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The importance of political and religious affiliation in explaining county-level COVID-19 Vaccine Hesitancy

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Abstract

The authors use county-level data to test whether an array of socioeconomic, demographic, political and religious variables explain COVID-19 vaccination rates. Results presented here build upon previous investigations of COVID-19 vaccine hesitancy in different contexts and are largely consistent with those findings. Background controls such as county's percent male (+), median age (+), percent White (-), median household income (+), percent self-employed (-), and the percent with a college or higher education (+) explain county-level vaccination rates for COVID-19. Political affiliation (Percent Republican (-)) remains the strongest predictor in terms of overall statistical significance. The county's percent Catholic (+) and percent Evangelical (-) are also very strong predictors, though in opposite directions. This analysis includes state-level fixed effects and several robustness checks.

Key points

Results presented here are consistent with and build upon previous investigations of COVID-19 vaccine hesitancy. While several socio-economic and demographic factors are important, political affiliation remains the strongest predictor. Religious affiliation is also a very important predictor.

Keywords Vaccine hesitancy, COVID-19

JEL Classification I1, I120

While millions of people have already safely received COVID-19 vaccines, we recognize that for some, the FDA approval of a vaccine may now instill additional confidence to get vaccinated. Today's milestone puts us one step closer to altering the course of this pandemic in the U.S. [Acting FDA Commissioner Janet Woodcock, M.D., August 23, 2021. [21]*]*

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Introduction

At the time of the quote by Acting FDA Commissioner, Janet Woodcock, many believed along with Dr. Woodcock, that the Pfizer-BioNTech COVID-19 Vaccine's status change from "Emergency Use Authorization" to "FDA approval" might be just what the doctor ordered to get more vaccines into arms across the country. Instead, vaccine hesitancy for the Pfizer-BioNTech vaccine, along with others to follow, would continue throughout the rest of the pandemic. Indeed, a recent Gallup poll [12] published in December 2023 suggested that US vaccination rates for COVID-19 were even lagging rates for the annual flu shot—a surprising figure given that just three years prior to publication, COVID-19 vaccines had

been largely heralded as a panacea and the best way to get society back to normal after enduring a global pandemic, unprecedented in Western societies at least since the Great Influenza Epidemic in the wake of World War I.

Why this hesitancy? And was it universal or limited to certain segments of the US population? In this current endeavor, we utilize a county-level data set combined with county-level vaccination rates to identify factors that explain vaccine hesitancy. We find that being fully vaccinated for COVID-19 (defined as having taken the first two MRNA shots or the single J&J shot) by March 31, 2022, is moderated consistently by percent male, median age, percent White, median household income level, percent of self-employed individuals in the county and percent having a college-level or higher education. However, the most significant factor is the percent of the county that is Republican (defined as the percentage of county residents who voted for Donald Trump in the 2020 election). Interestingly, religious affiliation also matters, with the percent of total county population who are Catholic or Evangelical Christian serving as very important predictors of overall county-level vaccination rates for COVID-19. In what follows, we provide a review of the extant literature, a description of the data and methods we employ in this current endeavor, results, and conclusions.

Background

Vaccine hesitancy has a storied past in the US. A foremost expert on vaccine hesitancy and the antivaccine movement, Dr. Peter Hotez, dean of the National School of Tropical Medicine and professor of Pediatrics and Molecular Virology and Microbiology at Baylor College of Medicine, traces antivaccine sentiments to Colonial America and a 1721 smallpox epidemic in Boston [11]. The famous Puritan minister, Cotton Mather and his physician, Dr. Zabdiel Boylston attempted variolation (a relatively new immunization practice at the time) but "suffered personal threats and attacks" as a result [11]. The antivaccine movement later found a home in the "Health Freedom" or "Medical Freedom Movement." The essence of this movement is the support of individual or family rights to make medical and health choices, without government interference. Hotez adds that this is "often coupled to the counter promotion of a spectacular or miracle cure."

Political beliefs

Dr. Hotez argues that the anti-vaccine campaign in the US really began "in earnest" about 20 years ago with "false assertions that vaccines cause autism" [9]. This is personal for Hotez, who has a daughter with autism. While reluctant to describe vaccination hesitancy in purely political terms, he concedes that this particular issue has been very much embraced by the far right and has gained political traction recently, including with "elected leaders in the House Freedom Caucus, certain senators, and local leaders amplified in Fox News with designated contrarians from the far right think tanks" [9].

