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Associations between population based voting trends during the 2016 US presidential election and adolescent vaccination rates

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ABSTRACT

Background: Politics play a role in the dissemination of public health information, including immunization-related issues. We aim to describe relationships between HPV vaccination rates and state voting patterns during the 2016 US presidential election.

Methods: We classified each of the 50 states as either "Red" or "Blue," based on whether a higher proportion of the state's casted votes were for the Republican or Democratic nominee during the 2016 US presidential election. State-specific HPV, Tdap, and meningococcal vaccination rates were obtained from the 2016-National Immunization Survey-Teen. State socio-demographic factors and HPV vaccine legislation were obtained from the US Census Bureau and National Conference of State Legislatures. Vaccination rates and socio-demographic variables were compared using independent t-tests. Multiple linear regression compared vaccination rates between "Red" and "Blue" states, adjusting for percentage of both uninsured children and educational attainment.

Results: Compared to "Blue" states, "Red" states had significantly lower unadjusted HPV vaccine series initiation (56% vs 66%, $p < 0.05$) and completion (39% vs 50%, $p < 0.05$) rates; yet had similar rates of Tdap (88% vs 89%, $p > 0.05$) and meningococcal (79% vs 83%, $p > 0.05$) vaccinations. After adjusting for potential confounders, the regression-adjusted mean rate for HPV vaccine initiation and completion remained significantly lower for "Red" states compared to "Blue" states (57% vs 65%, $p < 0.05$, and 41% vs 48%, $p < 0.05$, respectively).

Conclusion: HPV vaccination rates are associated with statewide-level voting patterns. Future interventions aimed at improving HPV vaccination rates should consider engaging local and national elected leaders to be proactive in disseminating accurate and authoritative immunization information.

1. Introduction

Each year, 14 million new human papillomavirus (HPV) infections, 33,000 new HPV-associated cancers, and over 6000 HPV-associated cancer deaths occur among US men and women. The 9-valent HPV vaccine series, recommended for universal administration to adolescents starting at age 11–12 years, is safe and effective in preventing HPV infection and HPV-associated dysplasias and cancers, yet, national HPV vaccine series completion rates among adolescents in 2016 was only 43% [1].

There are many factors contributing to suboptimal adolescent HPV vaccine uptake, including the lack of provider vaccine recommendations, concerns regarding the association between HPV and sexual activity, and the lack of understanding that HPV vaccine prevents cancer [2–6]. Provider and parental HPV vaccine hesitancy plays a major role in adolescent non-vaccination and can be exacerbated by negative vaccine-related media reports [7]. News media, in particular, strongly influences communication of public health issues, particularly with regards to vaccination. For example, during the 2011 US Republican presidential debate and subsequently, on national television interviews, Congresswoman Michele Bachman (US House of Representatives, Minnesota 6th Congressional District 2007–2015) claimed that the HPV vaccine was a "potentially dangerous drug" that could lead to "mental retardation" [8,9]. Following these statements, there was an

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increase in public interest regarding this vaccine, as demonstrated by a spike in US internet searches for "HPV Vaccine" [10,11]. In response, the American Academy of Pediatrics (AAP) issued a statement that there was no scientific validity to these claims, however, Bachman's controversial comment continued to be more widely disseminated than the AAP's authoritative response, despite her lack of any formal health care training or political experience as a member or leader of a government health committee [12]. The dissemination of vaccine misinformation by a politician changed the conversation of HPV from one of science and public health information regarding vaccine dosing, durability of protection, eligibility to receive it, and the diseases prevented to one on vaccine politics [12].

Political attitudes are known to align with certain healthcare beliefs and practices at the patient, provider, and community level. This influence may be direct, indirect, or epiphenomenal. More likely, the influence stems from a combination of all three given the complex sociopolitical factors involved. Specifically, physicians who self-identify as Republican assess patient health issues, including firearms, abortions, and marijuana use, differently than those who identify as Democrat, each offering treatment plans in concordance with their political ideologies [13]. Similarly, health outcomes have been associated with political partisanship. For example, national infant mortality rates tend to be lower during Democratic presidential terms [14]. Republican presidential candidates have higher support in counties reporting higher rates of obesity [15]. Even vaccines, while not as partisan a topic as abortions or firearms, were brought into the 2016 US presidential debates. Republican candidate and now President, Donald Trump, repeatedly insisted that there is a link between vaccines and autism, and incorrectly stated that spacing out vaccines would decrease the incidence of autism [16]. At the same time, Republican candidate and pediatric neurosurgeon, Dr. Ben Carson, made the unsubstantiated argument that "a lot of pediatricians now…. are cutting down on the number and the proximity in which those [vaccines] are done." [16] Due to the public health implication of politicizing immunizations, the relationship between political ideology and vaccination behaviors needs to be explored to most effectively drive necessary changes to keep our adolescents protected from the future development of HPV-associated cancer. In this work, we aimed to describe the relationship between state-level HPV vaccine completion rates among adolescents ages 13–17 years and state voting patterns during the 2016 US presidential election. Our findings will highlight sociopolitical associations with areas of unimmunized adolescents to guide future interventions aimed at improving HPV vaccine uptake and ultimately reducing HPV disease-associated morbidity and mortality.

2. Methods

For each of the 50 US states, we recorded the percentage of the state's population which voted for the Republican and the Democratic presidential candidates during the 2016 US presidential election [17]. If a higher proportion voted for the Republican candidate, the state was classified as a "Red" state. If a higher proportion voted for the Democratic candidate, the state was classified as a "Blue" state. State-specific adolescent immunization rates were obtained from the 2016 National Immunization Survey-Teen, including HPV vaccine series initiation, HPV vaccine series completion, and receipt of at least one dose each of tetanus-diphtheria-acellular pertussis (Tdap) vaccine and conjugate quadrivalent meningococcal vaccine (MCV4) [1].

