

RESEARCH ARTICLE

Left–Right-Position, party affiliation and regional differences explain low COVID-19 vaccination rates in Germany

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Email: sebastian.jaeckle@politik.uni-freiburg.de**Abstract**

Established vaccine hesitancy measurement instruments, such as the Vaccine Hesitancy Determinants Matrix, are not sufficiently equipped to adequately and consistently measure political and ideological attitudes. Focusing on Germany, which is a particularly interesting case since it witnessed the establishment of the by far most well-organized and sustained ‘anti-Covid’ movement in Europe, this quantitative study explores the impact of political ideology and partisanship on the degree of vaccine hesitancy based on four surveys (February–October 2021) among more than 30,000 individuals. We demonstrate that party affiliation, political ideology and region of residence all impact vaccine hesitancy. In fact, they turn out to have a greater impact than two factors often analysed with respect to vaccine hesitancy: gender and educational background. Further interaction models show that the effect of political ideology on vaccine hesitancy is moderated by age, gender and region of residency. For instance, while the more rightwing a young individual is, the more hesitant they are towards SARS-CoV-2 vaccination—for older individuals, this is not the case. Our findings are relevant for future investigators measuring vaccine hesitancy and policy makers contemplating the differential impact of complex public health interventions: as the impact of political and ideological attitudes on vaccine hesitancy are not adequately captured by established vaccine hesitancy measurement instruments, we recommend its modification to include a clear and harmonised definition of the political-ideological dimension of vaccine hesitancy together with pre-validated measurement items that improve future studies. In addition, we reason that vaccine hesitancy, while being an outcome of complex socio-political factors, is in itself an indicator for societal cohesion and anomie, the degree of which is associated with trust in (health) policy makers, (public) health authorities, health service providers, etc. Therefore, we further recommend that vaccine hesitancy questions should be integrated in pertinent national surveys.

INTRODUCTION

Vaccination is considered the most effective public health measure for preventing the spread of communicable diseases and pertinent, potentially devastating,

sequelae. Administration of vaccines against eight of the most common and serious vaccine preventable diseases (Tuberculosis, Meningitis, Whooping cough, Measles, Tetanus, Hepatitis B, Diphtheria, Yellow fever) prevented 1.7 million deaths worldwide in 2019 (Global

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Change Data Lab, 2022; Vanderslott et al., 2013). With respect to SARS-CoV-2, Watson et al. (2022) estimate that between December 2020 and December 2021, vaccines have prevented between 14.4 and 19.8 million deaths worldwide which, based on the latter estimate, equates to a striking 63% reduction of all cause deaths worldwide in the same period (Watson et al., 2022). Nevertheless, discussions revolving around the perceived versus clinically indicated effectiveness (or harm) of SARS-CoV-2 vaccines to prevent, or attenuate the effects of, COVID-19 have been prominent in many countries from the start of immunization campaigns. These discussions, which caused concern and confusion among many individuals, were not least triggered by inter alia unprecedented development and conditional marketing authorization timelines, in part due to the perceived technological novelty (mRNA). Importantly, if not moderated adequately, such discussions can lead to an erosion of trust in traditional public health campaigns and lead to spill-over effects, such as an impact on the willingness to have scheduled vaccines. Thus, vaccine hesitancy (VacHes) with regard to COVID-19 vaccines might serve as a more general indicator important for the overall health system entities and beyond.

Lack of information and/or exposure to misinformation, the latter facilitated in particular by social media, is considered an important contributor to VacHes (Wilson & Wiysonge, 2020). The increasing unpredictability of current domestic and international developments can lead to distrust in public/government institutions, pertinent arms-length bodies, and individuals, and groups thereof, with other viewpoints. While social media and other fora can be facilitators and incubators of social discontent, overall dissatisfaction and distrust are being increasingly recognized as the root causes of vaccine refusal. For example, Pertwee et al. (2022) found that VacHes is frequently not even linked to factors associated with a specific vaccine and that conspiracy theories play a major role in fueling distrust in public institutions and governing parties across a range of countries (Pertwee et al., 2022).

Political rhetoric and identity politics are playing an increasingly important role in influencing and polarizing different individuals and societal groups into endorsing or rejecting issues that were not initially central to debates in the political sphere, such as climate change, gender and vaccination (Sharfstein et al., 2021). While VacHes can be associated with a range of apolitical factors, such as lack of knowledge or past (negative) experiences with vaccination (Dubé et al., 2013), a recent study by Stoeckel et al. (2022) has found that, across Europe, VacHes most likely occurs in individuals who hold “anti-elite world views and culturally closed rather than cosmopolitan positions” (Stoeckel et al., 2022). Although this description most often characterizes supporters of, or those that identify

with, populist and protest parties, the study concludes that party affiliation does not have a significant effect on VacHes (Stoeckel et al., 2022). However, a recent Kaiser Family Foundation poll in the US (2021) found that the share of unvaccinated individuals identifying as Republican or leaning Republican increased from 42% to 60% between April and October 2021 while, in the same period, the share of unvaccinated individuals identifying as Democrat or leaning Democrat decreased from 36% to 17% (Kirzinger et al., 2021). Similarly, in another recent study in the US, Jones and McDermott (2022) have found “evidence that partisanship affects vaccine hesitancy indirectly through its influence on Americans’ concern over COVID, belief in vaccine conspiracy theories, and trust in government, science, and the medical profession” (Jones & McDermott, 2022).

