Identification of State-Level Factors Associated With Changes in Vaccination Coverage Rates in Adults Aged 18-64 Years in the United States

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Background

- Vaccination is recognized as an essential public health service, substantially reducing morbidity, mortality, and economic burdens associated with vaccine-preventable diseases
- Despite the recognized value of life-course vaccination, adult vaccine uptake remains low
- The Centers for Disease Control and Prevention (CDC) conducts a random survey in all 50 of the United States (US) and territories called the Behavioral Risk Factor Surveillance System (BRFSS)
  - Survey information is used to by the CDC to estimate vaccination coverage rates
- Studies utilizing BRFSS data have shown that adult vaccination coverage rate (VCRs) are highly variable across states[1,2], suggesting that factors such as state-level programs and policies may impact vaccine uptake
  - In an analysis of 2011-2014 BRFSS data, interstate VCR variability remained high after adjusting for individual characteristics (e.g., sex, income, and level of education)[1]
  - A study using 2015-2017 BRFSS data found a significant association between adult vaccination coverage and state-level factors, including insurance coverage and participation in adult immunization information systems[2]
- We present results from a quantitative analysis using data from the BRFSS to evaluate associations between state-level factors and changes over time in adult VCRs in the US to uncover promising practices and policies that can support increased vaccine uptake

Objective

- To identify state-level factors associated with increased adult VCRs in the US for influenza, tetanus-containing, herpes zoster (HZ), and pneumococcal vaccines over time

Methods

- We conducted a retrospective, exploratory database analysis of secondary, anonymized, individual-level data from the 2011-2019 BRFSS to estimate state-level adult VCRs, combined with publicly available data to evaluate state-level factors associated with increases in adult VCRs
- Study population: individuals aged 18-64 years who participated in any of the 2011-2019 BRFSS surveys
- Vaccines included in the study: influenza; tetanus and diphtheria (Td) and tetanus, diphtheria, and acellular pertussis (Tdap); HZ; pneumococcal; and human papillomavirus (HPV)
  - Between 2011 and 2019, influenza and pneumococcal vaccination questions were included in the core BRFSS component; HPV vaccination questions were optional modules; Td/Tdap and HZ vaccination questions were included in the core component for some years (Td/Tdap: 2013, 2016, and 2019, HZ: 2014 and 2017) and as optional modules in other years
- Influenza and Td/Tdap VCRs were estimated among adults aged 18 to 64 years; HZ VCR was estimated among adults aged 60 to 64 years; pneumococcal VCR was estimated among adults aged 18 to 64 years at increased risk of pneumococcal disease; and HPV VCR was estimated among adults aged 18 to 49 years
  - Note that adult recommendations for HZ and HPV have evolved over the years
  - Vaccine coverage was defined as the estimated proportion of adults who received each vaccine
  - Change in vaccine coverage per year (hereafter changes in VCR) was defined as the difference in vaccination coverage between the latest and earliest years with available BRFSS data for the given vaccine divided by the number of years over which that difference was computed
    - Influenza and pneumococcal: 2011 and 2019
    - Td/Tdap: 2013 and 2019
    - HZ: 2014 and 2017
    - HPV (11 states that included the optional BRFSS HPV module in either 2018 or 2019 and in at least 1 other year that was 3 years earlier): varied by state, with change calculated from the earliest year that the state included the optional HPV module to the latest year
- Multivariable logistic regression models were used to assess the simultaneous association between state-level characteristics and changes in VCR
- Publicly available data were used to identify candidate state-level factors for the multivariable models via a systematic variable selection routine:
  - Associations between state change in VCR and each state-level variable was evaluated using Spearman correlation coefficients and a Kruskal-Wallis Test for continuous and categorical state-level variables, respectively
  - Associations between state-level variables and change in VCR were assessed for all years of state-level data that overlapped with the study period. If only one year of data was available for a state-level variable, that year of data was used even if it was outside the study period
  - State-level variables meeting prespecified cutoffs (correlations > 0.4 or < −0.4 [continuous] or P value from Kruskal-Wallis Test < 0.2 [categorical]) were considered for inclusion in the final multivariable regression models