Early on in the COVID-19 pandemic, Brookings Institute economists, Rothwell and Makridis [17] conducted some of the earliest statistical analysis of COVID-19 vaccination hesitancy. Echoing Hotez' thesis, Rothwell and Makrides find partisan affiliation to be the "strongest single predictor of behavior and attitudes about COVID-19, even more powerful than local infection rates or demographic characteristics, such as age and health status." Their conclusion is embedded in the title of their article, "Politics is Wrecking America's Pandemic Response" [17]. The Kaiser Family Foundation's online post in June of 2021 indicated that Republicans were significantly less likely to be vaccinated [13], a result confirmed by Sun and Monnat's [18] analysis of vaccination rates through August 11, 2021. Other factors of note which Rothwell and Makrides found were also associated with lower vaccination rates included being middle aged, being White, having a high school education or less, earning less than $40,000, being insured and living in a suburban setting. In an Axios/Ipsos Coronavirus Survey of 8,000 individuals from November 2020 to February 2021, Cowan et al. [7] found strong evidence to support the Republican-Democrat divide when it came to COVID-19 vaccine hesitancy. In a similar vein, two years after the March 2020 mass closures in the US, an independent Gallup poll found that one in three Americans believed the pandemic was over. However, the poll seemed to present two different "Americas," with 67% of Republicans believing the pandemic was over while only 10% of Democrats (and 45% of Independents) agreed with the assessment [4].

Religious beliefs

Another significant predictor in COVID-19 vaccination hesitancy has been the role of religious beliefs. In a large, international survey on motivations for COVID-19 vaccination, Leung et al. [15] identify religious beliefs as a motivator for COVID-19 vaccine hesitancy. Slightly over one-third (36.3%) of US respondents who were not vaccinated indicated that "religious beliefs related to vaccines" served as a motivator. In a meta-analysis of 135 studies worldwide, Baghani et al. [2] reported that "religion," "religiosity" or being "religious" played a factor in COVID-19 vaccination hesitancy in seven of the 135 studies included in their analysis.

In the early days of the COVID-19 pandemic, Whitehead and Perry [24], identified Christian Nationalism ("an ideological view that seeks to return an exclusivist

religious traditionalism into the public sphere and grant epistemic primacy to community authorities") as a significant predictor of vaccination hesitancy. Whitehead and Perry focused on this group because of their "connection to anti-science skepticism, lower levels of scientific knowledge, and susceptibility to conspiracy theories." Writing before a COVID-19 vaccine was available, they predicted, based on vaccination concerns they identified in their research, that Christian Nationals would have a very high incidence of COVID-19 vaccination hesitancy. They concluded that Christian Nationals would be much more likely "to question the efficacy and safety of vaccines, to believe that doctors and drug companies are dishonest about vaccine risks, and to believe that it should be up to individuals to choose whether to vaccinate or not." In sum, they predicted (accurately, as it turns out) that a coming COVID-19 vaccine would be greeted with suspicion by a substantial subset of Americans [24].

Continuing with the Christian National theme, Corcoran et al. [6] utilized a survey of 2,000 US respondents in May—June 2021 to test whether respondents who identify as Christian Nationals (based on a filtering question that reflects the ideology) had significantly lower confidence in the COVID-19 vaccines. They found that Christian Nationals–who they believe comprise 20 percent of the total US population–were significantly less likely to report that they either had received or were going to receive the COVID-19 vaccinations. They concluded that "Christian nationalism's anti-science, anti-vaccine, anti-government intervention, pro-Trump ideology with a focus on protecting one's own freedoms at the expense of protecting medically vulnerable people makes it the perfect storm for COVID-19 vaccine hesitancy" [6], 6619).

Guidry et al. [10] surveyed 531 individuals to identify predictors of COVID-19 vaccination hesitancy among Evangelical Christians. They used a filtering question, "If you identify as Christian, which one applies to you?" with one of the options being "Evangelical Protestant, (such as Assemblies of God, Pentecostal, Southern Baptist, Non-denominational charismatic)." The authors found that perceived high benefits of and low barriers ("access") to the vaccine played a significant role in predicting vaccinations. They also found that those who were more open to faith-based influences were more likely to receive the vaccination. Critical to results presented in this current endeavor, Guidry et al. conclude " (t)his suggests that positive attitudes towards vaccination can be cued and reinforced by trusted religious leaders who themselves acknowledge getting the vaccine and encourage others to do the same or that clergy can be helpful in dealing with perceived barriers." They go on to state that "Information seeking from clergy as well as faith-based support are important factors that can influence vaccination status."