State-specific sociodemographic factors obtained from the US Census Bureau included the percentages of the population in the following categories: age between 10 and 19 years, minority race, individuals and families living below the federal poverty level, medically uninsured children, adults with a bachelor's degree or higher, and median household income.

3. Statistical analysis

3.1. Unadjusted associations and red-blue differences

Bivariate linear regression was used to assess the unadjusted relationship between state-level vaccination rates and the percentage of votes casted for the 2016 Republican presidential nominee. Means for vaccination rates and for sociodemographic variables for "Blue" and "Red" states were compared using independent t-tests and 95% CI for mean differences. Bivariate linear associations among vaccination rates and sociodemographic variables were evaluated using t-tests and confidence intervals for Pearson correlation coefficients.

3.2. Identification of potential confounders

In addition to the correlation analysis described above, bivariate logistic regression was conducted to determine which sociodemographic variables best predicted "Red" or "Blue" state classification. We conducted multicollinearity analysis for this subset of strong predictors using variance inflation factors, partial correlation analysis and eigenvector weighting patterns. Based on the results of the logistic regression and multicollinearity analyses, the percentage of medically uninsured children and the percentage of adults with a bachelor's degree or higher were used as covariates to produce adjusted mean estimates of vaccination rates for "Red" and "Blue" states. These two variables likely reflect the potential role that parental education and insurance barriers may play in vaccine uptake within families.

3.3. Adjusted differences in red-blue vaccination rates

Multiple linear regression was then used to compare the vaccination rates between "Blue" and "Red" states, adjusting for these two covariates. Variable entry for the regressions was hierarchical, with change in R^2 and percent change in the estimated coefficient for state classification noted at each step. The covariates were (grand) mean centered for the regression analysis. Standardized mean differences (Cohen's d) were calculated for all adjusted effects of political party. Tests of model assumptions, model fit and influential data points were conducted for all regression analyses. Outlier rates were observed for some states (RI, NV and UT), but sensitivity analysis indicated they had no substantive impact on results and these states were retained in the final regression models.

All interval estimation for mean differences in adjusted and crude vaccination rates and for bivariate correlations was carried out using bootstrap resampling methods, which provided a robust, non-parametric supplement to the *t*-test results. The bootstrapped bias corrected and accelerated (BCa) 95% confidence interval estimates were based on distributions of 5000 re-samples. A priori level of significance was set at 0.05, two-tailed. Statistical analysis was conducted using IBM SPSS version 24.

4. Results

Based on the 2016 US presidential election results, we classified 30 (60%) and 20 (40%) states as "Red" and "Blue" states, respectively. Compared to "Blue" states, the "Red" states had a higher percentage of 10–19 year olds, individuals and families living below the federal poverty line, and medically uninsured children, while having a lower median household income and percentage of adults with a bachelor's degree or higher (Table 1). There were no differences in percentage of population of minority race (p > 0.05).

Compared to "Blue" states, "Red" states had significantly lower unadjusted HPV vaccine initiation (56% vs 66%, p < 0.05) and completion rates (39% vs 50%, p < 0.05); yet had similar unadjusted rates of Tdap (88% vs 89%, p > 0.05) and meningococcal (79% vs 83%, p > 0.05) vaccinations (Table 1). Fig. 1A and B show the relatively weak linear relationship between the percentage of state-casted votes for the presidential Republican nominee and Tdap and MVC4 vaccination rates. In contrast, Fig. 1C and D and Table 2 show the comparatively strong inverse relationships between the

Table 1
Vaccination rates, sociodemographic and economic characteristics of US states by the political party of the candidate receiving the higher proportion of the vote statewide during the 2016 US presidential election.

Characteristic	Republican (n = 30) Mean (SE)	Democrat (n = 20) Mean (SE)	Mean Difference	t	P	95% BCa CI for Mean Difference
*HPV[a] Initiated (%)	55.70 (1.23)	66.35 (1.65)	−10.65	−5.28	<0.001	[−14.71, −6.59]
*HPV[a] Completed (%)	39.08 (1.17)	50.24 (1.64)	−11.14	−5.69	<0.001	[−15.08, −7.20]
Tdap[b] (%)	87.79 (0.79)	88.86 (1.00)	−1.1	−0.87	0.388	[−3.64, 1.44]
MCV4[c] (%)	78.64 (1.98)	83.37 (1.64)	−4.73	−1.73	0.09	[−10.38, −0.78]
*State Population Ages 10–19 (%)	13.35 (0.16)	12.76 (0.11)	0.59	2.72	0.009	[0.15, 1.03]
Minority Races (%)	18.16 (1.80)	22.61 (3.12)	−4.45	−1.35	0.183	[−11.07, 2.17]
*Median Household Income (USD)	51,729 (1220)	62,488 (1832)	−10759	−5.09	<0.001	[−15007, −6510]
*Population in Poverty (%)	15.55 (0.52)	12.84 (0.62)	2.71	3.31	0.002	[1.07, 4.35]
*Families in Poverty (%)	11.17 (0.48)	8.99 (0.53)	2.18	2.98	0.005	[0.71, 3.65]
*Uninsured Children (%)	6.52 (0.44)	4.46 (0.46)	2.06	3.12	0.003	[0.73, 3.86]
*BA or Higher Degree (%)	26.72 (0.55)	33.74 (0.99)	−7.02	−6.69	<0.001	[−9.13, −4.91]
Non-Medical Exemptions (%)	2.40 (0.43)	2.40 (0.33)	0	0	>0.99	[−1.01, 1.01]

* p < 0.05.
[a] HPV human papillomavirus.
[b] Tdap tetanus-diphtheria-acellular pertussis vaccine.
[c] MCV4 conjugate quadrivalent meningococcal vaccine.

