Public Opinion Quarterly (2024) **Vol 00 No 0,** 1–26

COVID-19 Spillover Effects onto General Vaccine Attitudes

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Abstract Even amid the unprecedented public health challenges attributable to the COVID-19 pandemic, opposition to vaccinating against the novel coronavirus has been both prevalent and politically contentious in American public life. In this paper, we theorize that attitudes toward COVID-19 vaccination might "spill over" to shape attitudes toward "postpandemic" vaccination programs and policy mandates for years to come. We find this to be the case using evidence from a large, original panel study, as well as two observational surveys, conducted on American adults during the pandemic. Specifically, we observe evidence of COVID-19 vaccine spillover onto general vaccine skepticism, flu shot intention, and attitudes toward hypothetical vaccines (i.e., vaccines in development), which do not have preexisting attitudinal connotations. Further, these spillover effects vary by partisanship and COVID-19 vaccination status, with the political left and those who received two or more COVID-19 vaccine doses becoming more provaccine, while the political right and the unvaccinated became more anti-vaccine. Taken together, these results point to the salience and politicization of the COVID-19 vaccine impacting non-COVID vaccine attitudes. We end by discussing the implications of this study for effective health messaging.

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https://doi.org/10.1093/poq/nfad059

Vaccine skepticism consistently leads to negative health outcomes globally (Simas and Larson 2021). This was acutely apparent during the COVID-19 pandemic, which brought sustained attention to vaccines as the most effective way to mitigate disease spread and severity (Fridman, Gershon, and Gneezy 2021). The pandemic sparked a wave of scholarship examining how to increase COVID-19 vaccine uptake (Larsen et al. 2022; Sylvester et al. 2022; Green et al. 2023a; Moehring et al. 2023) and identifying the potential challenges posed by misinformation and anti-vaccine messaging (Enders et al. 2020; Loomba et al. 2021). However, attitudes toward the COVID-19 vaccine are important for reasons beyond hindering society's ability to mitigate the spread of this specific disease. The chronic salience of COVID-19 in recent years has the potential to inform adjacent public health attitudes for years to come.

We argue that the case of the COVID-19 vaccine meets the necessary conditions for considerations to "spill over" into considerations regarding other vaccines: salience, affective charge, and conceptual similarity. That is, from the time it was introduced in December 2020, the COVID-19 vaccine received sustained attention as the subject of advocacy campaigns and public discourse such that the vast majority of the US public was thinking about it on a regular basis. Moreover, public discourse concerning the urgency surrounding the COVID-19 vaccine, its safety and efficacy, and the circumstances under which it should be required quickly became polarized along partisan lines (Green et al. 2020; Motta, Stecula, and Farhart 2020; Gadarian et al. 2022). Importantly, while some of these cues raised considerations that were relatively specific to the COVID-19 vaccine, such that it was relatively new and insufficiently tested (Callaghan et al. 2021; Nguyen et al. 2021), others called on more abstract principles relating to freedom and personal choice that could easily generalize to other, more established vaccines (Bluth 2022).

We use an original panel study of American adults conducted throughout the pandemic, along with additional original cross-sectional survey data, to test these dynamics. Longitudinally, we find that attitudes toward the COVID-19 vaccine at the beginning of its rollout (December 2020) are informative of how attitudes toward vaccines in general change over time (by March 2022), with Democrats in particular becoming less likely to express general vaccine skepticism over time. Cross-sectionally, we find that individuals who are less concerned about COVID-19, as well as those who do not intend to vaccinate themselves against the disease, are also less likely to take hypothetical vaccines (against cancer and Lyme disease) if and when such vaccines are available—after accounting for more general vaccine skepticism. Finally, we examine potential mechanisms underlying this relationship using a preregistered survey experiment (shown starting on p. 8 in the Supplementary Material),[1] which

1. This experiment was preregistered at https://aspredicted.org/889_FFJ (AsPredicted #95649).

finds that making COVID-19 vaccine mandates salient—particularly using more general frames—increases support for childhood vaccines and childhood vaccine mandates in public schools. Together, these results point to the salience and politicization of the COVID-19 vaccine affecting conceptually proximate vaccine attitudes and policy preferences.

Behavioral and Attitudinal Spillover

An attitudinal (or behavioral) spillover effect occurs when a change in attitude (behavior) regarding a specific concept becomes associated with related concepts, thereby causing the collection of attitudes (behaviors) to more closely resemble one another (Thøgersen 1999). Certain concepts, categories, and attributes are associated as a mental network, and a change in one aspect of this network will affect other parts (i.e., spillover) (Collins and Loftus 1975; Fazio 1986; Lee 2018; von Sikorski and Herbst 2020). For a spillover effect to occur, the attitude toward the specific concept and other concepts in the general network must be cognitively accessible, for example, the links between the target concept and related concepts are salient (Hopkins and Mummolo 2017). Spillover is also more likely to occur if the constructs are similar semantically or conceptually (Fazio 1986).

Others note that spillover effects occur only under certain conditions, like when the attitude has negative emotional attributes or when the attitude toward the concept is not as well established (Schwarz 2012; Tesler 2015; von Sikorski and Herbst 2020). Spillover effects can also occur when the attitude is originally applied to an exemplary case within a superordinate category (Puente-Diaz 2015), rather than to a case that is seen as a contrasting comparison (Schwarz and Bless 2007). For instance, the COVID-19 vaccine could come to be viewed as a stand-in for vaccines generally, or it could be a special case that differs from other vaccines. We would expect spillover in the former instance but not the latter.

Attitudinal spillover is relatively common. For example, political scandals often lead to negative evaluations of not only the individual politician, but the politician's party as well (Bowler and Karp 2004, but see Chanley, Rudolph, and Rahn 2000). Similarly, research finds that prejudice toward Black Americans spills over into opposition to policies seen as disproportionately benefiting non-whites (Tesler 2012; Benegal 2018) or toward issues and concepts that have been implicitly racialized (Gilens 1999; Tesler 2016). This is especially the case when the key construct of interest, such as race or, in our case, COVID-19, becomes "chronically salient" or "chronically accessible" such that it remains at the top of the head for many individuals (Luttig and Callaghan 2016; Tesler 2016).