Results

- In general, most states demonstrated increases in VCR across all five vaccine types
- A summary of state-level variables meeting prespecified cutoffs for association with changes in VCR are presented in Table 1

Table 1. Summary of State-Level Variables Meeting Criteria[a] for Association with Change in Coverage (Excluding HPV)

| State-level variable (years data were available)	Number of years criteria met			
	Influenza	Pneumococcal	Td/Tdap	HZ
ACA marketplace percentage receiving advance premium tax credits (2017-2019)	2			
Percentage of population who are noncitizens (2011-2019)		CHG		
Uninsured rate for nonelderly at 200%-399% of federal poverty level (2011-2019)			1	
Percentage of adults who report not seeing a doctor in past 12 months because of cost (2013-2019)	2	2		
Percentage of adults self-reporting fair health (2013-2019)	1			CHG
Percentage of adults self-reporting very good health (2013-2019)	3			
Percentage of adults who report participating in any physical activity or exercise (2013-2019)	2			
Medicaid expansion status (2014-2019)	4	2		2
At least 1 Medicaid eligibility expansion reported (2011-2019)	1	1	1	1
Accountable care organizations in place (2015-2019)	3			
Health homes in place (2015-2019)[b]	2	1		5
Evidence of provider feedback and quality improvement programs on state immunization website (2021)			1	

ACA = Affordable Care Act

[a] Correlations > 0.4 or < −0.4 (Continuous Variables) or P value from Kruskal-Wallis Test < 0.2 (categorical variables)

[b] An optional Medicaid State Plan benefit for states to establish Health Homes to coordinate care for people with Medicaid who have chronic conditions.

Note: Associations between change in VCR and state-level variables were assessed for all years of state-level data that overlapped with the study period (2011-2019). For each vaccine, the number of years for which the association between change in VCR and the state-level variable met the criteria above is displayed in the cells of the table. In addition, for state-level variables for which a change variable was calculated (i.e., change in the state-level variable between the start and end of the study period), if the change variable met the criteria for association with the change in VCR, "CHG" appears in the corresponding cell of the table.

- State-level variables were selected for inclusion in the final multivariable regression models based upon the following criteria:
  - Variables were associated with changes in VCR for at least 1 of the study vaccines
  - Variable were selected if multiple years of data were available that demonstrated an association with changes in VCR
- Variables that were considered actionable (e.g., Medicaid expansion status) were prioritized for inclusion in the final multivariate models over those considered unactionable (e.g., demographic composition of states)
- Because of the low sample size for change in HPV VCR, results from the associations for the other study vaccines were used to inform the selection of state-level variables for the final model for change in HPV VCR
- The final multivariable regression models for changes in influenza, pneumococcal, Td/Tdap, and HZ VCR included the following five state-level variables:
  - Medicaid expansion status, accountable care organizations in place, health homes in place, percentage of adults reporting not seeing a doctor in past 12 months because of cost, and percentage of adults reporting participating in any physical activity
- The final multivariable regression models for change in HPV VCR included the following 2 state-level variables:
  - Medicaid expansion status and health homes in place
- For each state-level variable, data corresponding to the latest year of the change in VCR computation was used for the final multivariable regression models
- Change in vaccination coverage was generally positive (Figures 3-5):
  - From 2011-2019 the change per year in seasonal influenza coverage among adults aged 18-64 years ranged from -0.53% to 1.51%
  - From 2011-2019 the change per year in pneumococcal vaccination coverage among adults aged 18-64 years and at increased risk of pneumococcal disease ranged from -0.27% to 1.29%
  - From 2014-2017 the change per year in HZ vaccination coverage among adults 60-64 years of age in the US ranged from -1.67% to 4.63%

