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Social asset or social liability? How partisanship moderates the relationship between social capital and Covid-19 vaccination rates across United States counties

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ABSTRACT

This study investigates the interactive effect of social capital and partisanship on COVID-19 vaccination rates. Using county-level data from the United States (U.S.), we empirically find that social capital is a double-edged sword. Its effect on the vaccination rate depends on the dominant partisanship of the jurisdiction. In more liberal counties, stronger social capital is a social asset that encourages people to seek vaccination and results in a higher vaccination rate. In contrast, in more conservative counties where the Trump-voting rate reaches 73% and beyond, stronger social capital becomes a social liability for public health by reinforcing residents' hesitancy toward or rejection of vaccinations, leading to a lower vaccination rate. This study implies the need for reducing the partisanship salience and investing in bridging and linking social capital in polarized communities.

1. Introduction

Although the prospects of herd immunity are fading (Mandavilli, 2021), the whole world has been fervently hoping for a break from the COVID-19 pandemic. A crucial method aimed at achieving this goal is vaccinations. The high efficacy of today's vaccines in preventing severe cases, hospitalization, and death from COVID-19 is critical to returning to normalcy. In the U.S., United Kingdom (U.K.), and France, COVID-19 is no longer a leading cause of hospitalization and death for the vaccinated population; however, it is still a leading cause of death among the unvaccinated (Charumilind et al., 2021a,b). The rising infection and death tolls in fall 2021 in the U.S. were likely avoidable, given that over 90 percent of COVID related hospitalizations and deaths were unvaccinated people (Johnson and Stobbe, 2021).

Vaccination is more cost-effective compared to other public-health policy interventions. Turner et al. (2021) compare the independent impacts of vaccination versus other containment or lockdown policies on the weekly GDP of OECD (Organization for Economic Cooperation and Development) countries. Policies compared include the closure of workplaces, public transport and schools, travel and gathering restrictions, and stay-at-home requirements. They conclude that "Fully

vaccinating 50% of the population would have a larger effect at reducing virus transmission than simultaneously applying all the containment policies in their most extreme form" (p 3). Relaxing containment policies would be expected to raise GDP by about 4-5% for an OECD country. Thus, a high vaccination rate would reduce the need for a country to use strict containment policies, generating huge economic benefits and fewer infections. Schools, workplaces and borders could reopen (Turner et al., 2021).

As of February 6th, 2022, 76.2 percent of the U.S. population had received at least one dose of a COVID-19 vaccine, and 64.4 percent had been fully vaccinated, according to the Centers for Disease Control and Prevention (CDC, 2022). Vaccine hesitancy, however, has been a persistent challenge to facilitate a transition toward normalcy. Approximate thresholds for herd immunity are benchmarked at 80 to 90 percent, which would require a minimum of roughly 80 million additional individuals to be vaccinated (Charumilind et al., 2021a,b).

One important factor that has yet to receive sufficient scholarly attention is the role of social capital in encouraging or hindering COVID-19 vaccination rates. Social capital refers to "features of social organization such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit" (Putnam, 1995, p. 667).

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Consistent with recent literature on the relationship between social capital and COVID-19 outcomes (Fraser et al., 2021; Elgar et al., 2020), we conceptualize social capital in three dimensions: bonding (in-group ties), bridging (inter-group ties), and linking social capital (vertical trust, or degree of trusting relationships with formal institutions and persons of authority) at the community/county level of analysis. The distinction between bonding and bridging social capital builds on the seminal sociological work on embeddedness and weak ties (Granovetter, 1973, 1985). While bonding and bridging social capital are based on horizontal ties in a community, linking social capital is embedded in vertical ties that connect residents, elected officials, and decision-makers, including medical experts and public health leaders. Trust in government helps residents make decisions involving safety-related behaviors in their daily life—e.g., flying on airplanes, access to key public goods and responsive governance during and after crisis (Bollyky et al., 2022).

Findings about social capital's impacts on public health are mixed. On the one hand, the health-promoting benefits of social relationships stem from residing in a place with cohesive social ties and a supportive community structure. For example, compared to parents with a low level of neighborhood social capital, measured by perceptions of trust in community residents and cohesiveness, their high-social-capital counterparts are more likely to vaccinate their children against H1N1 (Jung et al., 2013). Resources flowing in people's social ties include social support, the actual or potential economic, cultural, and political resources that could benefit individual and collective health (Moore & Carpiano, 2020). Empirical research shows that people's confidence in their governments is highly correlated with better pandemic outcomes, such as the case with H1N1 (Prati et al., 2011) and COVID vaccinations (Bollyky et al., 2022), compliance with social distancing rules (Bollyky et al., 2022), and lower COVID death rates (Elgar et al., 2020; Bollyky et al., 2022). On the other hand, while a large stream of research has identified the positive effects of community-level social capital on population health, such as HIV risk (Pronyk et al., 2008) and community COVID-19 mitigation measures (Borgonovi and Andrieu, 2020), a growing number of studies have noted potentially negative effects of social capital on health outcomes (Villalonga-Olives and Kawachi, 2017; Elgar et al., 2020). For instance, researchers have identified the spread of health-damaging information in a tightly-connected closed network as one of the overlooked negative consequences of social capital (Ozawa et al., 2016; Reich, 2020).

The inconsistent findings can be attributed to the possibility that the effect of social capital on health outcomes is contingent on other factors. Recent research has begun to pay attention to the contingent relationship between COVID-19 deaths and social capital (Elgar et al., 2020; Fraser et al., 2021). In the U.S., partisanship may play an important role in the relationship between social capital and COVID-19 vaccination rates, given the strong influence of partisanship on COVID-19 vaccination and death rates (Wood and Brumfiel, 2021). The rate of vaccination against COVID-19 among Republicans has flatlined at 59%, while 91% of Democrats were vaccinated by October 2021, according to the Kaiser Family Foundation COVID-19 Vaccinate Monitor (Kirzinger et al., 2021). The counties that voted heavily for Donald Trump in the 2020 Presidential election have seen much lower vaccination rates and nearly three times higher COVID-related death rates than those that voted heavily for President Biden (Wood and Brumfiel, 2021).

The partisan divide in COVID outcomes is a manifestation of ideological polarization, defined as the extent to which political views are widely dispersed. Polarization used to be strong among elites, including legislators and elected officials (Leonard et al., 2021), yet less pronounced among the general public (McCarty, 2019). However, American citizens increasingly dislike and distrust those of the other party or political labels—Democrat, Republican, Liberal, Conservative (Axelrod et al., 2021; Baldassarri and Page, 2021). Such affective polarization among the general public, coupled with polarized elites, could lead to increasing ideological polarization and boost the salience of partisan

identity during population health crises (Allcott et al., 2020). Like an individual's social identity (Ehsan et al., 2019), political identity is a salient individual characteristic that could interact with social capital in powerful ways in the politicized debate about COVID-19 vaccination.

To advance an emerging stream of literature on the effects of social capital on COVID-19 outcomes, including mobility (Borgonovi and Andrieu, 2020), case and growth rates (Kuchler et al., 2022; Varshney and Socher, 2020), and deaths (Fraser et al., 2021), we address two questions: Is social capital instrumental or detrimental to the COVID-19 vaccination rate? And does the relationship hinge on the dominant partisanship of the jurisdiction? We adopt a contingency perspective that examines the interactive effects of social capital and partisanship on vaccination rates in U.S. counties. We propose that social capital can be a double-edged sword, as it can be productive or counterproductive in regard to the vaccination rate, depending on the partisanship through which it communicates, shares, and sustains. More specifically, we articulate the following three hypotheses.