Vaccine Attitudes and COVID-19 Spillover

Before examining why COVID-19 vaccines have spillover potential, it is worth noting why people hold certain attitudes toward vaccines. Various demographic, psychological, and informational sources contribute to individuals' vaccine attitudes. For instance, prepandemic vaccine confidence was slightly higher among Democrats (Motta 2023), and lower among people with populist tendencies (Kennedy 2019). The latter tendency likely stems from distrust of relevant experts and elites (Algan et al. 2017), alongside elite cues by populist leaders (Kennedy 2019).

Moreover, there are multiple types of vaccine attitudes, including general attitudes toward vaccines (e.g., general vaccine skepticism), attitudes toward specific vaccines (e.g., for HPV, the flu, etc.), support for vaccine-related misinformation (including the myth that vaccines cause autism), attitudes toward vaccine policies (e.g., childhood vaccination requirements for public schools), and the likelihood to vaccinate. These various attitudes are often correlated, but they do remain distinct. For instance, while attitudes toward the COVID-19 and measles, mumps, and rubella (MMR) vaccines are positively correlated, MMR vaccine confidence tends to be higher (Farhart et al. 2022).

The COVID-19 pandemic, however, was particularly contentious along partisan lines. Republicans and populists, relative to Democrats and public health officials, tended to express less concern about the disease in general, more skepticism regarding the safety and efficacy of the COVID-19 vaccine, and more opposition to mitigation policies such as requiring the vaccine in particular settings (Green et al. 2020; Stecula and Pickup 2021; Gadarian et al. 2022). For partisans, salient and politically contentious issues become more emotionally and psychologically charged in the contemporary United States (Mason 2018), which could increase the likelihood of spillover effects.

Relatedly, it is important to consider the manner in which support for or skepticism regarding COVID-19 vaccines is framed by political elites for polarized issues, particularly if such frames appeal to political affiliation or other deeply held constructs (such as those related to health and safety, values, and so on). Previous research finds that certain topics create spillover effects through framing, though only onto proximate and structurally similar issues, because framing can introduce new pathways for conceptual similarity. For example, exposure to information about increasing crime as a security issue can impact attitudes toward another security issue such as terrorism, but not onto other politically salient issues (Hopkins and Mummolo 2017).

Further, the overwhelming, long-standing, over-time salience of the COVID-19 pandemic made COVID-19 vaccine attitudes much more salient and emotionally charged. COVID-19 featured very strongly both within people's immediate lives as well as in the news and media environment (Motta, Stecula, and Farhart 2020; Stecula and Pickup 2021), and this presence was linked with

heightened anxiety and anger associated with the pandemic (Abadi, Arnaldo, and Fischer 2021; Renström and Bäck 2021). Scholars demonstrate that salient issues are more important due to their greater cognitive accessibility and that issues of personal importance tend to be more salient than those of national importance (Lavine et al. 1996). In the context of COVID-19, the pandemic (and accompanying vaccines) remained at the forefront of national attention and personally disrupted most Americans' lives for extended periods. This combined national and personal importance likely allows considerations regarding COVID-19 vaccines to implicate attitudes toward other vaccines in a manner that less disruptive diseases have not.

Furthermore, a newer vaccine is more primed for spillover because people usually do not have well-formed attitudes about it; for instance, in the 2000s when the HPV vaccine became available to the public, vaccine mandates for tetanus, diphtheria, and pertussis (Tdap) not only resulted in a greater vaccination rate for this vaccine, but also resulted in greater HPV vaccination rates (Carpenter and Lawler 2019). Accordingly, we would expect COVID-19 vaccine attitudes to be more likely to occur for newer, postpandemic vaccines.

Put simply, the COVID-19 vaccines meet the necessary conditions under which we would expect to observe spillover effects: salience, affect, and conceptual similarity. In addition, spillover would be more likely for new post-COVID vaccines. However, these conditions may be insufficient if COVID-19 vaccines are promoted or objected to in a case-specific, pragmatic manner that isolates them from other vaccines. For example, promoting COVID-19 vaccination by highlighting the severity of the pandemic, or expressing skepticism regarding the COVID-19 vaccine on the grounds that it was too new or not sufficiently tested, are unlikely to connect COVID-19 vaccines to other vaccines. By contrast, ideological justifications that draw on more general principles, such as one's moral obligation to help others (pro) or freedom of choice not to get vaccinated (against), are more easily connected to vaccines in other contexts.

Therefore, we expect COVID-19 spillover onto other vaccine attitudes primarily through conceptual similarity, salience, and emotional intensity, though the channel through which specific attitudes did spillover is unclear. Our main focus in the present study is to establish the presence of COVID-19 vaccine spillover onto other vaccine attitudes, and these tests can be found below. That said, we also conducted a preliminary experiment testing some of these potential pathways; though these results are somewhat inconclusive, the information and results on the experiment can be found in the Supplementary Material.

Expectations

Based on the above discussion, we expect that most people categorize vaccines and vaccine-related ideas together, given their semantic and categorical

Table 1. Hypotheses.

Hypotheses		Data used
H1	Lower support for the COVID-19 vaccine should be associated with increased general vaccine skepticism, i.e., opposition to vaccines, and decreased flu shot intention over time.	Longitudinal and cross-sectional
H1a	Among Republicans in particular, lower support for the COVID-19 vaccine should be associated with increased general vaccine skepticism and decreased flu shot intention.	Longitudinal and cross-sectional
H2	Support for hypothetical vaccines against cancer and Lyme disease should be lower among people who are less supportive of the COVID-19 vaccine, and less concerned about COVID-19 in general.	Cross-sectional
H2a	This should be particularly true for Republican partisans and those who are not vaccinated against COVID-19.	Cross-sectional

similarities. Salient and emotionally charged information about a vaccine—which was often the case regarding the COVID-19 vaccine (Motta, Stecula, and Farhart 2020; Abadi, Arnaldo, and Fischer 2021; Renström and Bäck 2021; Stecula and Pickup 2021)—may subsequently be applied to the general category of vaccines and the flu shot (***H1***; see table 1 for a summary of hypotheses). Further, certain attitudinal considerations toward COVID-19 vaccines, including trust in relevant experts (Farhart et al. 2022), may be applied to vaccines generally due to the salience of the COVID-19 vaccine. The COVID-19 vaccine has been primed and emotionally charged due to its political affiliations in a polarized climate, with particular negativity among Republicans (Gadarian et al. 2022). Among Republicans, then, spillover effects should be negative (***H1a***).