The Roman Catholic church's position on the COVID-19 vaccines, like that of many mainline Protestant churches, was positive from the outset and, given the mixed views coming from Evangelical Christian leaders, provides a natural experiment to test whether attitudes towards the COVID-19 vaccines by religious leaders might influence outcomes on vaccination rates. Due to the potential concern around the use of aborted fetal cells in the development of the vaccines, Pope Francis, as early as December of 2020, issued a clarifying statement on the morality of COVID-19 vaccinations, stating that they "can be used in good conscience with *the certain knowledge that the use of such vaccines does not constitute formal cooperation with the abortion* from which the cells used in production of the vaccines derive" [22]. While the entire statement was somewhat complex and gave a nod to those who might object to the vaccine based on the use of aborted fetal tissue, the take-home was clear, namely that vaccines would be considered as morally acceptable by the Catholic Church. Indeed, the note went further, suggesting that Catholics have a moral duty to take a vaccine as a contribution to the common good [22]. In a quintessentially Pope Francis position, the Vatican made clear that COVID-19 vaccination was an important act since it involved protecting the "weakest and most exposed."

The United States Conference of Catholic Bishops (USCCB) issued a statement in December 2020 directed specifically at US Catholics and essentially echoing Pope Francis' official position [20]. In the statement, the bishops make it clear that, in their words, "(i)t is because of this respect for the human person that the USCCB, in collaboration with other organizations working to protect human life, has been engaged in the campaign advocating for the development of a vaccine for COVID-19 that has no link to abortion." They argue that "Neither Pfizer nor Moderna used morally-compromised cell lines in the design, development, or production of the (COVID-19) vaccine." While they raise some concerns about the AstraZeneca vaccine which, in their view, was "more morally compromised," the bishops conclude that "(g)iven the urgency of this crisis, the lack of available alternative vaccines, and the fact that the connection between an abortion that occurred decades ago and receiving a vaccine produced today is remote, inoculation with the new COVID-19 vaccines in these circumstances can be morally justified" (emphasis ours).

Eight months later, the Vatican rolled out a pro-vaccination PSA (in partnership with the Ad Council) clearly intended to reach a very broad audience. In the video, Pope Francis says in his native Spanish that "getting vaccinated is a simple but profound way to care for one another, especially the most vulnerable" [23]. In sum,

the Catholic Church's pro-vaccination position was both clear and widely telegraphed from the beginning, while that of Christian Nationalists (with overlap to Evangelical Christians) was skeptical at best.

Health belief model

Considering health-related behavior as a whole, the Health Belief Model (HBM) is one of the most widely-used models to explain health-related human behavior [3]. In the HBM, individuals are assumed to approach health-related decisions such as acquiring vaccinations in a rational choice framework, weighing individual perceptions of risk and reward. The HBM includes six basic constructs: (i) perceived susceptibility (perceived likelihood of contracting an illness), (ii) perceived severity (perceived seriousness of contracting an illness), (iii) perceived benefits (perceived benefits from taking a particular action to avoid contracting the illness, e.g., benefit from receiving a COVID-19 vaccination in preventing illness), (iv) perceived barriers (impediments to taking a particular action to avoid contracting the illness, e.g., cost of vaccination), (v) cues to action (cues such as media exposure, publicity, health "scares," etc. that may prompt an individual to take action against contracting the illness) and (vi) self-efficacy (the belief that one has the power and will to execute the decision to take action against contracting the illness) [5]. In the HBM construct, demographic factors such as age, gender, ethnicity, personality, socioeconomic status (SES) and knowledge are all potential "modifying factors" that feed into "individual beliefs," which ultimately (potentially) translate into "action" (see [5], Fig. 3.1). We model the issue of COVID-19 vaccine hesitancy in Fig. 1.