First, social capital promotes a higher vaccination rate (Hypothesis 1). Strong social capital could make it easier for a vaccination-supporting message to spread through social networks in schools, churches, civil organizations, and community forums. In strong social capital communities, people have a high level of interpersonal trust and trust in government. In a comprehensive study of pandemic preparedness and COVID-19 outcomes in 177 countries between 2020 and 2021, Bollyky et al. (2022) found that both types of trust are associated with higher vaccination rates as of Sep 30, 2021, in middle-income and high-income countries, including the U.S. Based on this insight, we posit that in counties with strong social capital, communities are more likely to have a high level of interpersonal trust, due to strong bonding and/or bridging social capital, and a high level of trust in government, due to strong linking capital. Increased trust of both types will increase the vaccination rate.

Second, counties with a heavy representation of conservative partisanship are associated with low vaccination rates (Hypothesis 2). Conservative citizens tend to elect and follow the cues of conservative leaders, including former President Trump, county commissioners, sheriffs, school board members, **former President Trump**, other Republican leaders and the conservative media. Most of them were quite vocal in their criticism and skepticism regarding measures to fight COVID, including the need to vaccinate (Bolsen and Palm, 2021). Some would even acquiesce or actively assist their conservative partners in the unchecked flow of misinformation about the vaccine and pandemic through public forums (Goodland and Puerro, 2021). The 2021 General Social Survey found American's trust in science was deeply polarized, with a trust gap in science and medicine widening substantially between Republicans and Democrats during the pandemic (Associated Press, 2022). Trust in government is also partisan (Bollyky et al., 2022). Conservatives are more likely to believe that the government exaggerated the severity of the pandemic by inflating the number of COVID deaths (Wood & Brumfiel, 2021). Thus, they are less worried about getting sick from COVID-19, as is evident in the use of the colloquialism "face diaper" in Trump-supporting regions (French, 2022). Barrios and Hochberg (2020) found that as Trump voter share rises in a county, individuals search less for information on the virus, and engage in less social distancing behavior, as measured by smartphone location patterns, despite state-lock-down mandates. This lack of perceived personal risk would contribute to low vaccination rates.

Third, the direction of the relationship between social capital and vaccination rates is dependent on the voters' support rate for Trump: a higher rate of voting for Trump weakens the positive relationship between social capital and vaccination rates (Hypothesis 3). Put another way, a higher voting rate for Biden strengthens the positive relationship between social capital and vaccination rates.

As suggested by Elgar et al. (2020), "social capital, in all its forms, is generally agnostic about whether it has positive or negative influences on health" (p. 5). Conservative voters are more likely to be friends with

other conservative voters than with liberal or independent voters. This is the homophily effect of similarity-breeds-connection—i.e., birds of a feather flock together (McPherson et al., 2001). The partisan identification and homophily seems to manifest group attachment dynamics, including in-group solidarity and out-group hostility (Baldassarri and Page, 2021). The 2020 Presidential election, the pandemic and the polarized media ecosystems and information cascades may have sharply reduced bridging ties between people from different ideologies (Tokita et al., 2021) and linking social capital in Trump-supporting regions. Low linking social capital manifests distrust in government and in health experts among conservative voters (Associated Press, 2022; Babington, 2021). Thus, conservative messages about individual choices and misinformation about the vaccine's side effects, bogus treatments, or pandemic severity could be carried and amplified in homogenous conservative networks (Tokita et al., 2021), which reduce exposure to or silence challenging information and increase outgroup hostility. Driven by the self-reinforcing logic of punishing defectors and eliminating moderating voices, Republican voters and elites may polarize more quickly than Democrats (Leonard et al., 2021).

By comparison, liberal and independent voters tend to favor vaccination (Wood and Brumfiel, 2021; Kirzinger et al., 2021). Homophily could play a significant role in their networks in promoting pro-vaccination messages. Liberal celebrities' public online pruning ties with anti-vaxxers is a case in point (BBC, 2021). Democratic voters tend to vote for liberal elected officials, who are more likely to deploy organizational and partnership resources to support vaccination and fight misinformation (Godfrey, 2021). They have stronger trust in science and confidence in leaders of science and medicine (Associated Press, 2022). Overall, the 2021 General Social Survey data show that sixty-four percent of Democrats say they have "a great deal" of confidence in the scientific community, compared with roughly half as many Republicans, 34% (Associated Press, 2022). Bollyky et al. (2022) found that high levels of trust in government and interpersonal trust are strongly correlated with COVID vaccination rates. Thus, liberal ideology, coupled with the independent positive effects of high linking social capital on vaccination, will produce a combined high vaccination rate in the county. In other words, social capital continues to be instrumental in encouraging vaccination in Democratic-dominated counties.

2. Methodology

2.1. Estimation strategy

County-level cross-sectional data in the U.S. were collected and analyzed to test our hypotheses. Counties within the same state share some state-specific characteristics, especially in regard to the COVID-related policies (e.g., mask requirement and vaccination priority policies) imposed by states. If these factors are unobserved or uncontrolled for, they may lead to biased estimates. To address this issue, we used a state fixed effects estimation model to evaluate the effects of the social capital index and partisanship on county-level COVID-19 vaccination rates. The fixed effects model yields unbiased estimates, as the model can eliminate the effects of unobserved state-specific factors. Equation (1) specifies the fixed effects model used to test hypotheses one and two:

$$CovidVacRate_i = \alpha_0 + \alpha_1 SocialIndex_i + \alpha_2 Partisan_i + \alpha_3 X_i + \theta_s + \varepsilon_i \quad (1)$$

In the model, the dependent variable is the county-level fully vaccinated rate for individuals aged 18 years and older; social capital index and partisanship are key independent variables of interest; X denotes a vector of controlled covariates; and θ_s refers to state fixed effects. α and ε_i represent estimated parameters and the disturbance term, respectively.

To test Hypothesis 3, an interaction term between the social capital index and partisanship is included in the regression model as follows:

$$CovidVacRate_i = \alpha_0 + \alpha_1 SocialIndex_i + \alpha_2 Partisan_i + \alpha_3 X_i + \alpha_4 SocialIndex_i * Partisan_i + \theta_s + \varepsilon_i \quad (2)$$

2.2. Sample

The sampling frame consists of all 3113 counties in the U.S. The main constraining factor is the social capital score, which is only available for 2971 counties. Thus, regression models including the social capital variable do not contain the complete set of counties. However, missing observations will not be a significant threat to the validity of our analysis for the following reasons. First, our sample consists of more than 95% of all observations in the sampling frame; counties in our sample contain 99.78% of the American population. Second, counties in our sample and those in the entire sample frame have no systematic differences in vaccination rates and other major variables used in this study.¹ Third, as further discussed in the regression results section, results based upon the sample with missing observations (the main and interaction models) are consistent with those based upon the full sample of all U.S. counties (the base model), suggesting that missing values in the main regression models do not create biased estimates.