We also examine attitudinal spillover onto specific types of vaccines, for example, those against influenza. Currently, few extant studies suggest such spillover effects. During the first half of the pandemic, longitudinal studies found that flu and COVID-19 vaccine intentions decreased over time, going against conventional wisdom that increased exposure to a disease prompts greater support of the vaccine against that disease (Fridman, Gershon, and Gneezy 2021; see also Lunz Trujillo and Motta 2021). Flu shot uptake politically polarized during the COVID-19 pandemic, with Democrats

increasingly likely to get the flu vaccine in 2021 and Republicans less likely; this division was not prevalent before widespread COVID-19 vaccine availability (Enten 2021). Further, prepandemic research finds that MMR vaccine misbeliefs significantly predict Zika vaccine intention in nationally representative cross-sectional survey data (Ophir and Hall Jamieson 2018). Here we use over-time analysis to look for spillover effects onto the flu vaccine, as well as onto general vaccine attitudes.

Finally, existing vaccines (like flu vaccines) may have well-established attitudes distinguishing them from attitudes about the newer COVID-19 vaccine. Therefore, using cross-sectional data, we also evaluate whether COVID-19 vaccine attitudes significantly predict attitudes toward hypothetical vaccines (vaccines currently in development), controlling for attitudes toward an established and well-known vaccine (i.e., the MMR vaccine) (***H2; H2a***). We examine people's intentions to get vaccinated against Lyme Disease and cancer.[2] Doing so should isolate the spillover effect from preestablished associations with existing vaccines that may be idiosyncratic.

Data and Methods[3]

The first data source and the experiment come from the Covid States Project,[4] a multi-institutional and multidisciplinary collaboration that has regularly fielded online surveys for each of the fifty states (plus Washington, DC) on attitudes relating to COVID-19, politics, and more since March 2020. We use eight survey waves conducted between July 2020 and March 2022, with each wave ranging from 20,669 to 24,414 American adults.[5] Cooperation rates range from 83 percent to 88 percent per wave; see Supplementary Material p. 7 for specific wave details. Surveys were conducted by PureSpectrum via an online, nonprobability sample, with state-level representative quotas for race/ethnicity, age, and gender. We

2. Since we theorize that spillover occurs due to categorical and semantic similarities between COVID-19 vaccines and other vaccines, we used noncommunicable vaccines (e.g., a different type of disease than COVID-19) as a more conservative test.

3. Data collection for this study was approved by the Northeastern University Institutional Review Board and the Oklahoma State University Institutional Review Board.

4. More information at www.covidstates.org.

5. Except for the early August 2020 wave, which was only a few thousand respondents. Wave dates and sample sizes are as follows. July 2020: N = 19,058, time period = 7/10/2020–7/26/2020; early August 2020: N = 2029, time period = 7/31/2020–8/7/2020; mid- to late August 2020: N = 21,196, time period = 8/7/2020–8/26/2020; December 2020: N = 25,640, time period = 12/16/20–1/11/21; February 2021: N = 21,500, time period = 2/5/21–3/1/21; April 2021: N = 21,733, time period = 4/1/21–5/3/21; June 2021: N = 20,669, time period = 6/9/21–7/7/21, September 2021: N = 21,079, time period = 8/26/21–9/27/21, November 2021: N = 22,277, time period = 11/3/21–12/3/21, January 2022: N = 22,961, time period = 12/22/21–1/24/22, March 2022: N = 22,234, time period = 3/2/22–4/4/22.

reweighted our data using demographic characteristics that match the US population on 2020 vote choice and turnout, race/ethnicity, age, gender, education, and residence in urban, suburban, or rural areas. This survey mirrors national demographic targets with weights and demonstrates convergent validity when comparing various respondent results with survey and administrative data (Green et al. 2023b). Additionally, this survey provider was used to recruit samples for other published work on vaccine attitudes and experiments (e.g., Green et al. 2023a). Sample details are in the Supplementary Material starting on p. 25.

For longitudinal comparisons of general vaccine skepticism, we ask three questions on general vaccine safety, effectiveness, and importance for seven of the eleven waves. Respondents were asked how much they agreed with three statements about vaccines: (1) vaccines are a safe and reliable way to help avert the spread of preventable diseases; (2) vaccines have negative side effects outweighing the benefits; and (3) vaccines are thoroughly tested in the laboratory and would only be made available to the public if they are safe and effective. Response options ranged from 1—Strongly disagree to 5—Strongly agree. The first and last statements were reversed, and then all three statements were averaged to form an aggregate vaccine skepticism scale (alpha = 0.70).

For measuring flu shot intention and uptake, we asked respondents whether they received or plan to receive a flu shot. Response options are in the Supplementary Material on p. 1; these two variables were collapsed into binary measures of either "Yes" or "No/Maybe."

We examine the average vaccine skepticism scores and flu shot uptake/intention over time, by partisanship and COVID-19 vaccination status. Partisanship is measured using the standard seven-point branching measure. COVID-19 vaccination status is measured in June 2021 through March 2022 by asking "Have you received a COVID-19 vaccine?" Response options include "Yes, one dose," "Yes, two or more doses," and "No."

We also assess within-respondent change in vaccine skepticism between December 2020 and March 2022 as a function of partisanship and COVID-19 vaccination intention in December 2020 using OLS regression. We use vaccination intention (as opposed to behavioral self-reports) because the vaccine was not widely available in December 2020. COVID-19 vaccination likelihood is measured by asking respondents how likely they would be to get a COVID-19 vaccine if one was available, with five-point Likert response options ranging from extremely likely to extremely unlikely (wording on Supplementary Material p. 2). For the flu shot, we assess within-respondent change in flu shot uptake in summer 2020 (with pooled responses from the July, early August, and mid- to late August 2020 waves) versus flu shot intention in winter 2021–2022 (with pooled responses from the November 2021, January 2022, and March 2022 waves) using logit

regressions. All missing responses from questions used here from this data set, including "don't know" responses, are excluded from analysis. For the vaccine skepticism scale, only 3/7 of the March 2022 sample received these questions, and the assignment to receive the scale was randomized. Beyond this, the amount of missing data here is minor (less than 2.5 percent) for those that did receive the vaccine skepticism scale, and for the flu shot questions (which were asked to all respondents in the waves examined).

Additionally, we embedded a survey experiment in one wave of the longitudinal data to begin exploring the mechanism for spillover. See Supplementary Material pp. 8–17 for details of this experiment, including expectations, procedure, and results.