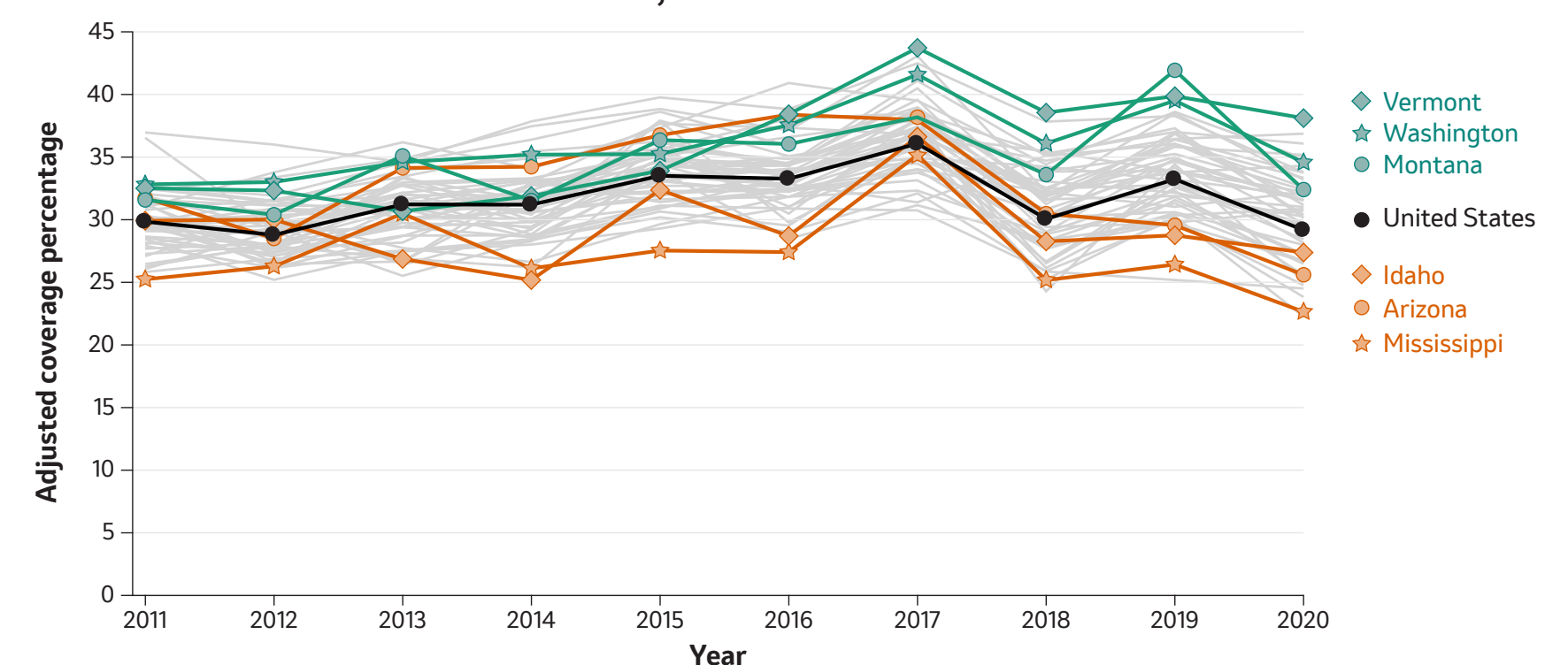- Based on the final multivariable regression models:
  - For influenza, increases in the percentage of adults reporting participating in any physical activity was significantly associated with increases in VCR (P = 0.015)
  - For pneumococcal, increases in the percentage of adults who report not seeing a doctor in the past 12 months because of cost was significantly associated with decreases in VCR (P = 0.016)
  - For HZ, health homes in place was significantly associated with increases in VCR (P = 0.035), and the increases in percentage of adults who report not participating in any physical activity or exercise (P = 0.010) were significantly associated with decreases in VCR. The percentage of adults who report not seeing a doctor in past 12 months because of cost was marginally significant (P = 0.057)
  - There were no significant findings for tetanus-containing and HPV vaccines