2.3. Dependent variable

The COVID-19 vaccination rate among U.S. adults was extracted from the Centers for Disease Control (CDC) and Prevention COVID-19 Data Tracker.

2.4. Key independent variables: social capital index and partisanship

The Congress Social Capital Project produces a county-level social capital index based on four components: three subindices and one stand-alone indicator. Subindices include the family unity subindex, community health subindex, and institutional health subindex. The collective efficacy is a stand-alone indicator that shows violent crimes per 100,000.² This index is considered an improvement to the Penn State county-level social capital index, as the latter does not include factors such as "family health, volunteerism, charitable giving, informal community engagement, social support, or collective efficacy" (SCP Report, 2018, p. 9), and the former has stronger correlations with 50 different benchmarks (SCP report, 2018, p. 26). These core dimensions reflect a basic family structure and ties among family members; community engagement and "institutionalized relationships of mutual acquaintance and recognition" (Bourdieu and Wacquant, 1992, p. 119); and trust and confidence in authority and county government. Although previous studies examining pandemics (i.e., 2003 SARS, influenza, and H1N1) did see a positive correlation between trust in government and in health

¹ We conducted independent-sample t tests and found there is no statistical difference between counties with social capital scores and all counties in the whole sampling frame regarding the vaccination rate or other key variables used in our regression model.

² A) Family unity subindex: share of births in past year to women who were unmarried; share of women ages 35–44 who are currently married (and not separated); share of own children living in a single-parent family. B) Community health subindex: registered non-religious non-profits per 1000; religious congregations per 1000; informal civil society sub-index. C) Institutional health subindex: Average (over 2012 and 2016) of votes in the presidential election per citizen age 18+; mail-back response rates for 2010 census; confidence in institutions sub-index (combination of share reporting at least some confidence in corporations, in the media, and in public schools. Data source: Volunteer Supplement to the November 2013 Current Population Survey). D) Collective efficacy: violent crimes per 100,000. Please refer to The Geography of Social Capital in America for more detail and discussions. <https://www.jec.senate.gov/public/index.cfm/republicans/2018/4/the-geography-of-social-capital-in-america#toc-002-backlink>.

institutions and public inclination to get vaccinated, the impact of living in a more connected, trusting, and engaged community, especially at the county level, on COVID-19 vaccination rates has yet to be seen (Cheung and Tse, 2008; Chuang et al., 2015; Freimuth et al., 2014; Gilles et al., 2011). More recently, Elgar et al. (2020) provided evidence that some aspects of social capital (civic engagement, confidence in institutional authorities, and low-income inequality) reduce the COVID-19 mortality rate at the country level; however, to our knowledge, our study is the first to systematically examine the impact of social capital on COVID-19 vaccination rates at the county level in the U.S.

Partisanship, another key variable of interest in our study, was operationalized using the county-level rate of support for the Republican candidate in the 2020 presidential election.³

2.5. Control variables

We introduced control variables for the following county-level characteristics: socioeconomic, demographic, and health profile of residents. We used median household income, education attainment (percentage of some college), and unemployment rate to control for the socioeconomic characteristics of the county. Those socioeconomic factors are well documented in Barry et al. (2021): low median household income, low education attainment, and high unemployment rates predict lower COVID-19 vaccination rates at the county level in the U.S.

Demographics were controlled for using the percentage of the population that is 65 years or older and the urbanization rate. Overwhelming scientific evidence suggests that an aging population (65 years and older) is a determining factor in COVID-19 patients' survival rate (Daoust, 2020; Zhou et al., 2020; Jordan et al., 2020), and governments around the world have paid special attention in persuading the aging population to comply with COVID-19 health preventative measures (Daoust, 2020; Utych and Fowler, 2020). Thus, an aging population should be positively correlated with the vaccination rate. Although a cross-country study identifies urbanization rate as a main reason for the COVID-19 mortality rate (Squalli, 2020), its impact on vaccination rate has not been comprehensively studied. A CDC study finds disparities in COVID-19 vaccination rates between rural and urban areas.⁴ To be more specific, "The agency found a lower percentage of adults in rural counties who received at least one shot than in urban counties, at 38.9% and 45.7%, respectively." As such, we believe the urbanization rate would be positively correlated with the vaccination rate, as well.

Furthermore, uninsured population percentage was included via small area health insurance estimate 2018 data. We elected to control for such measures but hypothesize the possibility of both "pushing" and "pulling" effects on vaccination rates. A county with a high uninsured population percentage might indicate residents tend to be risk-takers or lack access to health care facilities; hence they would be less likely to get vaccinated (i.e., the pushing effects). Alternatively, lack of medical insurance coverage for county residents might indicate financial or health trouble should they contract COVID-19. They might want to get the job in exchange for ease of mind, representing the pulling effects. As such, uninsured population percentage's estimated effect on the COVID-19 vaccination rate is indeterminant. In addition, the flu vaccination rate came from the 2018 Mapping Medicare Disparities Tool. Following the lead of Shmueli's (2021) study that finds a positive and statistically significant correlation between acceptance of the influenza vaccine and COVID-19 vaccine, we believe the flu vaccination rate will have a positive impact on the COVID-19 vaccination rate.

Lastly, it has been well documented that racial and ethnic minority

³ We also conducted robust checks by modeling social capital and partisanship as binary variables. The results remain consistent.

⁴ Accessed on Nov. 19th, 2021. <https://www.cnbc.com/2021/05/18/covid-vaccine-cdc-study-finds-disparities-in-coverage-between-rural-and-urban-areas.html>.

groups have been disproportionately impacted by the COVID-19 pandemic (Njoku et al., 2021; Bogart et al., 2022), and vaccine hesitancy tends to be high among those groups (Liu and Li, 2021; Ndugga et al., 2021; Khan et al., 2021). We have thus included African American population percentage and Hispanic population percentage at the county level as controls, as well. Table 1 presents brief descriptions and data sources for the variables used in this study.

2.6. Summary statistics

Table 2 presents the descriptive statistics of the variables used in this study. To provide a clear picture of the vaccine rollout trend, we also summarize the county-level vaccination rates at five time points between April 1, 2021, and September 1, 2021. The adult total vaccination rate increased more slowly during this period, ranging from 17.83% on April 1, 2021, to 42.85% on September 1, 2021. There exists a substantial variation in the vaccination rate across counties, as reflected by the minimum value of zero and maximum value of almost 100 percent. The jurisdictional variation is also demonstrated in Fig. 1, the county-level map of vaccination rates on August 1st, 2021.

Our focal variable, the social capital index developed by Congress, was normalized, and thus has a mean value of zero and a standard deviation of one. Another key variable, the Trump support rate, has a mean value of 54 percent. The mean values of the control variables seem to be consistent with what we expected. On average, residents with an age of 65 or older account for 20 percent of all residents in U.S. counties; approximately 41.5 percent of the population live in urban settings; 12 percent and 43 percent of the residents are uninsured and have taken the flu vaccine, respectively; 58 percent of residents have attended some college; the median household income is \$55,620; and African Americans and Hispanics account for 6.5 percent and 9.8 percent of the county population, respectively.