We also examine the potential spillover effects of COVID-19 vaccine refusal on attitudes toward vaccines currently in development by constructing a series of cross-sectional linear probability models that regress survey respondents' anticipated vaccine uptake for two vaccines currently undergoing clinical trials—one against Lyme disease (Pfizer 2021; see also Motta 2020) and personalized cancer vaccines (see Motta 2023)—on their attitudes toward the safety and efficacy of COVID-19 vaccination. Models include a series of social, demographic, and political controls.

To ensure that any effects attributed to COVID vaccine spillover are not the result of attitudes toward other vaccines, we control for respondents' general attitudes toward vaccine safety (specifically, views that the MMR vaccine can cause autism). For robustness, and given the dichotomous nature of our outcome variables, we reestimate all results using logistic regression modeling in Supplementary Material table S3.

We selected Lyme and personalized cancer vaccination for two reasons. Both vaccines are undergoing clinical trials in humans (Resnick 2019; Motta 2020; Blass and Ott 2021), and have the potential to be widely implemented. Lyme disease is expanding across the country due to warming average global temperatures (Bouchard et al. 2019), affecting between 30,000 and 40,000 Americans since 2008 (Schwartz et al. 2017). Likewise, in 2020, nearly two million Americans receive new cancer diagnoses every year, with over 600,000 ultimately dying from the disease (NCI 2020). Efforts to prevent (or slow) either disease should therefore be relevant considerations for Americans.

Data for this study come from two waves of a seven-wave rolling cross-sectional study, conducted via Lucid Theorem between April 2020 and September 2021. We fielded questions on Lyme disease vaccination in the first wave (April 2020, N = 1,014; cooperation rate = 80 percent), and questions about personalized cancer vaccination in the seventh wave (September 2021, N = 1,959; cooperation rate = 81 percent). Lucid Theorem uses quota sampling procedures to produce samples that closely approximate US Census benchmarks on respondents' age, gender, household income, racial

and gender identity, educational attainment, and partisan identification. Lucid data closely mirrors US demographic benchmarks and replicates well-studied experimental effects (Coppock and McClellan 2019; Peyton, Huber, and Coppock 2022). Researchers have also relied on Lucid data to study vaccine attitudes and behaviors both prior to (e.g., Callaghan et al. 2019; Lunz Trujillo et al. 2021) and throughout (e.g., Motta 2020, 2021a, 2021b; Callaghan et al. 2021; Kreps et al. 2021) the COVID-19 pandemic. See Supplementary Material tables S17 and S18 for a comparison of each sample to nationally representative demographic benchmarks.

The primary outcome variables in this analysis are measures of respondents' intentions to receive (1) a Lyme disease vaccine, and/or (2) personalized cancer vaccines. To measure Lyme vaccine uptake, we asked respondents "As you may know, a Lyme disease vaccine is currently undergoing clinical trials. When the vaccine becomes available for public use, how likely are you to request to be vaccinated?" Response options ranged from "very likely" to "not likely at all" on a four-point Likert scale.

Similarly, when measuring personalized cancer vaccine uptake, we first provided respondents with detailed background information about what personalized cancer vaccines are, as they rely on experimental mRNA methods that differ from conventional vaccination protocols and may be unfamiliar to most respondents. This text can be found on Supplementary Material pp. 2–3. We then asked respondents "If, in the next few years, the Food and Drug Administration (FDA) were to determine that personalized cancer vaccines are both safe and effective at preventing cancer, to what degree would you be willing to do each of the following activities?" A follow-up prompt then asked whether respondents would "receive a vaccine yourself, if deemed 'at risk' of developing cancer by a medical professional." Response options were on a seven-point Likert scale ranging from "almost certainly would" to "almost certainly would not."

To facilitate comparison across outcome variables featuring different sets of response options, we dichotomized each one to take on a value of 1 if respondents reported that they intend to vaccinate (i.e., indicating "very" or "somewhat" likely to vaccinate against Lyme; or indicating that they "almost certainly," "very likely," or "somewhat likely" would receive a personalized cancer vaccine), and 0 if they did not. Full question wording is on Supplementary Material pp. 2–3.

The primary independent variables are whether respondents abstained from COVID-19 vaccination (intended refusal, in April 2020; active refusal, in September 2021). We measured intended COVID vaccination refusal by asking respondents, "When a vaccine for the novel coronavirus (COVID-19) becomes widely available, how likely are you to request to be vaccinated?" Response options ranged from "very likely" to "not likely at all" on a four-point Likert scale. Similarly, we measured active COVID vaccination refusal

by asking respondents whether they were "fully vaccinated against COVID-19 in the past year," to which they could indicate either "yes" or "no." In both cases, we dichotomized responses, such that a score of 1 corresponds to the "very" or "somewhat" unlikely option for the intended uptake question, or "no" on the uptake question.

To ensure that more general vaccination attitudes are not driving any potential COVID-related spillover effects, we also control for respondents' attitudes regarding childhood vaccine safety. Respondents were asked whether "vaccines administered to children at young ages cause them to become autistic," to which they could respond that the MMR vaccine "definitely can," "probably can," "probably cannot," or "definitely cannot" cause autism (see Motta et al. 2018; Motta 2023).

Given the observational nature of this portion of our study, our models also account for a wide range of sociodemographic controls, including respondents' concern about the COVID-19 pandemic (measured on a five-point scale ranging from "very worried" to "not at all worried"); political ideology (a standard seven-point self-placement scale ranging from "extremely liberal" to "extremely conservative"); anti-intellectualism (a five-point Likert scale ranging from "strong agreement" to "strong disagreement" with the statement "I'd rather put my trust in the wisdom of ordinary people than the opinions of experts and intellectuals"; see Oliver and Rahn 2016; Motta 2018; Merkley 2020); household income (a twenty-one-point scale); and binary indicators of respondents educational attainment (four-year college completion), racial/ethnic identity (self-identification as Black [non-Hispanic] or Hispanic), and gender (self-identification as a woman). All variables were rescored to range from 0 to 1. Additional information is on Supplementary Material pp. 1–5. All missing responses for all Lucid questions, including "don't know" responses, are excluded from analysis.

Results

First, we examine average vaccine skepticism over time using the longitudinal data. Though this is not a direct test of COVID-19 vaccine spillover effects, it provides a sense of the over-time trend of vaccine skepticism during the pandemic. In other words, if there is spillover occurring as anticipated, then vaccine hesitancy during the pandemic should increase (if the spillover is in an anti-vaccine direction) or decrease (if the spillover is in a pro-vaccine direction). We find that, from December 2020 through March 2022, average general vaccine skepticism remained fairly constant over time, at around a 4 on a 0–12 scale, though average vaccine skepticism did significantly drop between December 2020 (4.25) and February 2021 (3.90), which followed the authorization of Pfizer and Moderna mRNA COVID-19

vaccines for emergency use. See Supplementary Material figure S1 for details.