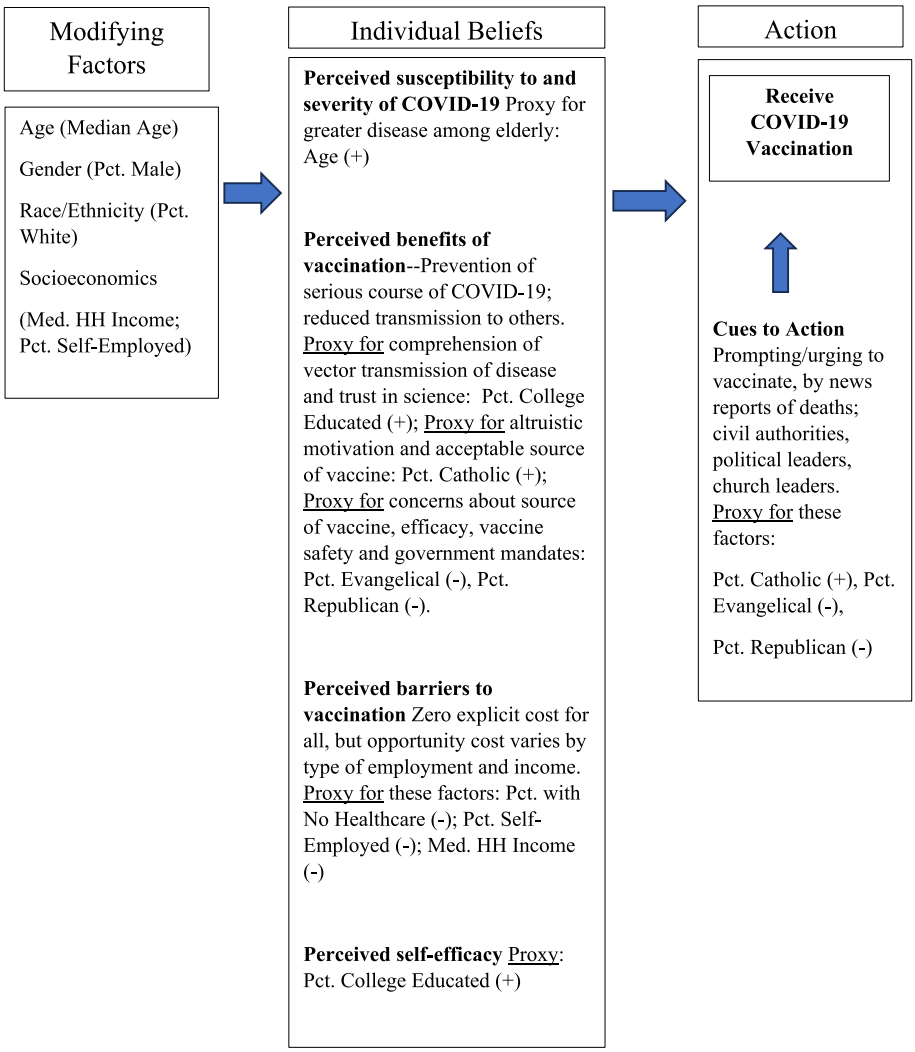

Fig. 1 Health Belief Model for COVID-19 Vaccination

Demographic and SES factors

Demographic, socioeconomic and other "background" factors have been shown to be associated with vaccine hesitancy. In a very large, international meta-analysis, Kafadar et al. [14] identify several factors, including age (younger), gender (women), ethnicity (non-White), living in a rural area, lower educational attainment, lower income and religious conviction. Leung and colleagues (2023) identify vaccine hesitancy to be positively associated with identifying as male, lower educational attainment, and living in rural areas. Sun and Monnat [18] focus on the rural–urban divide using data through August 11, 2021 and identify several factors that explain vaccine hesitancy, including rurality, lower median income, lower educational attainment and a higher percentage that voted for Donald Trump in 2020. In this current endeavor, we provide more recent data than Sun and Monnat [18] (going to March 31, 2022) and also improve upon Leung et al. [15] by including a political affiliation variable and a more comprehensive set of religious identifiers.

Data and methodology

Data for this analysis are drawn from four data sources. Our base data set is the American Community Survey (ACS) for 2020 using county-level data and including 3,113 counties for analysis. There are 3,241 FIPS counties but some did not include complete data so those counties were dropped from this analysis. We add religious data from the *US Religion Census: Religious Congregations and Membership Study, 2020 (County File)* posted on The Association of Religion Data Archives (ARDA) website (https://www.thearda.com/data-archive?fid=RCMSCY20&tab=3). Vaccination data are reported as of 3/31/2022 from the Center for Disease Control and Prevention (CDC)'s dataset: *COVID-19 Vaccinations in the United States, County*, and county-level election data are from MIT Election Data and Science Lab [16]. We utilize the 2020 ACS data, instead of ACS 5-Year Data or annual projections to ensure consistency across the demographic, religious, and political variables included in our analysis, and the datasets from which they were pulled. The U.S. Religion Census only collects information decennially, and the 2020 election provided us with a snapshot of the political landscape at the specific moment in time when the vaccine became available to the public. Ultimately, we wish to capture the state of pre-existing county-level factors when the vaccine was released, which is what utilizing 2020 datasets enable us to do.