In addition, Appendix A shows the correlation of all independent variables. The correlation between most pairs of variables is below 0.5, suggesting a weak to medium correlation. The exception is the variable social capital index, which has a relatively high and negative correlation with unemployment percentage (-0.586) and African American population percentage (-0.519). We further investigated the potential multicollinearity issue by calculating the variance inflation factor (VIF), which shows a moderate correlation between the variables mentioned above but not severe enough to warrant further action.

3. Results

This section first examines the vaccine rollout in the U.S. to determine a proper time frame for the empirical analysis. We then present and discuss the results of two multivariate regression models using county-level fully vaccinated rates for 18 years and older⁵ as the dependent variable.

The COVID-19 vaccine developed in a record-setting time – less than a year after a viral outbreak; its rollout, however, is far from ideal. In the early days of vaccine rollout, production bottleneck, logistical issues (i.e., lack of cold chain capacity), confusion of eligibility requirements, large volume of phone calls, and online registration requests crashing the booking system dominated the news cycle. Thus, choosing an appropriate time frame to disentangle the impact of partisanship and social capital on vaccination rates is paramount to our empirical analysis. Fig. 2 shows the full vaccination progression at the county level in four states. Based on the data for November 23rd, 2021, Vermont is ranked number one with a full vaccination rate of 72.57 percent. California fully vaccinated 62.76 percent of its population and ranked #16

⁵ We also tested the overall fully vaccinated rate; the results do not differ. We chose to use 18 years and older segment to control for child composition differences at the county level.

Table 1
Variables, Measures, and Data Sources.

Variables	Measures	Sources	Year
Dependent Variable			
Vac Rate	Fully vaccinated rate for 18 years and older (in %)	CDC Data Tracker https://covid.cdc.gov/covid-data-tracker/#datatracker-home	2021
Key Independent Variables			
Social Capital Index	Comprehensive county-level indicator calculated based on family unity subindex, community health subindex, and institutional health subindex; and the collective efficacy	Social Capital Project https://www.jec.senate.gov/public/index.cfm/republicans/socialcapitalproject	2018
Partisanship	2020 presidential election rate that support the Republican candidate	MIT Election Data and Science Lab, 2018, "County Presidential Election Returns 2000–2020", https://doi.org/10.7910/DVN/VOQCHQ , Harvard Dataverse, V9, UNF:6:qSwUYo7FKxI6vd/3Xev2Ng == [fileUNF]	2020
Control Variables			
Socioeconomic characteristics			
Income	Median household income	Small Area Income and Poverty Estimates, (2021). County Health Ranking Report. County Health Rankings & Roadmaps , https://www.countyhealthrankings.org/explore-health-rankings/rankings-data-documentation	2019
Education	Education attainment, percentage of some college	American Community Survey, 5-year estimates	2015–2019
Unemployment	Unemployment percentage	Bureau of Labor Statistics	2019
Demographics			
Aging population	65 years and older population percentage	Census Population Estimates	2019
Urbanization	urban population percentage	2010 Census Urban and rural Classification	2010
Health profile			
Uninsured	Uninsured population percentage	Small Area Health Insurance Estimates, (2021). County Health Ranking Report. County Health Rankings & Roadmaps , https://www.countyhealthrankings.org/explore-health-rankings/rankings-data-documentation	2018
Flu vaccinations	Flu vaccination rate	Mapping Medicare Disparities Tool, 2021 County Health Rankings Report	2018
African Americann pop. pct	County level African American pop. percentage	County Population by Characteristics: 2010–2019; Census Bureau	2018
Hispanic pop. pct	County level Hispanic pop. percentage	County Population by Characteristics: 2010–2019; Census Bureau	2018

Table 2
Summary Statistics.

VARIABLES	N	Mean	S	Min	Max
Fully vaccinated rate for 18 years and older percentage, progression across time					
4/1/21	3113	17.83	9.28	0.00	91.50
5/15/21	3113	33.16	16.06	0.00	99.90
7/1/21	3113	38.73	18.59	0.00	99.90
8/1/21	3113	40.35	19.17	0.00	99.90
9/1/21	3113	42.85	19.87	0.00	99.90
Key variables of interest					
Social capital index ^a	2971	0.00	1.00	−4.32	2.97
Voting Trump pct 2020	3112	0.54	0.26	0.00	0.96
County-level control variables					
Age 65 and older pct	3113	0.20	0.04	0.05	0.59
Urban population pct	3113	41.49	31.45	0.00	100.00
Uninsured pct	3113	0.12	0.05	0.02	0.32
Unemployment pct	3113	4.01	1.64	0.00	18.80
Flu vaccinated rate	3107	0.43	0.10	0.04	0.67
College rate	3113	0.58	0.12	0.01	1.00
Median household income	3113	55620.00	14447.00	24732.00	151806.00
African American pop. pct	3112	0.0658	0.117	0	0.790
Hispanic pop. pct	3112	0.0982	0.139	0.00648	0.964

^a We have social capital scores for 2992 of 3142 counties, containing 99.7 percent of the American population.

nationally. Roughly 54 percent of Kansans are fully vaccinated against the virus. West Virginia ranked the lowest in the nation with a 41.51 percent full vaccination rate. As is evident in Fig. 2, increases in the fully vaccinated rate stabilized in early August regardless of the overall vaccination rate. Lastly, CDC announced the Delta variant as the predominant strain of COVID-19 in the U.S. on August 6.⁶ As a result, before August 6, 2021, the individual decision to get or not to get vaccinated was not complicated by the presence of the Delta variant. The logistical and other technical issues were smoothed out in early August 2021. The vaccine was also readily available to any eligible person willing to get the job. Hence, we have chosen to use the August 1st, 2021, data point tentatively as the base for our primary analysis.

Table 3 presents the impact of the variables of interest on the fully vaccinated rate among the U.S. adult population (18 years and older) based on August 1st data. Column 1 reports the impact of all the control variables. Results are mostly as expected; the aging population (65 years and older) is positively correlated with the COVID-19 vaccination rate, as are the higher education attainment (some college), flu vaccination rate, and urbanization rate variables. Higher median household income also contributes to a higher vaccination rate. In addition, while other control variables are held constant, African American population percent and Hispanic population percent are positively correlated with the dependent variable. Based on the standardized x coefficients, median household income has the most significant impact on the overall COVID-19 vaccination rate. The uninsured population percentage failed to show any statistical significance. Although we do not have evidence to suggest either “pulling” or “pushing” effects, it is reasonable to conjecture that statistical non-significance might be the result of “pulling” and “pushing” effects that cancel each other out.

Column 2 shows the regression results with the social capital index and Trump support rate during the 2020 presidential election. The results tell a similar story regarding control variables, with the exception of unemployment rate. The key independent variables behave as expected. The social capital index is positively correlated with the vaccination rate and is statistically significant at the 5% level. One standard deviation increase, on average, translates to a 0.83% higher vaccination

⁶ <https://www.newsweek.com/first-us-covid-delta-variant-cases-how-did-it-mutate-1617871>.