However, if we instead look at general vaccine skepticism by partisanship (figure 1), subgroup variations occur in predictable ways. More specifically, the over-time trend of average general vaccine skepticism has become more polarized, with Democrats and Independents becoming less vaccine skeptical and Republicans staying more or less at the same levels of skepticism.

Further, if we break down average vaccine skepticism over time by COVID-19 vaccine status and partisanship, vaccine skepticism increased between June 2021 and March 2022 among Republicans and Independents regardless of their COVID-19 vaccine status (figure 2), and among Democrats who got zero or one COVID-19 vaccine dose (Supplementary Material figure S2). For Democrats who received at least two doses of the COVID-19 vaccine, however, overall vaccine skepticism slightly decreased.

Having established that vaccine skepticism has become increasingly politically contentious over time, we next assess whether changes in COVID-19 vaccine attitudes are responsible for these effects. We therefore isolate respondents who took the survey in both December 2020 and March 2022 and who were part of the subset of respondents who received the vaccine skepticism questions in both waves. Among these respondents, we ran OLS regressions with the change in individual vaccine skepticism over time as the main dependent variable (table 2, Models 1 and 2). We then use partisanship and COVID vaccination likelihood as independent variables, alongside a host of demographic and political control variables. We find that partisanship is associated with changes in vaccine skepticism over time ($p < .03$), while higher initial perceptions of one's likelihood of vaccinating against COVID-19 are associated with lower subsequent vaccine skepticism ($p < .02$). Notably, these effects do not substantively change when control variables are added in Model 2. Including an interaction term between partisanship and COVID-19 vaccination intention is not statistically significant at $p = .62$ (table 2, Model 3).

We also found that neither vaccine skepticism in December 2020 ($p = .72$) nor COVID-19 vaccination likelihood ($p = .71$) are significantly associated with changes in partisanship over time (table 2, Model 4). Finally, partisanship is not associated with changes in COVID-19 vaccination likelihood over time, though general vaccine skepticism is (table 2, Model 5).

Together, these results suggest that COVID-19 vaccination likelihood impacted vaccine skepticism change, suggesting a spillover effect. These effects hold when accounting for partisanship, which also exhibits unique effects on the direction of vaccine skepticism change over time.

Next, we turn to respondents' intention to vaccinate against the flu. Figure 3 below breaks out the proportion of respondents by partisanship who (1) expressed getting the flu vaccine during survey waves from July

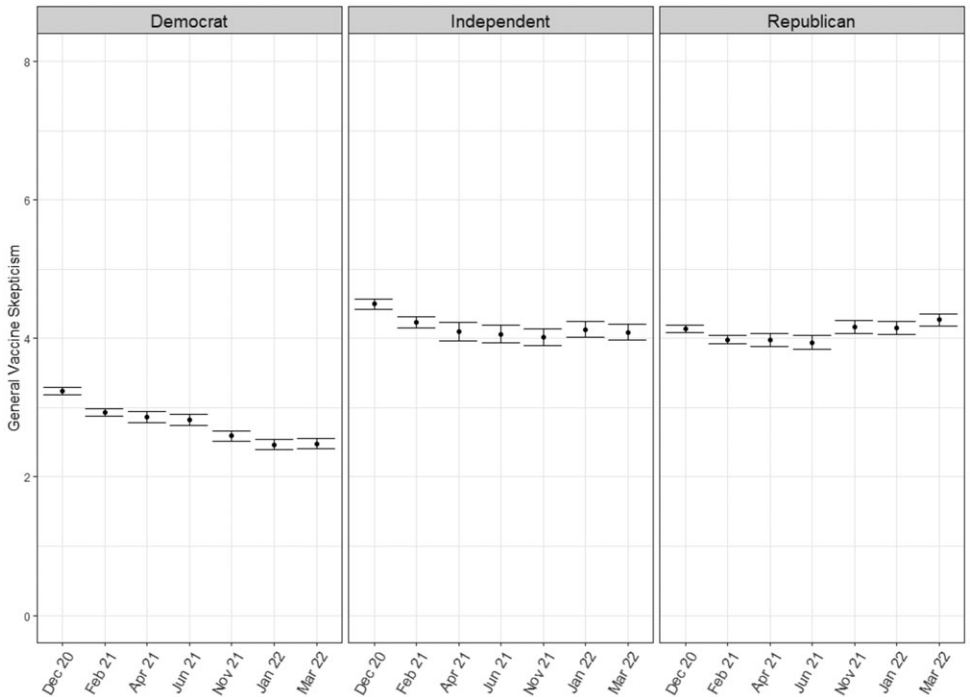

Figure 1. General vaccine skepticism over time, by partisanship. The general vaccine skepticism scale has a range from 0 to 12; 0 to 8 is shown here for figure clarity. 95 percent confidence intervals shown. Democrat N = 33,541, Republican N = 24,095, Independent N = 14,329.

