The Associations of Vaccination Speed with Incidence of COVID-19 and Social Vulnerability: An Ecologic Study in Maryland

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Background

Previous studies focused on COVID-19 vaccination coverage, a proportion of individuals who received one or more doses of a vaccine. However, coverage alone is insufficient to assess the progress of a vaccination campaign and should instead be reported with a corresponding time interval as a measure of speed. Mathematical models have shown that reaching a lower vaccination coverage proportion in three to six months was more effective in reducing the number of COVID-19-related hospitalizations and deaths than reaching a higher vaccination coverage; suggesting vaccination speed is an important consideration for reducing incidence and mortality.[1] Speed of vaccination was also expected to vary by level of vulnerability, similar to what has been reported for vaccination rates across U.S. counties.[2] The association between COVID-19 vaccination speed and social vulnerability has not been thoroughly investigated.

Objectives

1. Describe the relationship between vaccination speed and cumulative incidence at the county-level in Maryland using CDC data.
2. Identify predictors from the CDC Social Vulnerability Index (SVI) that significantly influenced the speed at which Maryland counties achieved 50% coverage of at least one vaccine dose.

Methods

- As the outcome variable, vaccination speed was defined as the number of days between the date SARS CoV-2 vaccines were first available in the county and the date 50% coverage of at least one dose was achieved.
- A correlation analysis was conducted to investigate the relationship between vaccination speed and COVID-19 incidence in Maryland.
- Negative binomial regression models were employed to predict vaccination speed, taking the county population as the offset. To prevent multicollinearity, predictors that were highly correlated with another one were removed from the model.
- Cumulative incidence was calculated per 10,000 county residents starting from the date 50% coverage was achieved and 42 days (6 weeks) after.
- A 14-day lag was applied to account for the incubation period of SARS-CoV-2 and time to develop an immune response from a vaccine dose.[3]

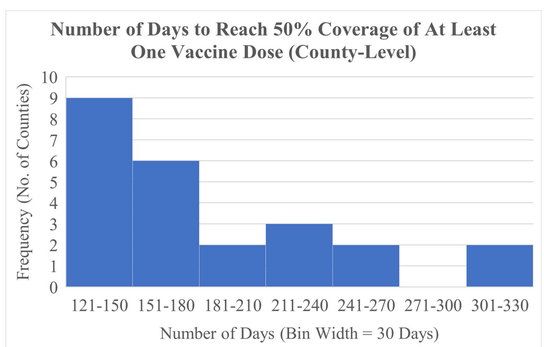

Figure 1. The distribution of vaccination speed. Speed was defined as the number of days to reach 50% coverage of at least one dose. (N=24 counties)

Table 1. Results from negative binomial regression analyses predicting vaccination speed (days to reach 50% coverage) using SVI predictors. (N=24 counties) [A]

	Simple Negative Binomial Regression		Multiple Negative Binomial Regression	
Parameter	**Regression Coefficient (95% CI)**	***P***	**Regression Coefficient (95% CI)**	***P***
SVI Themes				
Socioeconomic Status	0.02 (0.01 – 0.04)	0.01	0.03 (0.01 – 0.06)	<0.01
Household Composition and Disability	0.03 (0.01 – 0.06)	0.02	0.02 (-0.01 – 0.04)	0.11
Minority Status and Language	-0.02 (-0.04 – 0.01)	0.15	-0.03 (-0.04 – -0.01)	<0.01
Housing Type and Transportation	0.01 (-0.01 – 0.02)	0.37	-0.01 (-0.03 – 0.01)	0.18
Predictors Within Theme 1: Socioeconomic Status				
Below Poverty	0.13 (0.04 – 0.23)	0.01	-0.06 (-0.26 – 0.14)	0.57
Unemployed [B]	0.10 (-0.12 – 0.33)	0.38		
Income	-0.03 (-0.04 – -0.02)	<0.01	-0.03 (-0.05 – -0.01)	0.03
No High School Diploma	0.20 (0.07 – 0.34)	<0.01	0.11 (-0.16 – 0.38)	0.42
Predictors Within Theme 2: Household Composition & Disability				
Aged 65 or Older	0.15 (0.03 – 0.27)	0.02	0.06 (-0.09 – 0.21)	0.43
Aged 17 or Younger	-0.23 (-0.38 – -0.07)	<0.01	-0.06 (-0.26 – 0.14)	0.54
Civilian with a Disability	0.32 (0.19 – 0.46)	<0.01	0.21 (0.04 – 0.38)	0.02
Single-Parent Households	0.10 (-0.10 – 0.29)	0.32	0.11 (-0.08 – 0.29)	0.26
Predictors Within Theme 3: Minority Status & Language				
Minority	-0.02 (-0.05 – 0.00)	0.06	-0.01 (-0.03 – 0.03)	0.82
Speak Limited English	-0.57 (-0.83 – -0.30)	<0.01	-0.54 (-0.91 – -0.16)	<0.01
Predictors Within Theme 4: Housing Type & Transportation				
Multi-Unit Structures	-0.06 (-0.10 – -0.02)	0.01	-0.06 (-0.09 – -0.04)	<0.01
Mobile Homes	0.38 (0.24 – 0.51)	<0.01	0.37 (0.28 – 0.46)	<0.01
Crowding	-0.52 (-1.00 – -0.04)	0.03	-0.28 (-0.51 – -0.05)	0.02
No Vehicle	0.08 (-0.07 – 0.23)	0.30	0.02 (-0.03 – 0.07)	0.38
Group Quarters	0.08 (-0.01 – 0.16)	0.09	-0.01 (-0.07 – 0.05)	0.76
Composite Measure of Vulnerability Across All Themes				
Overall Vulnerability	0.01 (-0.01 – 0.03)	0.11		