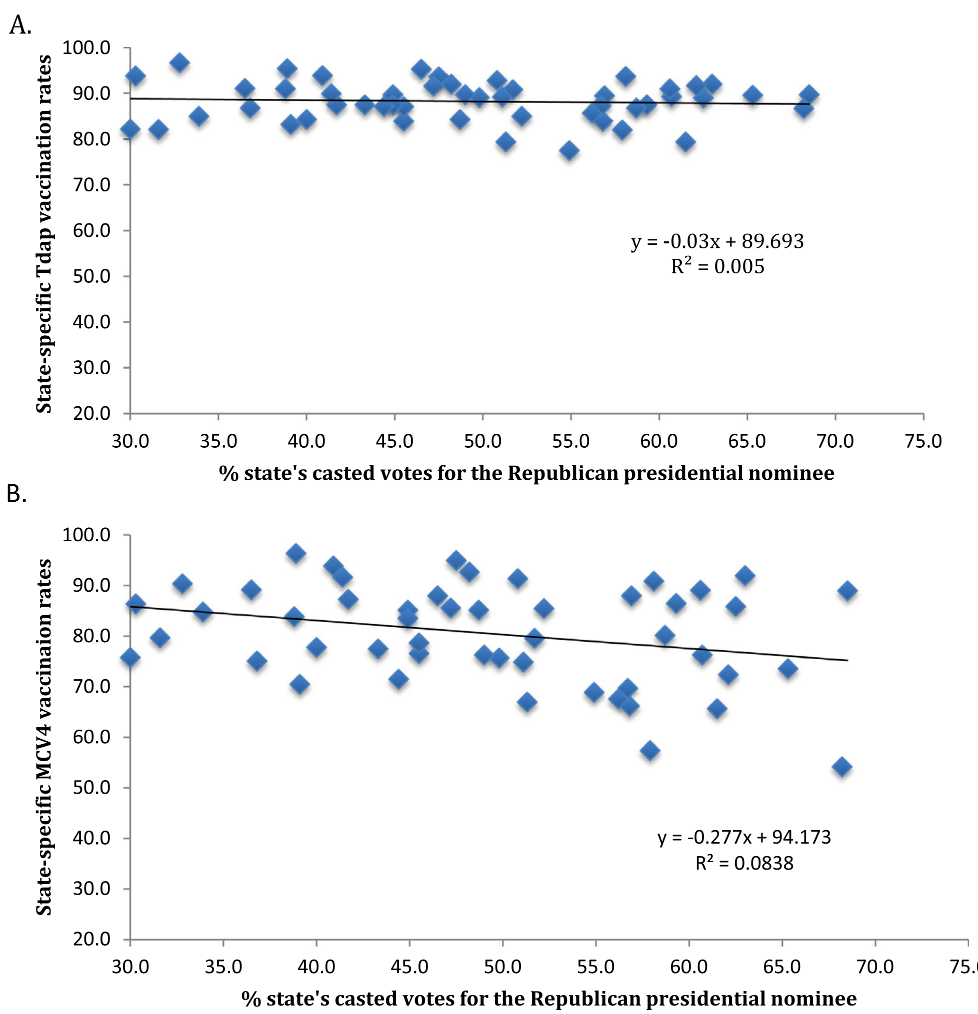

Fig. 1. Correlation between percentage of each state's population that voted for the Republican presidential nominee during the 2016 US election and state-specific Tdap vaccination rates (A), MCV4 vaccination rates (B), HPV vaccine series initiation rates (C), and HPV vaccine series completion rates (D).