We begin with a correlation estimation to identify pairwise relationships between the dependent variable, *Vaccination Rate*, the percent of the county population that is fully vaccinated as of March 31, 2022 (i.e., completed two shots for the MRNA vaccines or one shot for the Johnson and Johnson vaccine) and a set of demographic variables (percent male, median age, percent White and percent Black), background variables (percent that did not graduate from high school, percent with high school degree only, percent with college degree or higher, median household income in thousands, percent self-employed and proportion that have no health insurance), a political variable (*Percent Republican*, i.e., percent that voted for Donald Trump for president in the 2020 election) and religious variables (adherents per 1,000 population who identify as Mainline Protestant, Evangelical Christian, Roman Catholic, or Orthodox Christian). While our data set is at the county-level, we recognize the potential for state-level institutional idiosyncrasies and heterogeneity. Specifically, the COVID-19 response and the subsequent vaccination policies in the U.S. have been led by state governments. Therefore, we account for state heterogeneity by employing state-level fixed effects in each of our regression models. Based on our expectations from prior investigations and results in the correlation matrix we estimate a regression that takes on the form of

$$\mathrm{Y_i} = \alpha + \beta_a \mathrm{X_{ai}} + \beta_b \mathrm{X_{bi}} + \beta_c \mathrm{X_{ci}} + \beta_d \mathrm{X_{di}} + \beta_s \mathrm{X_s} + \varepsilon_i \quad (1)$$

where Y_i is the dependent variable, *Vaccination Rate*, for i counties, X_{ai} is a vector of demographic factors including percent of the county residents who are male, the median age of the county and percent White, X_{bi} is a vector of background variables including percent with a college degree or higher, the median household income (in thousands of dollars per year), percent self-employed and proportion of the county without health insurance, X_{ci} is the percent who voted for Donald Trump in the 2020 election, and X_{di} is a vector of religious variables including the number of Evangelical Christian adherents (per 1,000 population in the county), Catholic adherents (per 1,000 population) and Orthodox Christians (per 1,000 population), $\mathbf{X}_s$ is the state fixed effects vector and ε_i is the error term.

Results

We present the descriptive statistics for all of the variables in Table 1. The percentage of each county's population that was fully vaccinated by March 31, 2022 ranged from 13.5 to 95.0 percent with a mean of 60.1%. This percentage is important because the initial calls for herd immunity stressed the importance of achieving high vaccination percentages (e.g., 70—85% according to Anthony Fauci). However, herd immunity became

Table 1 Descriptive statistics

Variable	Obs	Mean	Std. Dev	Min	Max
Dependent Variable					
Vaccination Rate	3,126	60.06	12.57	13.50	95.00
Demographic					
Percent Male	3,143	49.90	2.48	29.06	58.01
Median Age	3,143	41.57	5.48	22.20	68.00
Percent White	3,143	81.75	16.93	3.29	100.00
Percent Black	3,143	9.02	14.45	0.00	87.79
Background					
No High School	3,143	12.40	6.04	1.39	78.15
High School	3,143	33.93	7.38	6.52	54.96
College-Plus	3,143	16.72	7.02	0.00	50.44
Median Household Income (000)	3,142	55.03	14.66	22.29	147.11
Self-Employed	3,143	4.85	2.36	0.00	19.76
No Health Insurance (Proportion)	3,143	0.09	0.05	0.00	0.42
Political					
Percent Republican (2020)	2,305	65.12	16.43	5.40	96.18
Religious					
Mainline Prot Adherents per 1,000	3,143	8.82	8.27	0.00	69.45
Evangel Christ Adherents per 1,000	3,143	23.45	18.13	0.00	452.45
Catholic Adherents per 1,000	2,961	12.47	12.35	0.05	95.79
Orthodox Christ Adher per 1,000	3,143	0.10	1.05	0.00	44.92

Table 2 Pairwise correlation with vaccination rates

Variable	Vaccination rate
Demographic	
Percent Male	0.133
Median Age	−0.121
Percent White	−0.263
Percent Black	0.028
Background	
No High School	−0.165
High School	−0.450
College-Plus	0.495
Median Household Income (000)	0.408
Self-Employed	−0.158
No Health Insurance (Proportion)	−0.187
Political	
Percent Republican (2020)	−0.702
Religious	
Mainline Prot Adherents per 1,000	−0.051
Evangel Christ Adherents per 1,000	−0.383
Catholic Adherents per 1,000	0.342
Orthodox Christian Adher per 1,000	0.257

very difficult to achieve due to the mutating nature of the virus and lack of global immunity [19]. There are five main categories of variables presented. In terms of demographic variables, there are about 49.9 percent males with a median age of the sample of 41.6 years. About 81.8 percent are White and 9.0% are Black. In terms of education, the median percent of county residents with no high school degree is 12.4 percent, 33.9 percent are high school graduates and 16.7 percent have a college degree or higher. The average median household income is about $55,000 in 2020 dollars and the average percent who are self employed is 4.9%. The mean percent who have no health insurance is 9.3%. The mean percent of county populations that are Republican is 65.1%. However, several states do not provide this voter information in any election season, so there are only 2,305 observations for this variable. The states that do not provide public voter information by party are: Arizona, Arkansas, Georgia, Iowa, Kentucky, Maryland, North Carolina, Oklahoma, South Carolina, Utah, Virginia. This factor is important in determining our model selection for the regressions, as noted below. Approximately 8.8% of county populations adhere to Mainline Protestant denominations, 23.5% are Evangelical Christian, 12.5% Catholic and 0.1% Orthodox Christian. Due to low county-level report rates for Jewish, Muslim and other religions, they were not included in this analysis.