Figure 1. Seasonal Influenza Vaccination Coverage Among Adults Aged 18-64 Years in the United States, 2011-2020
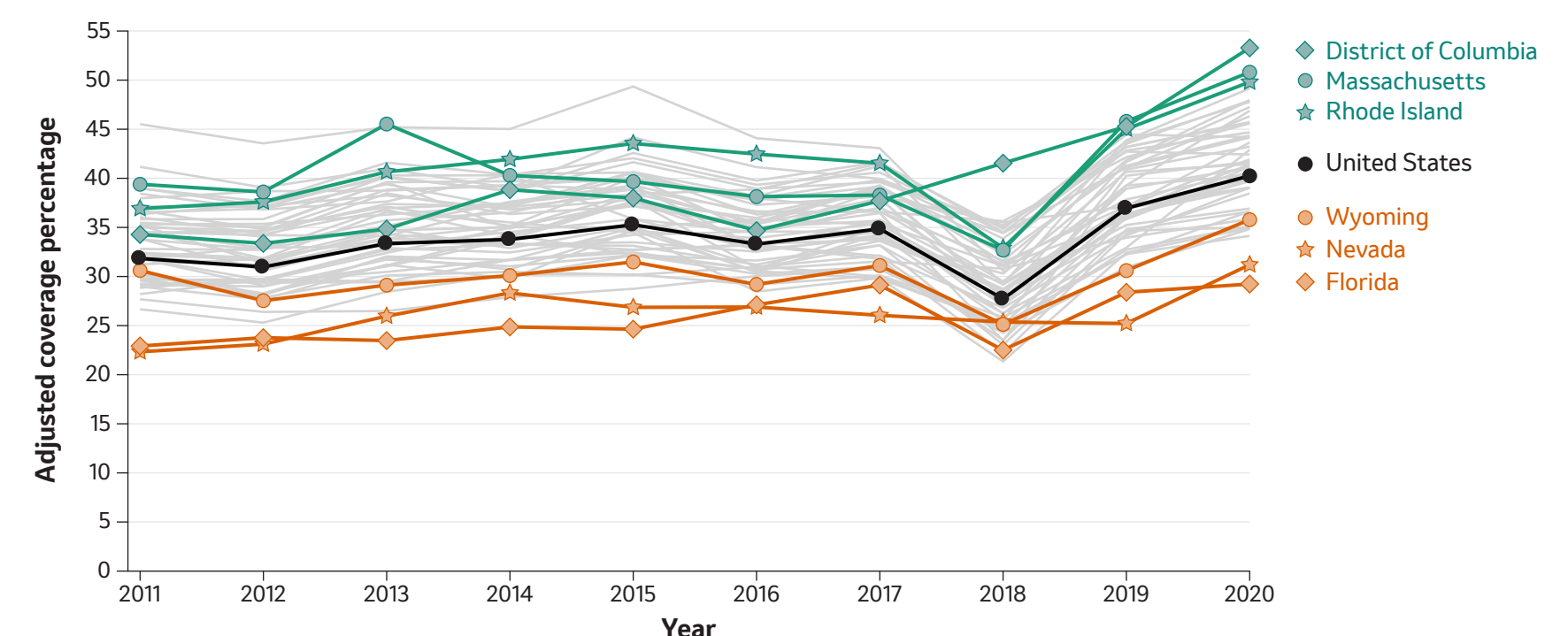
Note: The three states with the highest and lowest vaccination coverage rates in 2019 are represented by green and orange lines, respectively. The remaining states are represented by gray lines. Vaccination coverage rates from 2020 are displayed on the figure but were not used for selecting the highlighted states because of potential difficulties interpreting results due to the global COVID-19 pandemic.
Note: Coverage is weighted to the non-institutionalized United States population based on the Behavioral Risk Factor Surveillance System sampling design.

Figure 2. Pneumococcal Vaccination Coverage Among Adults Aged 18-64 Years at Increased Risk of Pneumococcal Disease in the United States, 2011-2020


Notes: The three states with the highest and lowest vaccination coverage rates in 2019 are represented by green and orange lines, respectively. The remaining states are represented by gray lines. Vaccination coverage rates from 2020 are displayed on the figure but were not used for selecting the highlighted states because of potential difficulties interpreting results due to the global COVID-19 pandemic. Coverage is weighted to the non-institutionalized United States population based on the Behavioral Risk Factor Surveillance System sampling design.