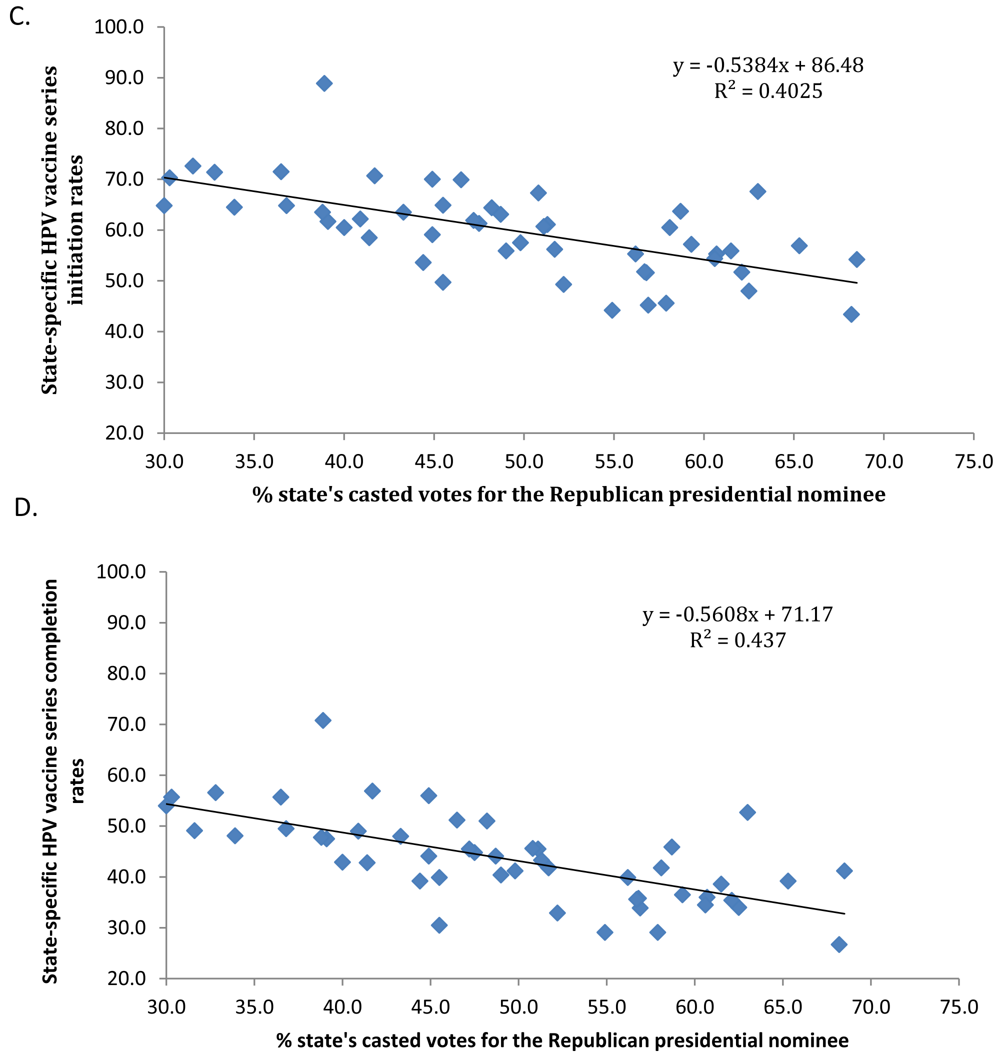

Fig. 1 (*continued*)

percentage of state-casted votes for the presidential Republican nominee and HPV vaccine initiation and completion rates (r = −0.65). Rates of HPV vaccine initiation, HPV vaccine completion, Tdap and MCV4 were all moderately ($0.3 \leq r < 0.5$) or strongly ($r \geq 0.50$) associated with each other. HPV vaccine initiation and completion rates positively correlated with household income and educational attainment, while negatively correlating with measures of poverty and percentage of medically uninsured children. In contrast, Tdap (r = −0.46, 95% CI[-0.66, −0.23]) and MCV4 vaccination rates (r = −0.27, 95% CI[-0.49, −0.03]) significantly correlated only with the percentage of medically uninsured children. The bivariate correlation analysis showed that the sociodemographic factors associated with vaccination are largely the same as the factors shown to differ between "Blue" and "Red" states (Table 1).

After adjusting for sociodemographic confounders, the regression-adjusted mean rate for HPV vaccine initiation remained significantly lower for the "Red" states than the "Blue" states (57% vs 65%, p = 0.006, 95% CI[-13.47, −1.88], d = −0.84). The adjusted R^2 for the model including the medically uninsured children and educational attainment covariates was 35%. Although the adjusted mean difference (8.4%) was 21.5% smaller than the unadjusted difference (10.7%), neither covariate was statistically significant. Similarly, the regression-adjusted mean rate for HPV vaccine completion remained significantly lower for "Red" states than "Blue" states (41% vs 48%, p = 0.011, 95% CI[-12.64, −1.74], d = −0.78). This adjustment reduced the crude mean difference (11%) by 35.1%, with an adjusted R^2 for the model of 44%. Neither the percentage of medically uninsured children (p = 0.06) nor the percent of adults with a bachelor's degree or higher were significant (p = 0.21) in this model. HPV vaccine initiation and vaccine completion rates, on average, were lower in the "Red" states than in the "Blue" states, with or without adjustment for potential sociodemographic and economic confounders.

Adjusted mean Tdap vaccination rates did not differ between "Red" and "Blue" states (89% vs 87%, p = 0.35, 95% CI[−1.96, 6.60], d = 0.28). While the percentage of medically uninsured children was a significant predictor for Tdap vaccination (b = −0.49, p = 0.001) with an adjusted R^2 for the model of 18%, the educational attainment covariate was not significant (b = 0.12, p = 0.435). Adjusted mean MCV4 vaccination rates also did not differ between "Red" and "Blue" states (80% vs 81%, 95% CI for difference [−7.47, 7.26], p = 0.759, d = −0.09). While the percentage of medically uninsured children was a significant predictor in the model (b = −1.19, p = 0.05, 95% CI[−2.29, −0.12]), educational attainment was again not significant (b = 0.15, p = 0.68). The adjusted R^2 for this model was 8.0% and the model was a significant fit for the data (F(3,46) = 2.46, p = 0.075).

Table 2
Human papillomavirus vaccine completion rates by state in rank order of the percentage of the state's population that voted for the Republican nominee during the 2016 US presidential election.

State	Republican votes %	HPV VC* rates %	State	Republican votes %	HPV VC rates %
West Virginia	68.5	41.2	Arizona	48.7	44.1
Wyoming	68.2	26.7	Pennsylvania	48.2	51.0
Oklahoma	65.3	39.2	Michigan	47.5	44.8
North Dakota	63.0	52.7	Wisconsin	47.2	45.5
Kentucky	62.5	34.0	New Hampshire	46.5	51.2
Alabama	62.1	35.4	Utah	45.5	30.5
South Dakota	61.5	38.6	Nevada	45.5	39.9
Tennessee	60.7	36.0	Minnesota	44.9	44.1
Arkansas	60.6	34.5	Maine	44.9	56.0
Idaho	59.3	36.5	Virginia	44.4	39.2
Nebraska	58.7	45.9	Colorado	43.3	48.0
Louisiana	58.1	41.8	Delaware	41.7	56.9
Mississippi	57.9	29.1	New Jersey	41.4	42.8
Indiana	56.9	33.9	Connecticut	40.9	49.0
Missouri	56.8	35.8	New Mexico	40.0	42.9
Kansas	56.7	35.6	Oregon	39.1	47.5
Montana	56.2	39.9	Rhode Island	38.9	70.8
South Carolina	54.9	29.1	Illinois	38.8	47.8
Texas	52.2	32.9	Washington	36.8	49.5
Ohio	51.7	41.8	New York	36.5	55.7
Alaska	51.3	43.3	Maryland	33.9	48.1
Iowa	51.1	45.5	Massachusetts	32.8	56.6
Georgia	50.8	45.6	California	31.6	49.1
North Carolina	49.8	41.2	Vermont	30.3	55.7
Florida	49.0	40.4	Hawaii	30.0	54.0

* HPV VC human papillomavirus vaccine series completion.