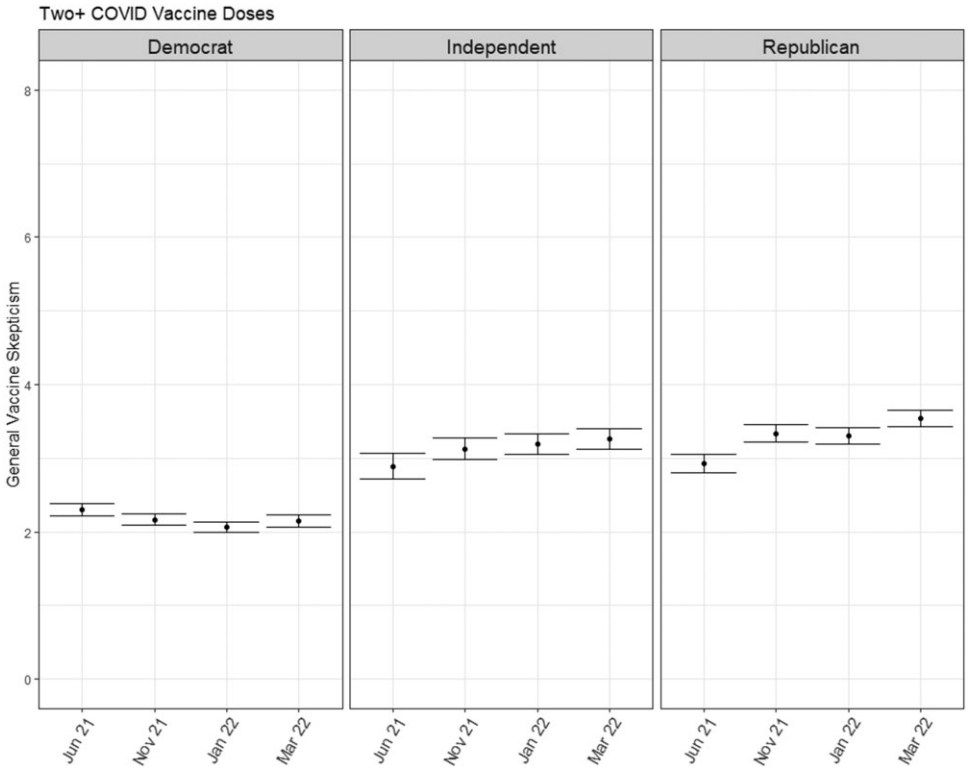

Figure 2. Vaccine skepticism in respondents who received two+ COVID-19 vaccine doses, over time and by party. The general vaccine skepticism scale has a range from 0 to 12; 0 to 8 is shown here for figure clarity. 95 percent confidence intervals shown. Democrat N = 11,099, Republican N = 5,427, Independent N = 3,322.

Table 2. Predicting change over time in vaccine skepticism, party ID, and COVID vaccination likelihood, with exact p values in parentheses.

	Vaccine skepticism change	Vaccine skepticism change	Vaccine skepticism change	Partisanship change	Change in COVID-19 vaccination intention
Partisanship	0.10	0.11	0.12	–	−0.13
	(0.001)	(0.024)	(0.02)		(0.136)
COVID-19 vaccination intention	−0.09	−0.10	−0.07	0.00	–
		(0.005)	(0.005)	(0.180)	(0.706)
Female	–	−0.01	−0.01	0.00	−0.10
		(0.713)	(0.685)	(0.554)	(0.006)
Black	–	0.05	0.05	−0.02	0.11
		(0.143)	(0.134)	(0.281)	(0.151)
Hispanic	–	0.08	0.08	−0.01	0.04
		(0.063)	(0.077)	(0.217)	(0.577)
Age	–	0.11	0.12	0.00	−0.01
		(0.061)	(0.060)	(0.988)	(0.911)
Education level	–	−0.06	−0.06	−0.01	−0.14
		(0.158)	(0.149)	(0.186)	(0.141)
Income level	–	0.01	0.01	0.01	0.11
		(0.788)	(0.791)	(0.452)	(0.276)
Ideology	–	0.01	0.01	−0.03	0.06
		(0.912)	(0.906)	(0.007)	(0.571)
Partisanship X COVID-19 vax intention	–	–	−0.04	–	–
			(0.615)		
Vaccine skepticism	–	–	–	−0.01	−0.59
				(0.723)	(0.000)
Constant	−0.05	−0.10	−0.11	0.52	0.66
	(0.009)	(0.030)	(0.032)	(0.000)	(0.000)
N	397	396	396	1001	202

Note: Exact p values in parentheses. Independent variables from December 2020 wave, dependent variables from March 2022. Repeat respondents only. Data weighted to national population benchmarks. Sample sizes across models vary because of nonresponse and because only a proportion of respondents were randomly provided the vaccine skepticism and vaccine intention questions.

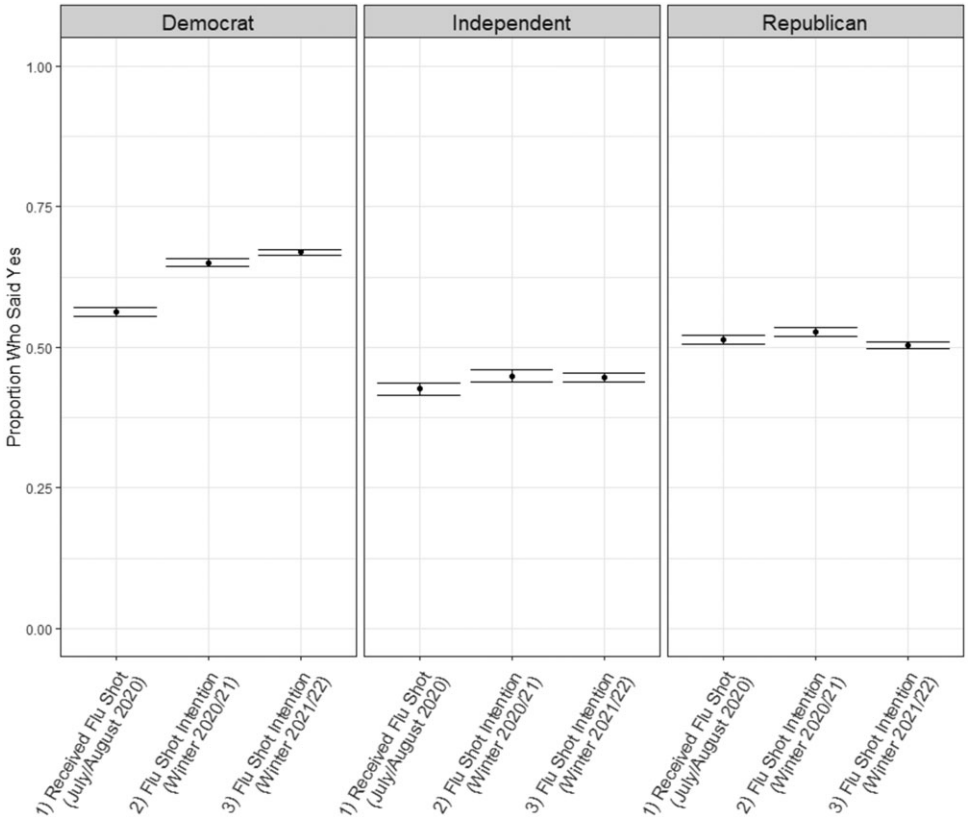

Figure 3. Flu shot uptake summer 2020, and flu shot intention over time, by partisanship. 95 percent confidence intervals shown. Democrat N = 15,285, Republican N = 11,114, Independent N = 6,098.

and August 2020, (2) intended to get the flu vaccine during survey waves from winter 2020–2021, and (3) intended to get the flu vaccine during survey waves from winter 2021–2022. While flu vaccination intention increased among Democrats between winter 2020–2021 and winter 2021–2022, it decreased for Republicans and stagnated for Independents during this same period.