**Table 2. Summary of Multivariable Logistic Regression Models**

State-level variable	Regression coefficient (P value)				
	Influenza	Pneumococcal	Td/Tdap	HZ	HPV
Medicaid expansion status	−0.04 (0.804)	−0.09 (0.507)	0.12 (0.510)	−0.47 (0.176)	0.43 (0.347)
Accountable care organizations in place	0.08 (0.551)	−0.05 (0.669)	−0.19 (0.291)	−0.22 (0.537)	−0.09 (0.827)
Health homes in place	−0.04 (0.770)	−0.02 (0.821)	0.13 (0.409)	**0.67 (0.035)**	–
Percentage of adults who report not seeing a doctor in past 12 months because of cost	−0.03 (0.326)	**−0.07 (0.016)**	0.01 (0.756)	−0.14 (0.057)	–
Percentage of adults who report participating in any physical activity or exercise	**0.04 (0.015)**	−0.00 (0.985)	0.02 (0.374)	**−0.12 (0.010)**	–

Figure 3. Change per Year in Seasonal Influenza Vaccination Coverage Among Adults Aged 18-64 Years in the United States, 2011-2019
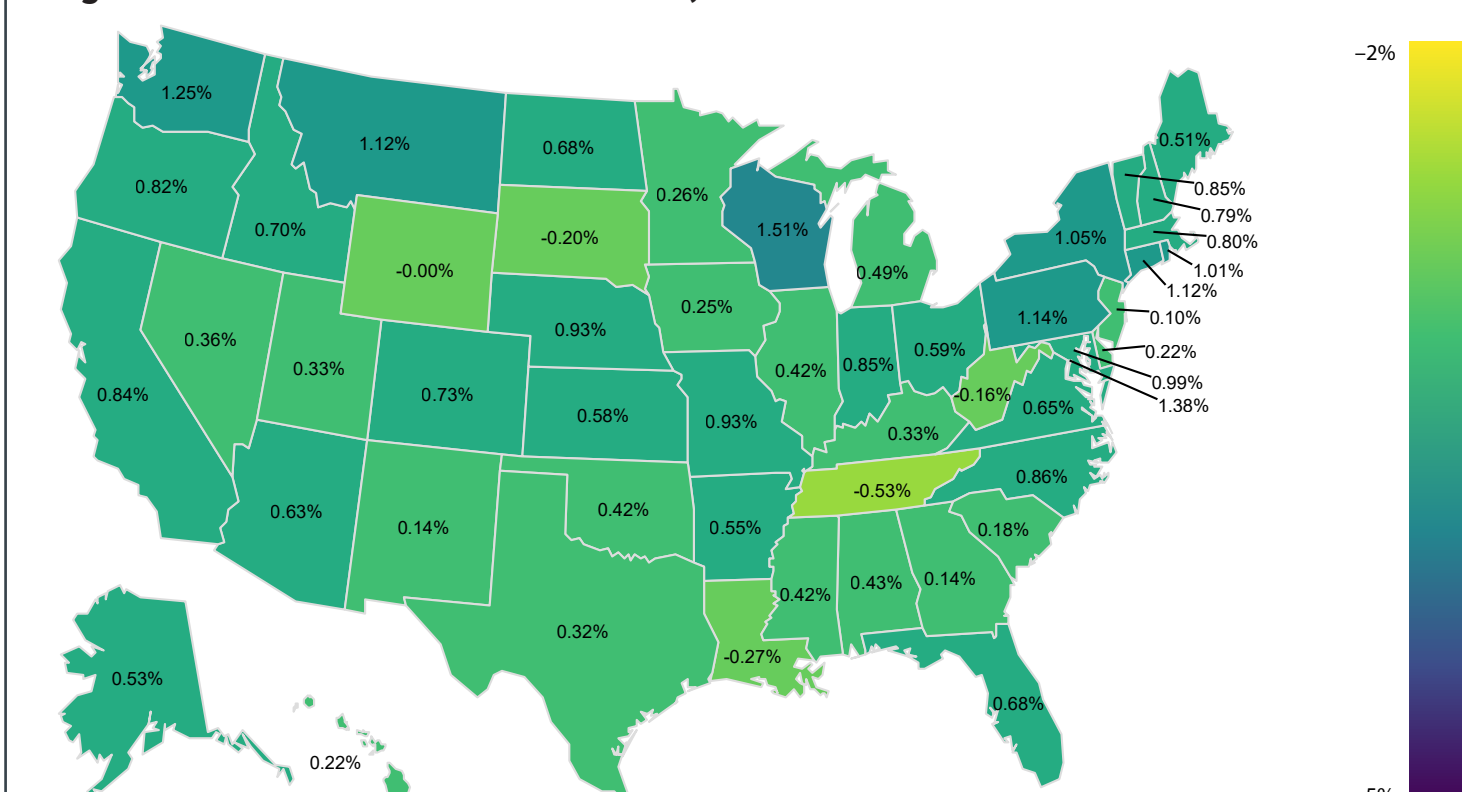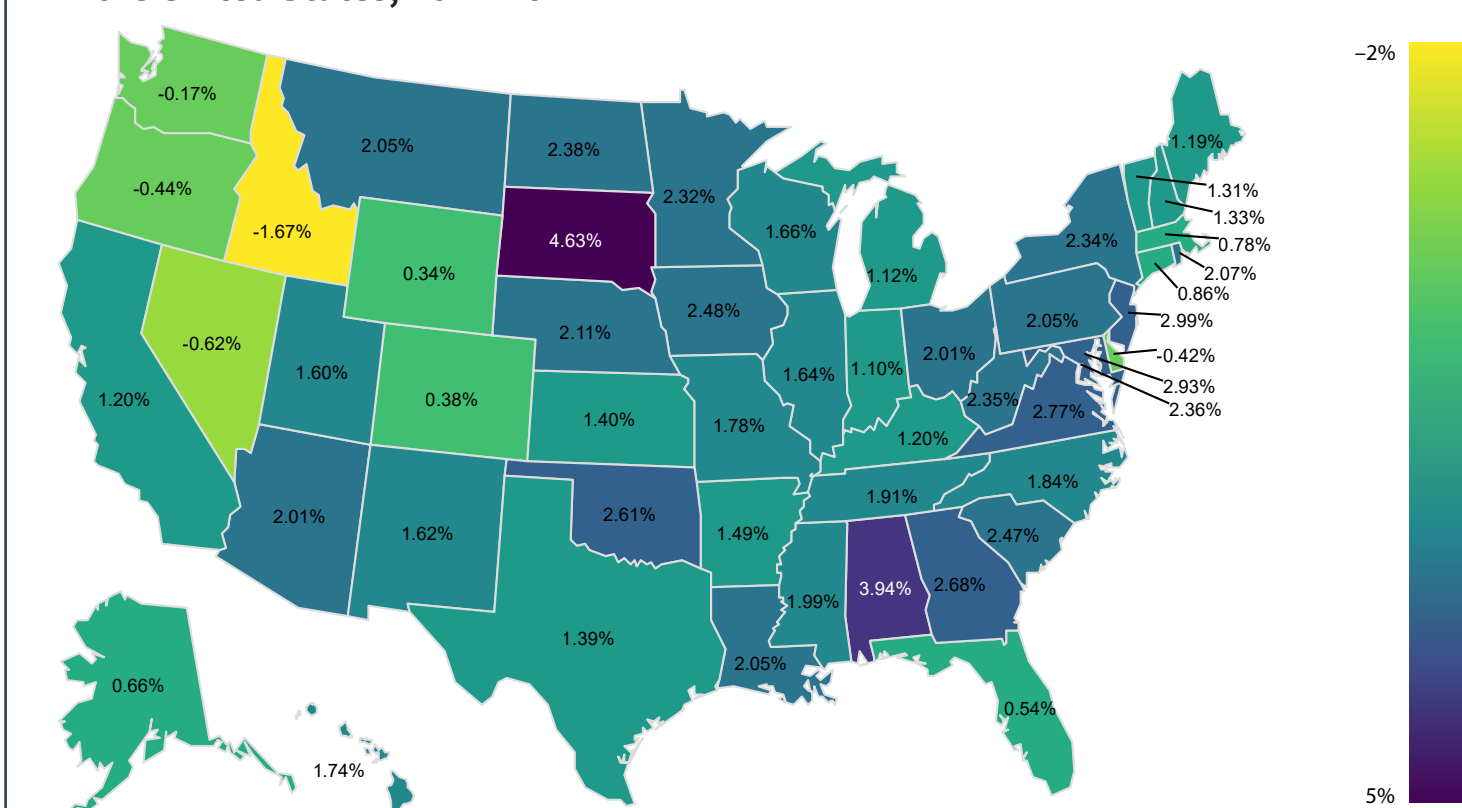