COVID-19 Fully Vaccination Rate 08/01/2021

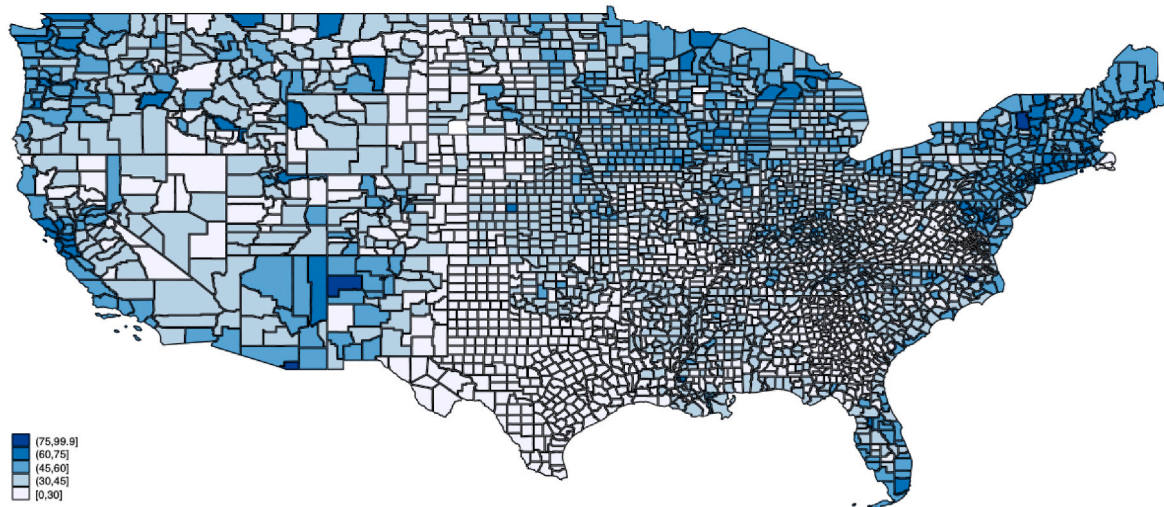


Fig. 1. COVID-19-fully vaccination rate January 08, 2021.

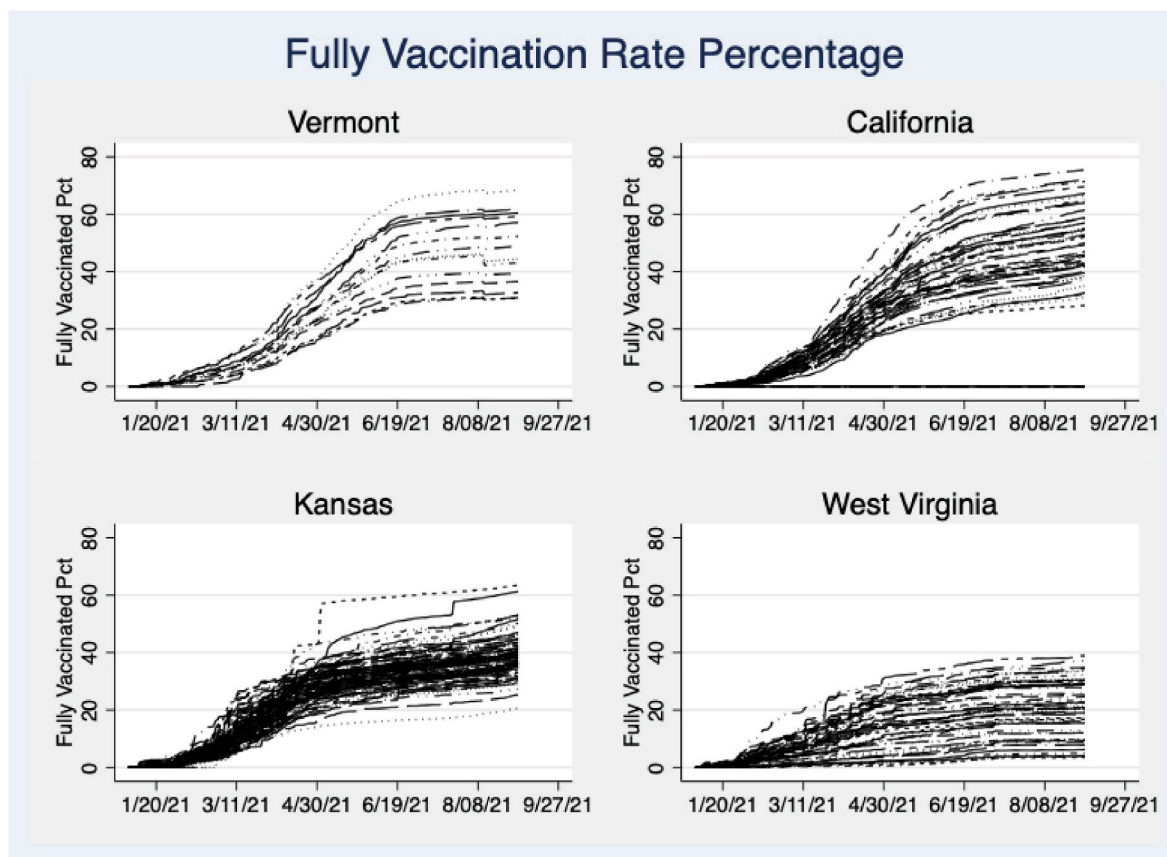


Fig. 2. Fully Vaccinated Rate Progression across Time.

rate at the county level. Supporting Trump during the 2020 presidential election, by comparison, is also highly statistically significant and negatively influences the COVID-19 vaccination rate among the population 18 years and older. Among all the variables shown in the column, partisanship (i.e., voting for Trump) is the strongest predictor acting as an impediment to county-level vaccination rates. A one standard deviation increase in the Trump-supporting rate decreases the vaccination rate by 5.6%. Hence, hypotheses 1 and 2 are supported.

Column 3 expands the model to include the interaction term between

the social capital index and trump supporting rate and illustrates a more accurate picture regarding the key variables of interest. The results present a consistent pattern compared to previous models. The results show that a one standard deviation increase in social capital index is associated with an increase in the fully vaccinated rate among adults by 3.0%, when the Trump voting rate is at its mean value. Secondly, the impact of supporting Trump at the county level on vaccination rates stays approximately the same. One standard deviation increase in the Trump-supporting rate during the 2020 presidential election leads to a

Table 3
Regression Results Comparison and Robustness Check.

Variables	(1)		(2)		(3)	
	Base Model	bStdX	Main Model	bStdX	Interaction	bStdX
County-level control variables						
65 yrs and older pct	28.08*** (4.781)	1.352	28.53*** (4.726)	1.332	29.31*** (4.711)	1.369
Uninsured pct	8.537 (8.904)	0.428	11.31 (8.649)	0.566	13.68 (8.630)	0.685
Flu vac rate pct	9.560*** (2.271)	0.950	5.729** (2.227)	0.554	5.005** (2.224)	0.484
Unemployment pct	0.553*** (0.137)	0.907	0.142 (0.150)	0.217	0.131 (0.149)	0.201
Ln of median income	10.70*** (1.152)	2.642	10.04*** (1.190)	2.472	9.318*** (1.195)	2.294
College pct	17.51*** (2.283)	2.078	13.71*** (2.359)	1.606	15.42*** (2.376)	1.806
Urbanization rate	0.0563*** (0.00818)	1.770	0.0398*** (0.00850)	1.239	0.0392*** (0.00846)	1.218
African American pct	16.10*** (2.201)	1.877	7.335*** (2.332)	0.855	11.53*** (2.479)	1.343
Hispanic pct	12.63* (2.196)	1.753	7.706* (2.156)	1.063	8.295*** (2.151)	1.145
Key variables of interest						
Social capital index			0.828** (0.369)	0.830	2.998*** (0.579)	3.004
Voting Trump pct 2020			-21.44*** (1.432)	-5.611	-21.38*** (1.426)	-5.597
Social capital index* Voting Trump pct 2020					-4.097*** (0.844)	-2.359
Constant	-104.8*** (12.52)		-75.41*** (13.10)		-69.58*** (13.11)	
Observations	3106		2966		2966	
Adjusted R-squared	0.766		0.798		0.800	
Interaction Effects					YES	
State FE	YES		YES		YES	

Standard errors in parentheses.
bStdX = x-standardized coefficient.
p < 0.01, **p < 0.05, *p < 0.1.

decrease in vaccination rates by approximately 5.59 percent, when social capital is at its mean value. The interaction term is negatively correlated with vaccination rate and statistically significant at 1% level.