Only 2/30 (7%) of "Red" states, compared to 8/20 (40%) of "Blue" states, had HPV vaccine completion rates that exceeded 50% (Fig. 2). Fig. 3 depicts that 10/30 (33%) of the "Red" states, compared to 13/20 (65%) of the "Blue" states, enacted HPV-related legislation between the years of 2006 and 2016.

5. Discussion

Here we show that "Red" states have lower mean HPV vaccine initiation and completion rates when compared to "Blue" states. We also found that, contrary to a previously published study, HPV vaccine initiation and completion rates negatively correlated with measures of poverty and percentage of medically uninsured children [1]. It is possible that the larger proportion of families living in poverty and without insurance in "Red" states reflects poor medical access within these communities. However, with comparable Tdap and meningococcal vaccination rates, access to medical care does not appear to be the major factor in HPV non-vaccination since all three vaccines are recommended to be given at the same medical visit. Moreover, all uninsured and underinsured US children under the age of 19 years have access to vaccines at no cost through Vaccines for Children (VFC), a federal entitlement program created as part of the 1983 US Congressional Omnibus Budget Reconciliation Act (OBRA) [18]. These vaccines are provided, at no-costs, by the federal government via the state government to registered VFC providers.

It is not surprising that population-based vaccination patterns align with voting patterns. Individuals identifying as Republicans, or political conservatives, express a lesser degree of trust in the government and its experts [19]. Confidence in government, on the other hand, is strongly associated with willingness to receive vaccine, an observation that was particularly striking during government distribution of the 2009 monovalent H1N1 influenza vaccine [20]. In contrast to a previously published study that evaluated 2012 state-level voting patterns and adolescent immunization rates that showed higher immunization rates in "Blue" compared to "Red" states for HPV, Tdap, and MCV4 [21], we found the association of higher vaccine receipt and "Blue" states to hold true only for the HPV vaccine, likely due to the increase in the number of states mandating Tdap and MCV4 vaccines for school entry, further separating this vaccine from the other routinely administered adolescent immunizations. The approach to using HPV vaccine has been different from that of Tdap and MCV4 from the beginning, in part due to the belief that sexual activity needs to be discussed prior to HPV vaccination and the initial approval and marketing of vaccine only to girls [22–26]. This type of feminization of medical and public health agendas is known to negatively impact public awareness and provider approach as previously described for poverty, HIV, and contraception [26].

Feminization of the HPV vaccine has also penetrated policy-making decisions. The state of Virginia, for example, still only requires HPV vaccination for females entering 6th grade [27] even though the vaccination series has been recommended for female and male adolescents since 2009. Despite enactment of this mandate, Virginia's HPV vaccine completion rate is at 39.2%, well below the current national average [1]. On the other hand, the state of Rhode Island began to require HPV vaccine for females and males entering 7th grade in 2015, through Department of Health provisions rather than through legislation. This approach geared towards all students does not allow for an easy opt-out process. The state of Rhode Island currently has the highest vaccine completion rate in the country at 70.8% and remains the only state to exceed rates of 60% [1]. Strictly-enforced school-mandated vaccine laws are difficult to pass into legislation, with concerns for government intrusion and perceptions of impinging on parental autonomy. However, dating back to the early 1900s, the US Federal Supreme Court ruled that it was within the power of the state to require vaccinations for school entry for the protection of public health. Current evidence continues to demonstrate that school-mandated vaccine laws result in higher vaccination rates among the middle school cohort [28–30].

While Virginia and Rhode Island are the only US states that require HPV vaccination for public school attendance, several others have enacted legislation related to the dissemination of