Notes: Change in coverage per year was calculated as the difference in vaccination coverage between the latest and earliest years divided by the number of years over which that difference was computed. In 2019, New Jersey was unable to collect enough data to meet the minimum requirements for inclusion in the aggregate BRFSS data. Therefore, change in vaccination coverage for New Jersey was computed from 2011 to 2018.

Figure 4. Change per Year in Pneumococcal Vaccination Coverage Among Adults Aged 18-64 Years at Increased Risk of Pneumococcal Disease in the United States, 2011-2019
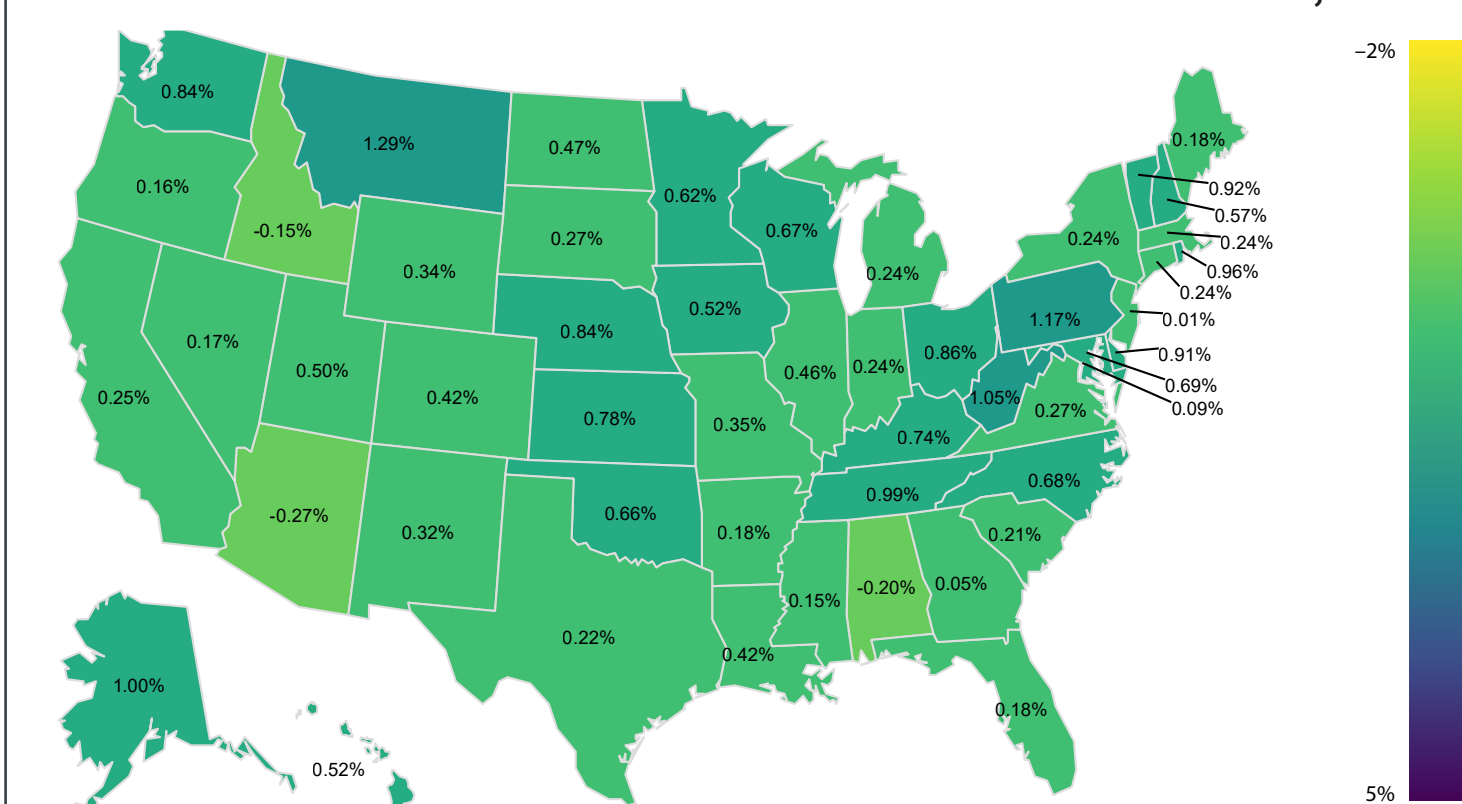
Notes: Increased risk for pneumococcal disease was defined as a self-report of one or more of the following: being a current smoker; currently having asthma; ever having had diabetes, myocardial infarction, angina, or coronary heart disease; having chronic obstructive pulmonary disease, emphysema, or chronic bronchitis; or having any cancer except skin cancer. Change in coverage per year was calculated as the difference in vaccination coverage between the latest and earliest years divided by the number of years over which that difference was computed. In 2019, New Jersey was unable to collect enough data to meet the minimum requirements for inclusion in the aggregate BRFSS data. Therefore, change in vaccination coverage for New Jersey was computed from 2011 to 2018.