This negative interaction term, coupled with the positive coefficient of social capital, suggests that as the supporting rate for Trump increases, the positive effect of social capital on COVID-19 vaccination rate would

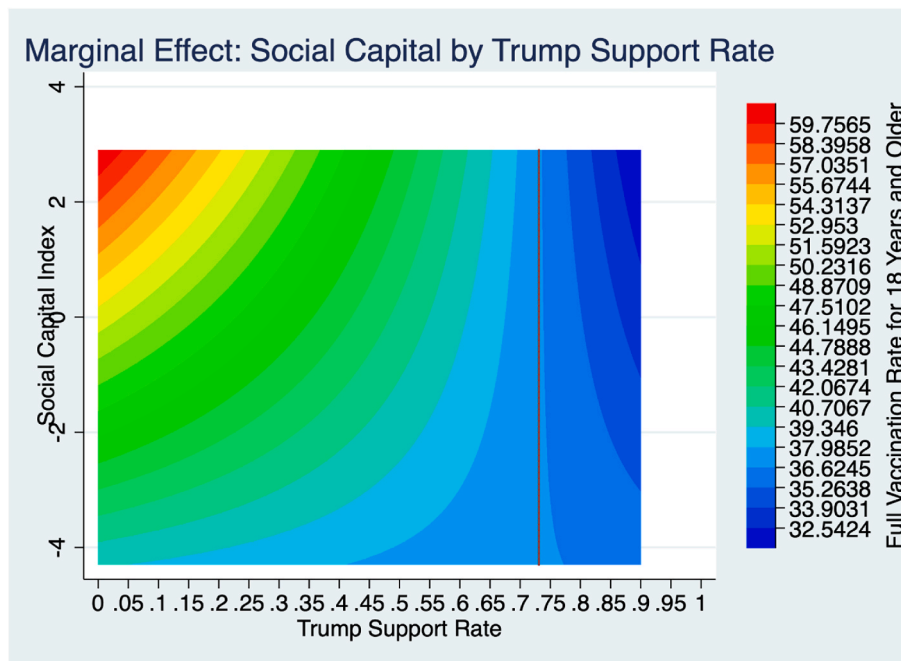


Fig. 3. Marginal effect: Social capital by trump support rate.

be weakened, supporting Hypothesis 3. In fact, when Trump voting rate reaches above 73 percent ($2.988/-4.09 = -0.73$), the effect of social capital on vaccination rate turns from positive to negative.

Regarding the control variables, median household income is statistically significant at a 1% level and correlates with the vaccination rate in the same direction. A one standard deviation uptick in median household income leads to a 2.29% increase in vaccination rate among U.S. adults. It is also worth noting that the unemployment rate at the county level ceases to show any statistical significance once key variables of interest are added (Columns 2 and 3). This is understandable since a person's decision to get vaccinated against COVID-19 is determined more by his/her political ideology and/or whether they trust the science behind it rather than socioeconomic status.

Fig. 3 shows marginal effects of the social capital index and Trump-supporting rate as a function of COVID-19 fully vaccinated rate. The two-dimensional graph on the left illustrates the interaction between the two key variables of interest (social capital index*Trump-supporting rate), and the color pattern combo shows the outcome of COVID-19 fully vaccinated rate for population 18 years and older, with the corresponding numerical values displayed in the bar chart on the right.

Starting from the origin, where the Trump-supporting rate is near zero, the social capital index starts around -4. As we trace the social capital index along the (vertical) axis, the higher the social capital index value, the higher the overall county-level COVID-19 vaccination rate among U.S. adults. As we progress on the horizontal (Trump-supporting rate in the 2020 presidential election) axis, a similar pattern can be seen until the Trump supporting rate reaches approximately 73 percent. Such a pattern illustrates the outcome when the Trump-supporting rate is coupled with the social capital index at a different level. It is evident that when the Trump-supporting rate is low, the social capital index promotes a positive outcome within which the county-level COVID-19

vaccination rate increases. The most pronounced combination that leads to the highest vaccination rate is the highest social capital value and lowest Trump-supporting rate (red portion, NW corner). By comparison, low social capital value, joined with a low Trump support rate, leads to a modest vaccination rate (green portion, SW corner).

However, the positive impacts generated by higher social capital value diminish as we progress on the horizontal axis. This can be seen between the 55%–65% Trump-supporting rate values, within which positive impact still exists but does not significantly contribute to a higher vaccination rate. The impact further deteriorates as Trump's supporting rate is between 65% and 73%, wherein the social capital value does not alter the community's decision to get the vaccine. Consistent with the calculation above, we identify the 73% Trump-supporting rate as a critical threshold where the social capital value begins to negatively impact the community vaccination rate. The high Trump-supporting rate with the social capital index paints an entirely different picture. When the Trump-supporting rate reaches 73%, social capital becomes a social liability in that it seems to reinforce people's refusal to get vaccinated. The highest Trump-supporting rate combined with the highest social capital value brings about the lowest possible vaccination rate at the county level (blue portion, NE corner). Similarly, the light blue region (SE corner, high Trump-supporting rate coupled with low social capital index) generates the second-lowest vaccination rate outcome. As the social capital index increases, the county's overall vaccination rate decreases.

In addition, as mentioned above, we have chosen August 1st tentatively. The models we have examined shed light on the importance of partisanship and social capital on the COVID-19 vaccination rate. As a robustness check, we expanded the time frame to see if we could detect any difference on the key variables of interest.

Table 4 reports five different time frames ranging from April 1st to

Table 4
Vaccination Rate across Time Regression Results.