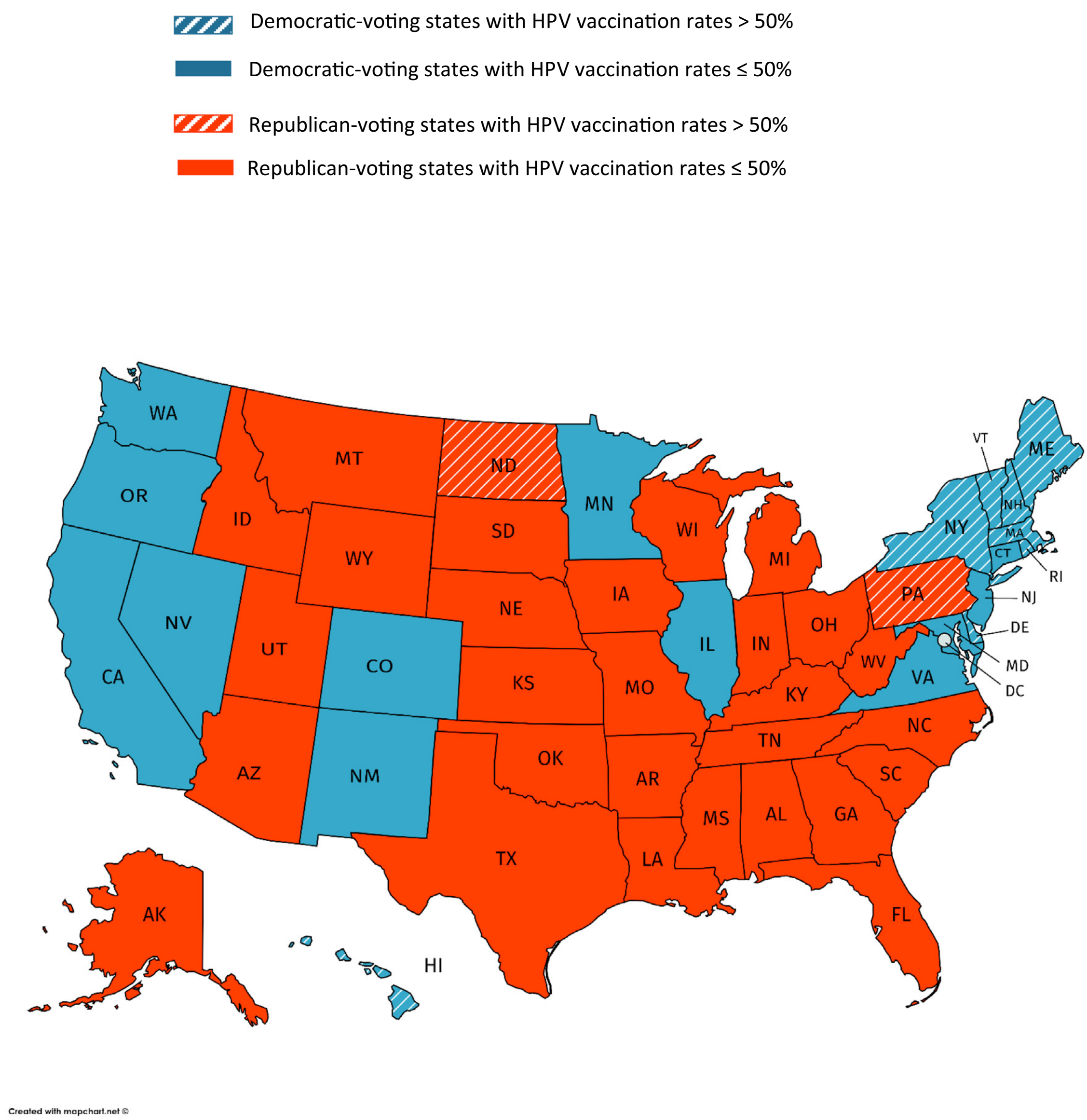

Fig. 2. US map stratifying "Blue" and "Red" states by HPV vaccination rates.

educational materials and the organization and funding of vaccine awareness campaigns. Individuals have partisan-preference with regards to presented subject content, despite the quality of the source, choosing sources which typically reflect a similar ideology to their own personal beliefs [19,30–32]. This behavior, also known as confirmation bias, where individuals obtain and process information in a manner consistent with their existing beliefs influences how people receive not only political-related information, but healthcare-related information as well [33]. Furthermore, messages that are sought after and then repeatedly received tend to then be viewed as authentic, as Twitter users who are exposed to primarily negative comments regarding HPV vaccine are more likely to go on to tweet negative opinions about the vaccine [34]. This type of behavior needs to be considered when developing vaccine education and awareness campaigns. Effective awareness, education, and communication of HPV vaccine within communities of individuals with a variety of beliefs requires the engagement of sources with different political views to most effectively and widely disseminate the cancer prevention message. Such effort logically requires the support of legislators with a wide variety of political ideologies.

There are several limitations to our study. We reviewed data derived from large geographical areas, not from counties or local communities. State-level data were used because of concern that migration and mobility between counties, such as families moving from one county to the next or living in one county and being vaccinated in another, would lead to significant variability with more regional data. However, state data may mask sub-state level differences. State population may also account for differences in rates, accounting for differences in public health funding and available resources for immunization delivery and tracking. Our data collection method did not allow for gathering information regarding reasons for HPV vaccine acceptance or refusals by individuals of either political affiliation, nor does it allow for determination of cause and effect, particularly at an individual level and our results are subject to ecological fallacy. The vaccination of the older adolescent cohort may have occurred over 5 years ago, thus reflecting state voting patterns from a different time. As there may be general shifts in

