encountered, such as higher levels of vaccine hesitancy or logistical issues in vaccine distribution. Furthermore, our analysis reveals that states enforcing mandatory vaccination policies, notably progressive states such as New York and California, tend to achieve higher vaccination coverage. This observation suggests that policy mandates, coupled with demographic and societal factors, play a crucial role in shaping the public's engagement with vaccination programs, thereby affecting overall vaccination success.

Conclusion and Implications for Future Policy

The research highlights the dynamic nature of policy effectiveness in influencing COVID-19 vaccination rates over time and across different strategies. The initial positive correlation demonstrates the critical role of proactive measures, while the negative shift in 2021 reveals the complexities faced as the public health landscape evolved. The insights into specific policy roles further elucidate the strategies that were more effectively correlated with increased vaccination rates, offering valuable lessons for future public health policymaking.

In summary, the study underscores the importance of flexible, inclusive, and equity-focused policy approaches. Future public health policies and pandemic responses should draw on these findings to navigate the challenges of encouraging widespread vaccination uptake effectively, adapting to changes in public attitudes and health crises dynamics.

References

Assistant Secretary for Public Affairs (ASPA). “Covid-19 Vaccines.” HHS.Gov, U.S. Department of Health and Human Services, 13 Mar. 2024, www.hhs.gov/coronavirus/covid-19-vaccines/index.html.

D. Biau et al. "P Value and the Theory of Hypothesis Testing: An Explanation for New Researchers." Clinical Orthopaedics and Related Research®, 468 (2010): 885-892. https://doi.org/10.1007/s11999-009-1164-4.

Gilpin, Andrew R. “Table for Conversion of Kendall’S Tau to Spearman’S Rho Within the Context of Measures of Magnitude of Effect for Meta-Analysis.” *Educational and Psychological Measurement*, vol. 53, no. 1, 1993, pp. 87–92, https://doi.org/10.1177/0013164493053001007.

Puth, Marie-Therese, et al. “Effective Use of Spearman’s and Kendall’s Correlation Coefficients for Association between Two Measured Traits.” Animal Behaviour, vol. 102, 2015, pp.77–84, https://doi.org/10.1016/j.anbehav.2015.01.010.

Weichao Xu et al. "A comparative analysis of Spearman's rho and Kendall's tau in normal and contaminated normal models." Signal Process., 93 (2013): 261-276. https://doi.org/10.1016/j.sigpro.2012.08.005.

WHO Director-General’s Opening Remarks at the Media Briefing on COVID-19. 11 Mar. 2020, www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020.