These results suggest that general vaccine skepticism and flu shot intention changed before versus after COVID-19 vaccine rollout for the general public, but this change varied by partisanship. Specifically, Democrats were more likely to exhibit a decrease in vaccine skepticism and an increase in flu shot intention. Conversely, Republicans on average were more vaccine skeptical over time and less likely to intend to get the flu vaccine. Further, regression results predicting the change in vaccine skepticism over time again find that COVID-19 vaccine attitudes, and partisanship, significantly predicted changes in vaccine skepticism ($p > .01$ and .001, respectively). See Supplementary Material table S1 and figure S7 for details. These results point to attitudinal spillover.

Next, we examine associations between COVID-19 vaccine attitudes and support for hypothetical vaccines. Figure 4 displays the results of each LPM (one for Lyme disease uptake, the other for personalized cancer vaccine uptake) as coefficient plots. Shaded circles correspond to parameter estimates from the LPMs, with 95 percent confidence intervals extending out from each one. Circles falling to the right of the dashed line, and that do not intersect with the dashed vertical line, indicate a positive and statistically significant effect of each corresponding variable on vaccine refusal. Results can be interpreted as the percentage point change in the likelihood of intending to receive each vaccine (x-axis), moving from the minimum to maximum value of each variable listed on the y-axis.

Even after accounting for attitudes toward childhood vaccination and a series of other sociodemographic controls, COVID-19 vaccine refusal is positively and significantly associated with intentions to refuse a Lyme disease vaccine (+41 percent points, $p = .00$) and personalized cancer vaccines (B = +20 percent points, $p = .00$). Few entries in the model produce significant, positive effects on vaccine refusal, with the exception that respondents who express less concern about the pandemic are more likely to refuse both vaccines. See Supplementary Material table S2 for full regression results.

We again find that COVID-19 attitudinal spillover varies by partisanship. When we revise the models summarized in figure 4 to include an interaction term between partisanship and COVID-19 vaccination refusal, we find a significant difference by party for the cancer vaccine but not for the Lyme disease vaccine. The predicted effects for cancer vaccine refusal by party are in figure 5 (see Supplementary Material tables S4 and S5 for full model results).

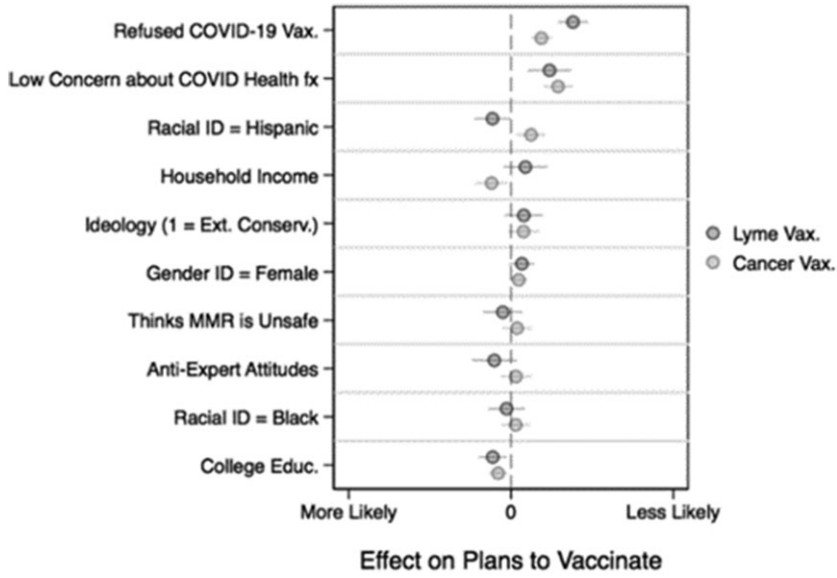

Figure 4. COVID-19 vaccine refusal and refusal of vaccines currently undergoing clinical trials. N = 2,634. Parameter estimates (shaded circles) from Linear Probability Models presented, with 95 percent confidence intervals extending out from each one. Coefficients are presented as the percentage point change in the likelihood of vaccinating, given movement from the minimum to maximum value of each variable. See the Supplementary Material for full model output.

Independents and Democrats unvaccinated against COVID-19 were significantly more likely to refuse the cancer vaccine compared to their vaccinated counterparts. Unvaccinated Independents were 2.5 times as likely to say they would refuse the cancer vaccine compared to vaccinated Independents, while unvaccinated Democrats were around 1.3 times as likely to refuse the cancer vaccine compared to vaccinated Democrats. For Republicans, cancer vaccine refusal was a little over 50 percent more likely for the unvaccinated compared to the vaccinated, but that difference was not statistically significant.[6]

These results suggest that COVID-19 vaccine spillover effects not only influence attitudes toward *current* vaccination programs but also toward

6. We also interact degree of concern over getting COVID-19 with partisanship, but the results are not statistically significant. This is perhaps unsurprising, given that it is about COVID-19 broadly rather than something specific to the vaccine. See Supplementary Material tables S4 and S5 for results.

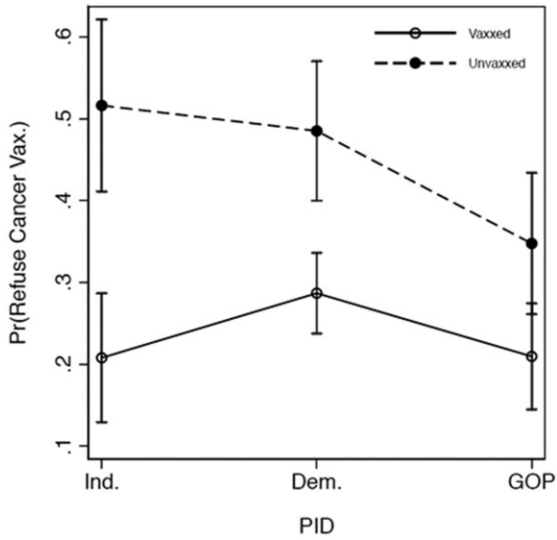

Figure 5. COVID-19 vaccine refusal and refusal of vaccines currently undergoing clinical trials, by partisanship. 95 percent confidence intervals shown. Democrat N = 860, GOP/Republican N = 612, Independent N = 277.

potential *future* vaccination efforts. This includes, quite literally, a potential cure for cancer. Further, attitudinal spillover appears to be contingent on partisanship.