	(1)	(2)	(3)	(4)	(5)
All models with state fixed effects					
Variables	04/01/2021,	05/15/2021	07/01/2021	08/01/2021	09/01/2021
County-level control variables					
65 yrs and older pct	19.13*** (2.909)	33.48*** (4.120)	30.07*** (4.581)	29.31*** (4.711)	27.65*** (4.880)
Uninsured pct	7.775 (5.337)	6.847 (7.558)	13.46 (8.400)	13.68 (8.630)	18.64** (8.953)
Flu vac rate pct	-0.301 (1.374)	4.796** (1.947)	5.445** (2.165)	5.005** (2.224)	5.098** (2.304)
Unemployment pct	0.0239 (0.0921)	-0.0701 (0.131)	0.0826 (0.145)	0.131 (0.149)	0.153 (0.155)
Ln of median income	0.101 (0.738)	5.390*** (1.046)	8.834*** (1.163)	9.318*** (1.195)	9.516*** (1.238)
College pct	7.384*** (1.467)	15.07*** (2.081)	15.38*** (2.311)	15.42*** (2.376)	16.22*** (2.463)
Urbanization rate	-0.000143 (0.00523)	0.0258*** (0.00740)	0.0361*** (0.00823)	0.0392*** (0.00846)	0.0416*** (0.00877)
African American pct	0.754 (1.525)	8.760*** (2.128)	11.15*** (2.387)	11.53*** (2.479)	12.39*** (2.543)
Hispanic pct	-0.693 (1.328)	5.733*** (1.883)	7.335*** (2.092)	8.295*** (2.151)	8.644*** (2.227)
Key variables of interest					
Social capital index	0.971*** (0.361)	2.843*** (0.509)	3.103*** (0.563)	2.998*** (0.579)	3.012*** (0.603)
Voting Trump pct 2020	-7.023*** (0.882)	-17.42*** (1.247)	-20.84*** (1.383)	-21.38*** (1.426)	-21.64*** (1.473)
Social capital index*Trump_2020	-0.903* (0.525)	-3.615*** (0.741)	-4.202*** (0.822)	-4.097*** (0.844)	-4.157*** (0.878)
Constant	11.55 (8.090)	-34.59*** (11.47)	-66.25*** (12.75)	-69.58*** (13.11)	-68.97*** (13.59)
Observations	2966	2966	2966	2966	2966
R-squared	0.667	0.781	0.798	0.800	0.799

Standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

September 1st, within which the impacts of independent variables are shown. In the early stage of vaccine rollout (Apr. 1st, 2021; column 1), key variables of interest behave the same way we hypothesized. The social capital index is positively correlated with the vaccination rate and statistically significant at a 1% level. The support rate for Donald Trump during the 2020 presidential election is negatively correlated with the vaccination rate at a 1% level. The interaction term of the social capital index and support for Trump is negatively correlated with the fully vaccinated rate but failed to show statistical significance at a 5% level. When comparing the results across the board, the key independent variables' impacts on vaccination rate (magnitude) and their statistical significance increase drastically as time goes by. A similar pattern is shown for all the control variables, except the county urbanization rate. In column 1, the urbanization rate is negatively correlated with the vaccination rate, whereas in columns 3 and 4, the impact of the urbanization rate on the vaccination becomes positive and statistically significant. However, such inconsistency is expected as early days of vaccine rollout are marred by high demand coupled with production bottleneck, logistical issues, and prevalent technical issues of vaccine appointment. Thus, the key variables' impact is muted or even skewed. The expanded time check validated our choice of August 1st as the appropriate time to measure adult COVID-19 vaccination rates.

4. Discussion

Elgar et al. (2020) found that social capital's positive or negative influence on health is contingent, possibly on income inequality, in their cross-country analysis of COVID-19 mortality during an early phase of the pandemic. Similarly, Moore and Carpiano (2020) noted the need to investigate the degree to which social capital's health advantages and disadvantages are embedded within larger institutional structures. We extend this agenda by proposing a contingency approach via an

examination of the interaction effects of social capital and partisanship on county-level COVID-19 vaccination rates in the U.S.

U.S. vaccination rates show vast differences across sub-national regions. Our focus on county-level vaccination rates within one country thus fills an important gap in the cross-country comparative literature. The measurement of country-level social capital, drawing on survey research such as the World Values Survey (WVS) Social Capital scale, could mask drastic regional differences in the stock of horizontal and vertical ties that unite or divide a region in a large and diverse country such as the U.S. The Congressional county-level index combines the indicators of bonding, bridging, and linking social capital. Thus, it offers a robust measurement of social assets and liabilities in a region.

Our study confirms the contingency perspective positing that the risks and benefits of social capital depend on contextual factors, such as the nature of tasks, norms, and beliefs (Adler and Kwon, 2002; Reich, 2020). Our research answers the call to expand the range of social groupings and contexts to study how social capital affects the health and well-being of subpopulations (Carpiano and Moore, 2020). We extend the contextual dependence of social capital by empirically testing under what configurations of partisanship and social capital the risks or benefits become manifest or amplified. The conservative and liberal movements are crucial spaces where individuals form relationships and build a salient partisan identity. We identify four subpopulations, as detailed below, drawing on different combinations of social capital and partisanship at the county level.

First, we found that counties with a high level of social capital and a high level of Trump support have the lowest vaccination rate (Fig. 4, NE Corner). Regions of high social capital, when joined with a high level of conservative partisanship, become social liabilities in terms of collective rejection of vaccination. The dark side of social capital manifests in a lower vaccination rate and likely higher death rate from COVID-19 in highly conservative regions. Seventy three percent Trump support rate

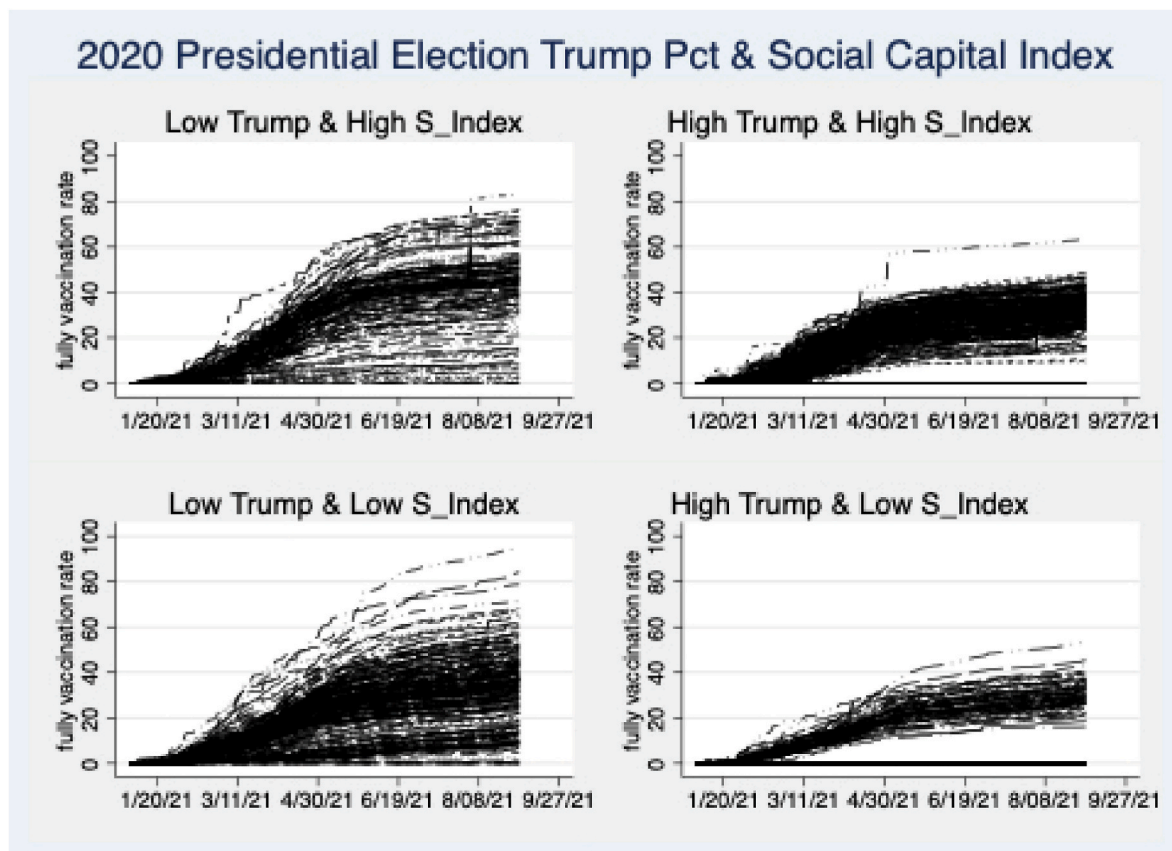


Fig. 4. 2020 presidential election trump pct & social captial index.