Figure 5. Change per Year in HZ Vaccination Coverage Among Adults Aged 60-64 Years in the United States, 2014-2017

Note: Change in coverage per year was calculated as the difference in vaccination coverage between the latest and earliest years divided by the number of years over which that difference was computed.

Discussion

- Changes in VCR were generally modest and positive for most states over the study period
- However, some states were outliers in the analysis regarding changes (and directionality of changes) in VCR
- State-level factors that were significantly associated with changes in VCR were percentage of adults reporting participating in any physical activity (influenza and HZ), percentage of adults reporting not seeing a doctor in past 12 months because of cost (pneumococcal), and health homes in place (HZ).
  - These associations lead to a need for further information to elucidate these findings particularly with regard to directionality. Additional research will consider age, patient subpopulation, and vaccination setting as some interventions may be associated with negative impacts on VCR
- Understanding the state-level interventions and programmatic practices that lead to high VCR or increases in VCR is important, as variation in vaccination coverage was found across states
- Additional research is needed to clarify whether these findings can be attributed to specific state-level interventions and program practices
- Additional research is underway to examine the published literature and qualitative research with state-level policymakers is planned to potentially gain insights into these preliminary findings

Limitations

- BRFSS data are self-reported and therefore subject to recall bias
- BRFSS does not collect information about vaccine eligibility, so we assumed that everyone who reported receiving a vaccine was eligible to receive it
- State-level data were limited to those that are publicly available and may not reflect the entirety of state-level factors that could influence vaccine uptake
- Vaccine uptake is impacted by many factors; therefore, study findings could be the product of other programs, systems, local cultural practices, beliefs, and policies that work together to foster a stronger vaccination ecosystem

Conclusions

- While few state-level variables demonstrated a significant association with changes in VCR, some significant findings were observed in final models
- The associated variables may not have a direct relationship; however, they could be associated with public health infrastructure that supports the vaccination ecosystem
- Data regarding facilitators, barriers, and initiatives impacting adult vaccination coverage and compliance in each state remains limited, and further research is needed to inform the development of evidence-based policies and practices to improve adult vaccination coverage
- Further research is underway to better understand the factors affecting the adult vaccination ecosystem

References

1. La EM, Trantham L, Kurosky SK, Odom D, Aris E, Hogea C. An analysis of factors associated with influenza, pneumococcal, Tdap, and herpes zoster vaccine uptake in the US adult population and corresponding inter-state variability. Hum Vaccin Immunother. 2018;14(2):430-441.
2. Garbinsky D, Hunter S, La EM, Poston S, Hogea C. State-Level Variations and Factors Associated with Adult Vaccination Coverage: A Multilevel Modeling Approach. Pharmacoecon Open. 2021;5(3):411-423.

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