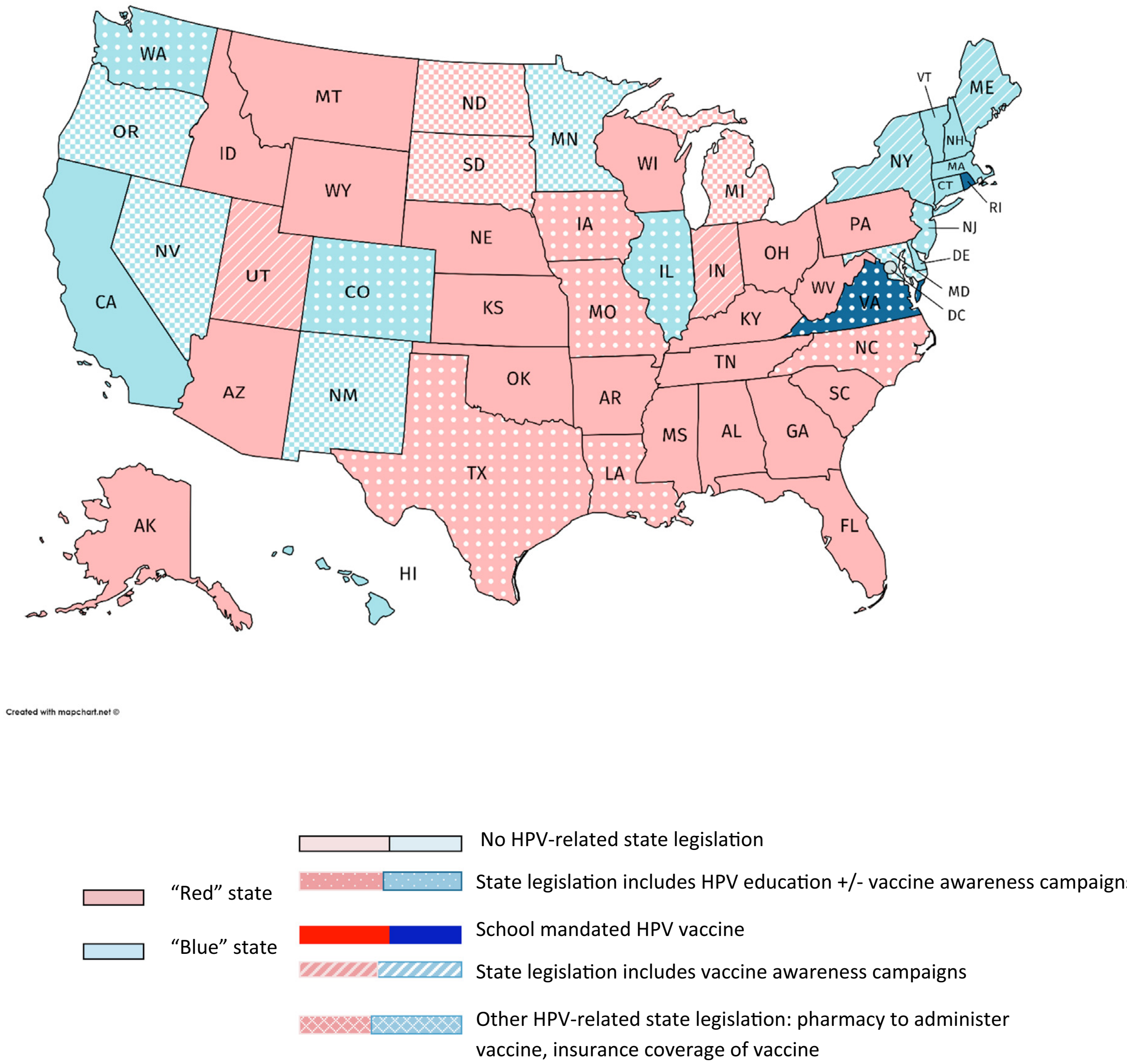

Fig. 3. US map depicting enacted states legislation related to HPV disease and/or prevention.

voting patterns over time, we used the 2016 data as a surrogate for the most recent statewide political tendencies. Political affiliation does not necessarily take into consideration the wide range of beliefs within each party. We acknowledge that individuals who self-identify with a particular political party do not necessarily share all beliefs of that party. Generally, however, one's political affiliation does play an important role in where and how people obtain information they deem trustworthy.

HPV infection is a known cause of at least six different cancer types, the majority of which are now vaccine-preventable. Despite widespread availability and clear evidence that the HPV vaccine is safe and effective [35–37], national HPV vaccination rates remain sub-optimal. "Red" states, in particular, have lower HPV vaccine initiation and completion rates when compared to "Blue" states. Current interventions aimed at improving HPV vaccine uptake focus primarily on improving knowledge and awareness about vaccine across all stakeholders, including providers, parents, and adolescents. For this strategy to prove most effective, the sociopolitical factors influencing the dissemination of healthcare information and guidance related to HPV disease and prevention, needs to be better understood. Individuals tend to be selective when choosing partisan-specific sources, whether they be expert opinion, guidance from religious leaders, or announcements from news or social media, most of which provide information reflecting their own ideologies. The dissemination of vaccine-related information from government and healthcare-related sources has a low likelihood of reaching those individuals who distrust government and their experts. Politicians can certainly influence their constituents via media outlets emphasizing the need to provide those politicians with evidence-based, authoritative facts. Politicians who are open to HPV vaccine and cancer prevention education improve bipartisan support for HPV vaccine policy, reduce concerns about teenage sexual activity as a consequence of vaccination, and result in successfully enacted HPV vaccine legislation [38]. Future interventions aimed at improving HPV vaccination rates and ultimately reducing HPV-associated illness should continue to engage local and national elected leaders. Statewide immunization coalitions may offer the unique opportunity to reach and educate this influential group. Politicians can be highly effective in addressing the perspectives and ideological assumptions of their constituents in the dissemination of important messages. When those messages include information about HPV disease and prevention, it is particularly important that the information conveyed is accurate, evidence-based, and void of hyperbole. School entry requirement mandates can result in very high immunization rates, but education efforts using appropriate sources to deliver common, consistent messages should be optimized first.

Conflict of interests

The authors have no conflicts of interest to declare.