Discussion

Taken together, the above results suggest countervailing spillover effects across subgroups—particularly across political affiliation—for general vaccine hesitancy and for hypothetical vaccines. Although general vaccine skepticism has decreased through the pandemic, this has particularly occurred among Democrats and those who received at least two doses of the COVID-19 vaccine. Conversely, Republicans, Independents, the unvaccinated, and those who got one COVID-19 vaccine dose became more vaccine skeptical over time. Similarly, throughout the pandemic flu shot intention has increased among Democrats and decreased among Republicans. Further, those who expressed a low likelihood of getting the COVID-19 vaccine—particularly Republicans—were more likely to become vaccine skeptical over time. Republicans who expressed low levels of concern for COVID-19 early in the pandemic were also less likely to intend to get the flu shot, controlling for previous flu shot uptake.

Next, we measure support for hypothetical vaccines and find that COVID-19 vaccine refusal and low concern about COVID-19 significantly predict decreased support for vaccines against cancer and Lyme disease. The effect for the cancer vaccine is particularly pronounced among Democrats, Independents, and those more hesitant of the COVID-19 vaccine. We also take an initial, exploratory look at the mechanism for spillover using an embedded survey experiment; although spillover tends to occur in less COVID-19-specific arguments, the results are inconsistent. We therefore suggest that future research should aim to identify the specific mechanisms of spillover.

This study has a few limitations. We do not have data that compares pandemic-era attitudes to those from before the pandemic. Doing so would provide a stronger sense of how non-COVID vaccine attitudes changed with respect to the pandemic. It is possible that, because our data come from around the time of vaccine rollout or later, the vaccine spillover effect may have occurred before data collection. We leave it to other scholars to add to this gap in our study. Additionally, we rely on online convenience samples. Although this is common in survey research on vaccine attitudes (e.g., Callaghan et al. 2019; Motta 2020; Kreps et al. 2021; Lunz Trujillo et al. 2021; Green et al. 2023a), we recognize that the samples may have biases that could affect results. For this reason, we include survey weights in any nonexperimental regression analyses and exclude respondents who fail attention checks, though this does not entirely counteract the issues with online nonprobability surveys.

In addition, though we begin exploring potential mechanisms for spillover, we do not fully test these possible pathways. As noted previously, this would be an excellent direction for future research. Relatedly, understanding the spillover mechanisms could help us understand the extent of COVID-19 vaccine spillover, beyond attitudinal and behavioral spillover onto other vaccines. If the pathways involve highly generalizable factors, such as partisanship directly or a decrease in the trust of experts and medical professionals, then spillover could be very widespread. For instance, if COVID-19 vaccines altered trust in medical experts, then COVID-19 vaccine attitudes have the potential to impact the likelihood of getting an unrelated medical procedure that involves medical expertise endorsement. Or, because the COVID-19 vaccine has become politicized, these attitudes may have spilled over into partisan affect. For instance, a recent study finds that Germans are more affectively polarized because of the pandemic and of COVID-19 vaccine mandates in particular via increased anger (Nguyen, Mayer, and Veit 2022). A similar trend could very well have occurred in the United States.

That said, as discussed above, spillover is much more likely when two conceptual areas are semantically or categorically similar to one another. Furthermore, previous work suggests that political framing is somewhat narrow in causing spillover effects across a number of issues (Hopkins and

Mummolo 2017). These two points suggest that the extent of COVID-19 vaccine spillover may be somewhat limited to more directly relevant topics.

A final potential limitation of this study is that some effect sizes are relatively small. However, although the effect sizes are often substantively small, modest changes in vaccine attitudes can have significant real-world consequences. First, even small increases in vaccine skepticism could jeopardize public health due to declining vaccination rates for established vaccines or for future vaccines. For instance, small increases in vaccine skepticism created localized pockets of measles in the United States before the pandemic. However, the COVID-19 pandemic could also have highlighted the importance of vaccination for many, resulting in a positive spillover onto non-COVID vaccinations. We find the latter is more so the case, though negative spillover occurred for a subset of the population.

Second, policies mandating non-COVID vaccines could be weakened. State policymakers have already pushed for removing childhood vaccine mandates to attend public schools in recent years; soured public attitudes toward vaccines could impact vaccination policies (Joslyn and Sylvester 2019). Further, the reasons antimandate policymakers cited for opposing such laws reflect similar considerations to COVID-19 mandate opposition. If these policymakers succeed, it would overturn established public health policy and jeopardize the health of Americans, and of American children in particular (Lantos, Jackson, and Harrison 2012). Third, anti-vaccine movements in the United States can influence the supply of vaccine misinformation available cross-nationally, thereby decreasing vaccination rates in other countries, and jeopardizing the health and well-being of people around the globe (Lunz Trujillo and Motta 2021; Hotez 2022).

From these results, we recommend that investigators and health communicators develop and incorporate messaging strategies that aim to reduce potential anti-vaccine spillover from the COVID-19 vaccine. Some extant research suggests general strategies may be helpful (Green et al. 2023a), though given the variation in spillover effects by subgroup, these strategies should also aim to target certain specific populations (Lunz Trujillo et al. 2021). Most notably, health communicators should pay attention to messaging aimed at different political subpopulations, given the apparent politicization of the COVID-19 vaccine and its potential spillover onto other vaccines more broadly.

Supplementary Material

Supplementary Material may be found in the online version of this article: https://doi.org/10.1093/poq/nfad059.

Funding

Part of this project was supported by the National Science Foundation [SES-2029292 and SES-202929 to D.L., Matthew Baum, Katherine Ognyanova, and James Druckman]. Any opinions, findings, and conclusions or recommendations expressed here are those of the authors and do not necessarily reflect the views of the National Science Foundation. This research was partly supported by the Knight Foundation [awarded to D.L.], the Russell Sage Foundation [awarded to Matthew Baum, D.L., and Katherine Ognyanova], and the Peter G. Peterson Foundation [awarded to James Druckman]. Data collection was supported in part by Amazon [awarded to D.L.].

Data Availability

Replication data and documentation are available on the Harvard Dataverse at https://doi.org/10.7910/DVN/C78KOG.

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