The results of the dependent variable correlation analysis are presented in Table 2. We draw two important conclusions from this analysis. First, with a correlation coefficient of about −0.70, the percent Republican demonstrates the strongest (negative) correlation with vaccination rates. Second, there are three background variables and three religious variables that demonstrate a strong correlation with vaccination rates. These are all included in the regression analysis.

We test for the presence of multicollinearity and heteroskedasticity and find both to be present. For the former, the correlations matrix (Appendix Table 1) indicates high correlation between the following variable pairs: (i) percent of county population with no high school degree and the percent with a college degree or higher, (ii) percent of county population with no high school degree and percent of county population with no health insurance, (iii) percent of county population with a high school degree and the percent with a college degree or higher, (iv) percent of county population with a high school degree and the median county household income, (v) percent of county population with a college degree or higher and the median county household income, (vi) percent of population who voted Republican in the 2020 presidential

Table 3 Regression results (Explaining Covid-19 Vaccination Rates)

Variables	Model 1	Model 2	Model 3
Demographics			
Percent Male	0.658***	0.279**	0.092
	[0.119]	[0.115]	[0.123]
Median Age	0.098**	0.226***	0.197***
	[0.046]	[0.046]	[0.047]
Percent White	−0.257***	−0.217***	
	[0.018]	[0.017]	
Background			
Median Household Income (000)	0.250***		0.199***
	[0.017]		[0.017]
Self-Employed	−0.381**	−0.829***	−0.318**
	[0.159]	[0.154]	[0.148]
No Health Insurance	−12.189	4.815	2.804
	[7.575]	[7.282]	[8.416]
College-Plus		0.721***	
		[0.032]	
Religious			
Evangel Christian Adherents Per 1,000	−0.100***	−0.085***	0.020
	[0.017]	[0.017]	[0.020]
Catholic Adherents Per 1,000	0.200***	0.204***	0.163***
	[0.024]	[0.023]	[0.022]
Orthodox Christ Adherents Per 1,000	−0.168	−0.320	−1.378**
	[0.339]	[0.274]	[0.548]
Political			
Percent Republican (2020)			−0.505***
			[0.018]
Constant	26.770***	39.070***	63.089***
	[6.440]	[6.067]	[6.783]
Observations	2,941	2,942	2,176
State Fixed Effects	Yes	Yes	Yes
Adjusted R-Squared	0.497	0.543	0.636

Robust standard errors in brackets

*** $p < 0.01$

** $p < 0.05$

* $p < 0.1$

elections and the percent of the population identifying as White in the county, (vii) percent of population who voted Republican in the 2020 presidential elections and percent of county population with a college degree or higher. The variance inflation factors (VIFs) reveal no other instances of multicollinearity. We proceed by dropping the two lowest categories of educational attainment from our econometric analysis, leaving us with the multicollinearity in pairs (v), (vi) and (vii) above. To address these, we estimate three different regressions (Models 1, 2 and 3), where multicollinear variables are never present in the same model (Table 3). We address heteroskedasticity by employing robust standard errors.

To account for multicollinearity, we estimate three different regressions: (i) in Model 1, we retain both the percent White and the median household income variables, (ii) in Model 2, we employ the percent White and the percent of county population that is college educated or higher, and (iii) in Model 3 we include the median household income and the percent of population that voted Republican in the 2020 presidential election. Model 3 thus includes our three variables of interest: Percent Republican (2020), Evangelical Christian Adherents per 1,000 population and Catholic Adherents per 1,000 population.

Overall, four variables demonstrate a positive, significant relationship with vaccination rates across each of the models in which they appear: Median Age, College-Plus, Median Household Income (000) and Catholic Adherents per 1,000. This suggests that counties with (a) older populations, (b) higher percentages of college graduates, (c) higher median incomes and (d) a greater proportion of the population that is Catholic have higher COVID-19 vaccination rates. Since older persons are more vulnerable to COVID-19 this first outcome fits with the nature of this virus. Higher incomes and educational attainment may also be associated with a greater understanding of risk, probability, disease transmission/prevention and science in general and are consistent with previous findings (Leung, 2023, Sun and Monnat, 2023). The Catholic Church's leadership on COVID-19 vaccines seems to have paid off in terms of Catholic adherents' adoption of the vaccines. These results suggest that at the mean, an increase of one Catholic adherent per 1,000 population is associated with an increase in vaccination rates by between 0.16 and 0.20 percent.