CI = Confidence interval, SVI = Social Vulnerability Index

[A] Log of the county population was used as the offset for all negative binomial regression analyses.

[B] Proportion of unemployed residents was removed from the multiple negative binomial regression model due to high correlation with other theme 1 predictors.

References

1. Alvarez MM, Bravo-González S, Trujillo-De Santiago G. Modeling vaccination strategies in an Excel spreadsheet: Increasing the rate of vaccination is more effective than increasing the vaccination coverage for containing COVID-19. *PLoS ONE*. 2021;16(7 July 2021). doi:10.1371/journal.pone.0254430
2. Brown CC, Young SG, Pro GC. COVID-19 vaccination rates vary by community vulnerability: A county-level analysis. *Vaccine*. 2021;39(31). doi:10.1016/j.vaccine.2021.06.038
3. U.S. Centers for Disease Control and Prevention. COVID-19. Published March 24, 2022. Accessed March 24, 2022. https://www.cdc.gov/coronavirus/2019-nCoV/index.html.

Results

- The median number of days to 50% coverage in Maryland was 157 with an interquartile range (IQR) between 137.5 – 223 days (Figure 1). Fifteen of the 24 Maryland counties reached 50% coverage within six months.
- Strong positive correlation between the number of days to reach 50% coverage of at least one vaccine dose and cumulative incidence of COVID-19 in the following several weeks (r=0.85, P<0.01, Figure 2).
- The number of days to reach 50% coverage significantly increased as vulnerability due to socioeconomic status (SES) increased (Table 1).
- Increased vulnerability due to minority status and language resulted in a decrease in number of days to 50% coverage; a result that was significant when controlling for the other themes.
- Increased proportion of mobile homes and civilians with a disability were associated with a significant increase in days to 50% coverage in theme-specific multivariable models.
- Increases in income, proportion that speak limited English, proportion of multi-unit structures, and crowding were significantly associated with a decrease in number of days to 50% coverage in theme-specific multivariable models.

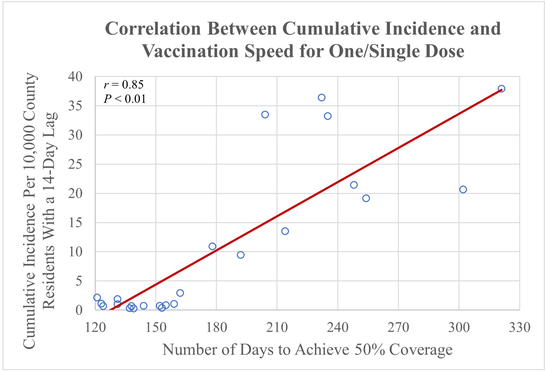

Figure 2. Scatterplot fit with a trendline to display the linear relationship between time to reach 50% coverage of at least one vaccine dose and cumulative incidence of COVID-19 at the county-level. (N=24)

Conclusions and Importance

This study documented that there was a strong relationship between vaccination speed and the reduced incidence of COVID-19 in Maryland. It also identified social vulnerability factors that potentially predict the vaccination speed. The findings of this study indicate that public health efforts should address the speed of vaccination and its impact on disease incidence, rather than overall coverage. To increase the speed, intervention programs should continue to focus on equitable access to vaccines, which has been effective for reaching minority groups. Additional characteristics of the target population for enhancing vaccination programs include low SES, civilians with disabilities, and mobile home communities. When evaluating vaccination programs in other regions, a similar analysis could be conducted to identify and address population-specific factors associated with vaccination speed. Applying these methods and results would allow for informed decision making, equity in vaccine accessibility, and reduction of COVID-19 incidence, especially within vulnerable communities.