at the county level seems to be the threshold for the dark side effects to be salient. To our knowledge, this is the first study that unveiled a quantifiable partisanship level that pushed social capital's effects to highly negative territory. This provides empirical evidence for Macy et al., 2021 computational modeling that reveals a tipping point, or threshold level, of polarization.

In this configuration, social capital functioned as a hindrance to high vaccination rates, consistent with the dark side of the solidarity entailed in bonding social capital. Strong solidarity with ingroup members may reduce the flow of new ideas into the group, resulting in parochialism and inertia (Gargiulo and Benassi, 1999). As Powell and Smith-Doerr put it, "The ties that bind may also turn into ties that blind" (1994: 393). As bonding social capital increases, a stronger ingroup/outgroup distinction becomes ingrained, potentially leading to increased outgroup hostility (Putnam, 2000; Svendsen and Svendsen, 2004). This ingroup solidarity and outgroup hostility could be salient in the partisan divide of a county, generating a strongly shared partisan COVID-19 narrative.

To reduce the liability of high social capital in highly conservative counties, trusted community leaders—e.g., physicians, churches, nonprofit leaders with deep local roots, etc.—need to reach out at nonconventional sites such as funeral homes, radio shows, and churches (Levitz and Kamp, 2022). The key is to use respect and patience to answer questions and build bridging relationships with those harboring vaccine doubt. Resources should be used to fight online and offline disinformation, for example, by providing web-based training to primary care physicians to counter online misinformation.

Second, counties with a low level of social capital and high level of Trump support have the second-lowest vaccination rate (Fig. 4, SE corner). We need to increase social capital and avoid the liability of partisanship. Care should be spent on bridging and linking social capital by increasing positive interactions and relationships with pro-vaccine sources and local governing institutions, e.g., city and county governments, business associations, and school boards. Also, efforts to protect people's privacy and reduce community shaming need to be strengthened so that people can get vaccinated without bringing attention and shame to themselves in their anti-vaccine community (i.e., provide discrete vaccination sites). Since the vaccine is politicized, it could be better to have in-person social interactions in a non-politicized way. The key is to reduce the saliency of partisan identity and replace it with overlapping community-oriented identity, e.g., religious, racial, or ethnic identity (Chu et al., 2021), to increase trust and cooperation.

Third, counties with a low level of social capital and a low level of Trump support have a modest vaccination rate (Fig. 4, SW corner). We need to increase the bridging social capital and the pro-vaccine message in the new networks. Partisanship is not an impeding factor here. Thus, increased convenience such as providing mobile vaccination vehicles, language, and cultural competence of vaccination personnel could be helpful. Native American communities have low levels of Trump support and low confidence in government institutions due to forced relocation and historical trauma. Nevertheless, they have strong family and community values. They achieved high vaccination rates early but stalled at around 60% in regard to full vaccinations (CDC COVID data tracker, 2022; Read, 2021). Perhaps non-Native-American counties can learn from the successes and challenges of the tribal community.

Lastly, counties with a high level of social capital and a low level of Trump support rate have the highest vaccination rate (Fig. 4, NW

corner). High levels of social capital and low levels of Trump support have produced high vaccination rates, but the vaccinated people may be angry toward those low-vaccination-rate counties in the same state or region due to concerns with unvaccinated COVID patients filling up hospital beds (Bichell, 2020; Daley, 2021). Good listening and open-minded engagement facilitated by civil groups and/or trusted local government leaders would help restore social cohesion and shared identity (Seib, 2022).

5. Conclusion

By unpacking interaction effects of partisanship and social capital on a key COVID-19 outcome— vaccination rates— we found intriguing patterns of joint effects, notably, whether social liabilities or assets occur as the result of increased social capital is contingent on high and low voting rates for Trump, respectively. We propose subpopulation-specific interventions to increase bridging social capital across partisan boundaries and linking social capital between citizens and trusted authority figures. Our findings elaborate on the contingency perspective on social capital's role in population health and raise important questions about the unknown threshold of other contextual variables that could exacerbate social capital's negative effects on community well-being.

Our study's findings are limited in several aspects. First, COVID-19 is a global public health shock, and we chose to study the United States, one of the wealthiest democratic countries in the world. Thus, our findings may not be generalizable to low-or-middle-income countries. Second, we used the 2021 vaccination rate as our dependent variable. Future research should examine whether our results hold under new variants and when considering children's vaccination rates during the Omicron surge. Third, we need qualitative, mixed-methods research to conduct interviews, focus groups, and ethnographies to document local understandings and meanings of social capital, partisanship, and health. Fourth, county-level wealth disparity, likely measured by the Gini index, needs to be studied together with social capital and partisanship to disentangle the socioeconomic determinants of health behavior and outcomes. Lastly, the joint effects of online and offline social capital deserve attention since online social media/capital could affect people's attitudes and behaviors.

Credit author statement

Zhiwei Zhang: Conceptualization, Methodology, Formal analysis, Data curation, writing -original draft, writing, review and editing, Project administration. Gao Liu: Propose the project, Conceptualization, Methodology, Formal analysis, Data curation, writing-review & editing. Bin Chen: Conceptualization, Methodology, Writing – original draft, writing-review and editing, Project administration. Kun Huang: Conceptualization, Methodology, Writing – original draft, writing-review and editing, Project administration.

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Appendix A. Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) 65 yrs and older pct	1.000										
(2) Uninsured pct	-0.027	1.000									
(3) Flu vac rate pct	-0.225	-0.295	1.000								

(continued on next page)

(continued)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(4) Unemployment pct	-0.206	0.080	-0.034	1.000							
(5) Median income	-0.262	-0.350	0.418	-0.249	1.000						
(6) College pct	-0.061	-0.465	0.326	-0.241	0.590	1.000					
(7) Urbanization rate	-0.493	-0.163	0.407	0.185	0.396	0.324	1.000				
(8) African American pct	-0.143	0.187	-0.031	0.419	-0.256	-0.224	0.051	1.000			
(9) Hispanic pct	-0.251	0.445	-0.152	0.063	0.054	-0.176	0.284	-0.092	1.000		
(10) Social capital index	0.253	-0.304	0.062	-0.586	0.381	0.456	-0.270	-0.519	-0.247	1.000	
(11) Voting Trump pct 2020	0.177	0.021	-0.276	-0.257	-0.109	-0.114	-0.276	-0.443	-0.002	0.245	1.000

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