There are three variables which demonstrate a consistent pattern of negative association with vaccination rates: Percent of Population identifying as White, Percent Self Employed, and Percent Republican (2020). A one percent increase in the percentage of White people in a county is associated with a 0.22 to 0.26 percent decrease in vaccination rates, on average, holding all else constant. It is not clear what is driving this outcome. In terms of the Percent Self-Employed result, perhaps these individuals are more independent-minded and thus more likely to eschew government, corporate or societal norms and mandates. Depending on their line of work they may also have been less likely to work in large groups or crowded spaces and less subject to workplace vaccination mandates. The Percent Republican outcome is consistent with early research in this area (e.g., [18]), though it is difficult to know how much of this result is due to the conservative ideology's

general opposition to government mandates, regulations, etc. and how much may be due to the leadership of the Republican party at the time of the pandemic and its inconsistent messaging. On one hand, Operation Warp Speed, a federally-funded program initiated by the Trump Administration, was a success in driving the development, production and widespread approval of the vaccines. It should also be noted that President Trump, himself, was vaccinated. On the other hand, President Trump's messaging included almost daily attacks on Dr. Anthony Fauci, particularly on Twitter [8], and as the pandemic wore on, Trump seemed to downplay the importance of vaccination and lethality of COVID-19 often pointing to policies of Republican governors such as Ron DeSantis of Florida whose approach to the pandemic was more laissez-faire. The fact that this was playing out during a presidential election year likely made the political aspect even more salient [1].

Comparing Models 1 and 2 with Model 3, it is clear that adding the *Percent Republican 2020* in Model 3 has an impact on two of the religious variables in the model: (i) Evangelical Christian Adherents per 1000 becomes insignificant and (ii) Orthodox Adherents per 1000 becomes significant. For the former, Evangelical Christians per 1,000 population is negative and statistically significant in the first two models but becomes insignificant with the inclusion of the Percent Republican variable. This finding certainly fits the pattern found in prior research as noted above (e.g., by [10]) though it is not known to what extent the vaccine hesitancy is a result of suspicion or lack of trust about the vaccines, science in general or perhaps even an unintended consequence of a theological norm that eschews hierarchy and broad administrative leadership writ large. The significance-change for Orthodox Christian Adherents per 1,000 may be influenced by the fact that the population identifying as Orthodox Christian is less than 1% on average, so the change in significance should be considered in that context. These two results also add further clarity to the "religious beliefs" effect demonstrated in Leung et al. [15] as an important motivation for vaccine hesitancy. This is likely due to the fact that these factors serve as partial proxies for the "Republican effect" not explicitly accounted for in Models 1 and 2.

We perform two robustness checks for our analysis. First, in our Data section, we shared the ten states that do not disclose voter percentages by party in any election cycle. Because of this, the regression in Column (3) in Table 3 has considerably fewer observations (2,176) than Models 1 and 2 (2,941). To account for potential selection bias, we repeat our analysis for all three models using only the restricted sample that includes states that provide voter data by party (Table 4). We find the initial results (in Table 3) to be robust to the restricted sample (Table 4).

Table 4 Regression results (Explaining Covid-19 Vaccination Rates) – Restricted Sample

Variables	Model 1	Model 2	Model 3
Demographics			
Percent Male	0.614***	0.276**	0.092
	[0.138]	[0.130]	[0.123]
Median Age	0.094*	0.215***	0.197***
	[0.054]	[0.053]	[0.047]
Percent White	−0.304***	−0.250***	
	[0.025]	[0.024]	
Background			
Median Household Income (000)	0.264***		0.199***
	[0.021]		[0.017]
Self-Employed	−0.458**	−0.968***	−0.318**
	[0.178]	[0.169]	[0.148]
No Health Insurance	−12.400	7.814	2.804
	[8.692]	[8.377]	[8.416]
College-Plus		0.799***	
		[0.039]	
Religious			
Evangel Christian Adherents Per 1,000	−0.108***	−0.084***	0.020
	[0.021]	[0.021]	[0.020]
Catholic Adherents Per 1,000	0.191***	0.209***	0.163***
	[0.026]	[0.025]	[0.022]
Orthodox Christ Adherents Per 1,000	0.897	−1.598***	−1.378**
	[0.964]	[0.585]	[0.548]
Political			
Percent Republican (2020)			−0.505***
			[0.018]
Constant	32.296***	44.541***	63.089***
	[7.487]	[6.866]	[6.783]
Observations	2,176	2,176	2,176
State Fixed Effects	Yes	Yes	Yes
Adjusted R-Squared	0.511	0.568	0.636