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References

[1] Walker TY, Elam-Evans LD, Singleton JA, et al. National, regional, state, and selected local area vaccination coverage among adolescents aged 13–17 years – United States, 2016. MMWR Morb Mortal Wkly Rep 2017;66:874–82.
[2] Clark SJ, Cowan AE, Fillipp SL, et al. Parent perception of provider interactions influences HPV vaccination status of adolescent females. Clin Pediatr 2015. https://doi.org/10.1177/0009922815610629.
[3] Bynum SA, Staras SAS, Malo TL, et al. Factors associated with Medicaid providers' recommendation for the HPV vaccine to low-income adolescent girls. J Adolesc Health 2014;54:190–6.
[4] Daley MF, Crane LA, Markowitz LE, et al. Human papillomavirus vaccination practices: a survey of US physicians 18 months after licensure. Pediatrics 2010;126:425–33.
[5] Perkins RB, Clark JA, Apte G, et al. Missed opportunities for HPV vaccination in adolescent girls: a qualitative study. Pediatrics 2014;134:e666–74.
[6] Gargano LM, Herbert NL, Painter JE, et al. Impact of a physician recommendation and parental immunization attitudes on receipt or intention to receive adolescent vaccines. Hum Vacc Immunother 2013;9:2627–33.
[7] Dunn AG, Surian D, Leask J, Dey A, Mandl KD, Coiera E. Mapping information exposure on social media to explain differences in HPV vaccine coverage in the United States. Vaccine 2017;35:3033–40.
[8] CNN-tea party republican debate. CNN transcripts. September 12, 2011.
[9] Mulcahy N. Bioethicists offer $11,000 for proof of HPV Vaccine story. <https://www.medscape.com/viewarticle/749775>.
[10] Zucker RA, Reiter PL, Mayer MK, Brewer NT. Effects of a presidential candidate's comments on HPV vaccine. J Health Commun 2015;10:783–9.
[11] Gollust SE, LoRusso SM, Nagler RH, Fowler EF. Understanding the role of the news media in HPV vaccine uptake in the United States: synthesis and commentary. Hum Vacc Immunother 2016;12:1430–4.
[12] Mahoney LM, Tang T, Ji K, Ulrich-Schad J. The digital distribution of public health news surrounding the human papillomavirus vaccination: a longitudinal infodemiology study. JMR Publ Health Surveill 2015;1:e2.
[13] Hersh ED, Goldenberg MN. Democratic and republican physicians provide different care on politicized health issues. Proc Natl Acad Sci USA 2016;113:11811–6.
[14] Rodriguez JM, Bound J, Geronimus AT. US infant mortality and the President's party. Int J Epidemiol 2014;43:818–26.
[15] Shin ME, McCarthy WJ. The association between county political inclination and obesity: results from the 2012 presidential election in the United States. Prev Med 2013;57:721–4.
[16] <http://time.com/4037239/second-republican-debate-transcript-cnn> [accessed April 10, 2018].
[17] Official 2016 presidential general election results. <https://transition.fec.gov/pubrec/fe2016/2016presgeresults.pdf> [accessed May 4, 2018].
[18] <www.cdc.gov/vaccines/programs/vfc/about/index.html> [accessed April 11, 2018].
[19] Baumgaertner B, Carlisle JE, Justwan F. The influence of political ideology and trust on willingness to vaccinate. PLoS ONE 2018;13:e0191728.
[20] Mesch GS, Schwirian KP. Confidence in government and vaccination willingness in the USA. Health Promot Int 2015;30:213–21.
[21] Bernstein S, North A, Schwartz J, Niccolai LM. State-level voting patterns and adolescent vaccination coverage in the United States, 2014. Am J Publ Health 2016;106:1879–81.
[22] Thomas TL, Strickland O, Diclemente R, Higgins M. An opportunity for cancer prevention during preadolescence and adolescence: stopping human papillomavirus (HPV)-related cancer through HPV vaccination. J Adolesc Health 2013;52:S60–8.
[23] Rand CM, Schaffer SJ, Humiston SG, et al. Patient-provider communication and human papillomavirus vaccine acceptance. Clin Pediatr 2011;50:106–13.
[24] Holman DM, Benard V, Roland KB, et al. Barriers to human papillomavirus vaccination among US adolescents. a systematic review of the literature. JAMA Pediatr 2014;168:76–82.
[25] Perkins RB, Clark JA. Providers' perceptions of parental concerns about HPV vaccination. J Health Care Poor Underserv 2013;24:828–39.
[26] Daley EM, Vamos CA, Thompson EL, et al. The feminization of HPV: How science, politics, economics, and gender norms shaped US HPV vaccine implementation. Papillom Res 2017;3:142–8.
[27] <www.vdh.virginia.gov/immunization/requirements>. Virginia Department of Health School Requirements [accessed April 3, 2018].
[28] Bugenske E, Stokley S, Kennedy A, Dorell C. Middle school vaccination requirements and adolescent vaccination coverage. Pediatrics 2012;129:1056–63.
[29] CDC. Effectiveness of a middle school vaccination law – California, 1999–2001. MMWR Morb Mortal Wkly Rep 2001;50:660–3.
[30] Averhoff F, Linton L, Peddecord KM, Edwards C, Wang W, Fishbein D. A middle school immunization law rapidly and substantially increases immunization coverage among adolescents. Am J Publ Health 2004;94:978–84.
[31] Frimer JA, Skitka LJ, Motyl M. Liberals and conservatives are similarly motivated to avoid exposure to one another's opinions. J Exp Soc Psychol 2017;72:1–12.
[32] Dvir-Gvirsman S. Media audience homophily: partisan websites, audience identify, and polarization processes. New Media Soc 2017;19:1072–91.
[33] Strickland AA. Motivated reasoning and public opinion. J Health Polit Policy Law 2011;36:935–44.
[34] Dunn AG, Leask J, Zhou X, Mandl KD, Coiera E. Associations between exposure to and expression of negative opinions about human papillomavirus vaccines on social media: an observational study. J Med Int Res 2015;17:e144.
[35] Petrosky E, Bocchini JA, Hariri S, Chesson H, Curtis CR, Saraiya M, et al. Use of a 9-valent human papillomavirus (HPV) vaccine: update HPV vaccination recommendations of the advisory committee on immunization practices. MMWR 2015;64:300–4.
[36] Garland SM, Pitisuttithum P, Ngan HYS, Cho CH, Lee CY, Chen CA, et al. Efficacy, immunogenicity, and safety of a 9-valent human papillomavirus vaccine: subgroup analysis from participants from Asian countries. J Infect Dis 2018;218:95–108.
[37] Kash N, Ma Lee, Kollipara R, Downing C, Guidry J, Tyring SK. Safety and efficacy data on vaccines and immunization to human papillomavirus. J Clin Med 2015;4:614–33.
[38] Abiola SE, Colgrove J, Mello MM. The politics of HPV vaccination policy formation in the United States. J Health Polit Pol Law 2013;38:645–81.