Robust standard errors in bracket

*** $p < 0.01$

** $p < 0.05$

* $p < 0.1$

For the second robustness check, we check to see whether there are spatial effects at work at the county level. We use the latitude and longitude for a central point for each county. Here, we develop an inverse distance matrix measuring the distance between a county X and all other counties in continental US. We then employ a spatial autoregressive model with both a spatial lag of the dependent variable (vaccination rate) and a spatial lag

of the error term (Table 2 in the Appendix). We find the results to be similar and robust to those in Table 3.

Conclusions

In this investigation we have combined four data sets–the American Community Survey's county-level data from the US Census, vaccination data from the CDC, religious data from the US Religion Census for 2020 from the Association of Religious Data Archives and 2020 county-level election results from MIT's Election Data and Science Lab. We draw from a vast literature on vaccine hesitancy and more recent research on COVID-19 vaccine hesitancy. However, to our knowledge, this is the first comprehensive county-level analysis to include this combination of data sets with vaccination rates through March 31, 2022. Our results suggest that county-level political and religious composition are very important factors in explaining COVID-19 vaccine hesitancy.

In terms of political affiliation, the most important factor demonstrating higher vaccine hesitancy is the percent of county population who voted for Donald Trump in the 2020 presidential election. This negative coefficient has the highest level of significance across all models. Religious affiliation also matters–particularly the percent Catholic and percent Evangelical–with percent Catholic having a consistent, positive effect on vaccination rates regardless of model specification. Percent Evangelical Christian has a strong, negative effect on vaccination rates in our first two models. However, once percent Republican (in 2020 presidential election) is introduced in Model 3, the Evangelical Christian effect seems to disappear. There is clearly a large overlap between these two effects. We suspect that much of the difference in the Percent Evangelical Christian and Percent Catholic "effect" has to do with the difference in church leadership, with Pope Francis taking a clear and early position in favor of COVID-19 vaccinations, whereas Evangelical Christian leaders presented less of a unified position on vaccinations. While there may have been some bishops or priests who privately expressed skepticism, the overwhelming majority were in alignment with the Vatican's and the USCCB's unequivocal stance: get vaccinated. If there is a common thread between the religious and political results presented here, it is leadership. In the case of Catholic leadership, Pope Francis' clear, unequivocal stance in favor of vaccination–even framing it in terms of a moral imperative to help the most vulnerable elderly and poor living in close quarters–likely created a positive impact on vaccination rates. On the other hand, messaging from Evangelical Christian churches, as well as some political figures, was less uniform and consistent, even negative. While initially it was the Trump administration that advocated a quick rollout of the vaccine, his administration's subsequent minimization of the lethality of COVID-19, public criticism of Dr. Fauci, and support for Florida Governor Ron DeSantis' open-COVID policies likely contributed to higher vaccination hesitancy, particularly among Trump's followers, even if the vaccine was created under his administration [1]. However, as this paper demonstrates, although the COVID-19 vaccine may have ultimately become a political football, politics is clearly not the only significant deciding factor when it comes to getting vaccinated .

Results presented here are consistent with the HBM model as well as previous empirical investigations and seem to add further credence to the conclusion drawn by Leung and colleagues (2023) that "to address vaccination hesitancy, and to protect public health, collaboration is needed between governments, private companies, religious groups and the community to promote public trust of vaccines." Perhaps an additional learning from this and previous studies is that educational attainment levels matter. A one percent increase in a county's population with a college degree or higher is associated with a 0.80 percent increase in vaccination rates. If there is a way to combat vaccine hesitancy in the future it is likely through thoughtful civic and religious leadership, clear messaging and education.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13561-025-00605-y.

Supplementary Material 1.

Authors' contributions

Declan R. Carroll is responsible for: Original conception of the paper and co-responsible for: contribution to paper design, data acquisition, data analysis, data interpretation and manuscript writing and editing. Stephen J. Conroy is responsible for: Substantial revision and repositioning of original draft of paper and co-responsible for: contribution to paper design, data acquisition, data analysis, data interpretation and manuscript writing and editing. Adriana Vamosiu is responsible for: Creation of coding for data-set creation and co-responsible for: data analysis and data interpretation and manuscript writing and editing.

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Data availability

All data are available upon request from the corresponding author: sconroy@sandiego.edu.

Declarations

Competing interests

The authors declare no competing interests.

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