In Germany—the subject of this study—there remain substantial differences between Eastern and Western federal states regarding, for example, average income and, more pertinently, voting patterns—rightwing, populist and protest parties are stronger in East Germany while centrist parties are more prominent in West Germany (Radkowski, 2021). Regarding political rhetoric and identity politics, the German right wing populist AfD (*Alternative for Germany*) and other protest parties, the latter of which were founded in the wake of the COVID-19 crisis, have clearly formulated and publicized their opposition towards government-based SARS-CoV-2 containment measures and pertinent vaccines. Aggregate data furthermore show that states with the best results for the AfD at the federal election in November 2021 have the lowest vaccination rates in Germany (as of November 2021) (Reuband, 2022). Amplified by social media and alternative sources of information vis-à-vis traditional news outlets, Germany witnessed the establishment of the by far most well-organized and sustained ‘anti-COVID’ movement (*Querdenken 711*) and, since then, the strongest protest responses in Europe—in particular during the period mandating SARS-CoV-2 containment measures before vaccines were available—and later, during the concurrent and complementary vaccination campaign. The *Querdenker protests*, that in some cases attracted nearly 40,000 individuals, included participants of all walks of life and, oftentimes opposing, sociopolitical backgrounds. By some estimates, 10%–14% of Germans considered joining the protest movement at some point (Deutschlandfunk, 2020). Again, aggregate data at the German state level show that there is a positive correlation between belief in conspiracy theories and a positive attitude towards COVID-19 protests (Reuband, 2022). Other jurisdictions in Europe, for example, Austria, the Netherlands and France, also witnessed protests, but, while sometimes taking more violent courses, these tended to be considerably less well-organized, and more ad hoc and local. Therefore,

Germany is a compelling case to study specific determinants and patterns of VacHes. This article reports our analysis of the causes of VacHes in Germany regarding SARS-CoV-2 vaccination at the individual level focusing on the relevance of political-ideological attitudinal patterns.

Specifically, our aims were to test if (i) political-ideological attitudinal patterns and party affiliation have an impact on the degree of VacHes in Germany, and should this be the case, (ii) these effects are differential across diverse group characteristics, such as age, sex, federal state and/or region (East; North/West; South) of residence.

Descriptive overview of course of the COVID-19 pandemic and the vaccination campaign in Germany

During the course of the COVID-19 pandemic, most experts and politicians came to the conclusion that only a sufficiently high vaccination coverage of the population could end the pandemic. The first two vaccines received conditional marketing authorization from the European Medicines Agency (EMA) within just 2 weeks—*Comirnaty* (BionTech/Pfizer) on 21 Dec. 2020, and *Spikevax* (Moderna) on 6 Jan. 2021. Initially, vaccination was first offered to high-risk groups (e.g., the elderly and immunocompromised) and to those who have close contact with high-risk patients. While major shortages of vaccines frustrated the vaccination campaign in the initial months, it became apparent in the second half of 2021 that it would be difficult to achieve a vaccination rate of well over 80%–90% which virologists called for, particularly due to the emergence of the significantly more infectious and potentially more dangerous delta variant in early June 2021 (Glucroft, 2021; Schneeweiß, 2021).

Figure 1 shows the development of the vaccination campaign (2021). The graph presents the absolute number of fully immunized individuals, i.e. who had received either two doses of *Comirnaty* (BionTech/Pfizer), *Spikevax* (Moderna) or *Vaxzevria* (AstraZeneca), or a single dose of *Janssen COVID-19 Vaccine* (Johnson&Johnson). It is evident that, after a gradual start, the vaccination campaign gained significant momentum from the middle of May 2021, particularly due to the significant increase in availability of *Comirnaty*, but also recent emergency approvals of *Vaxzevria* and *Janssen COVID-19 Vaccine*. From the beginning of August, however, a plateauing of all curves can be observed—despite the availability of vaccines. The relatively low vaccination rates from August to the end of October 2021 (the end of our observation period) can no longer be explained by a lack of vaccines but, rather, because a large number of people had not actively sought vaccination. The reasons for this VacHes will be examined in this article.

Figure 2 shows that, in direct comparison of vaccination rates across German federal states, there exists a strong regional variation, in particular over time: in September 2021, the East German states of Saxony, Thuringia and Brandenburg had the lowest vaccination rates, the Southern states of Baden Württemberg and Bavaria had somewhat lower rates, respectively, whereas the Northern states of Schleswig-Holstein and Bremen had the highest vaccination rates. Figure 2 also shows that the magnitude of variation increased dramatically between May 2021 and the end of our observation period (October 2021).

Measuring vaccine hesitancy

Traditionally, vaccine hesitancy and its determinants have most often been explored by inter alia vaccinology,

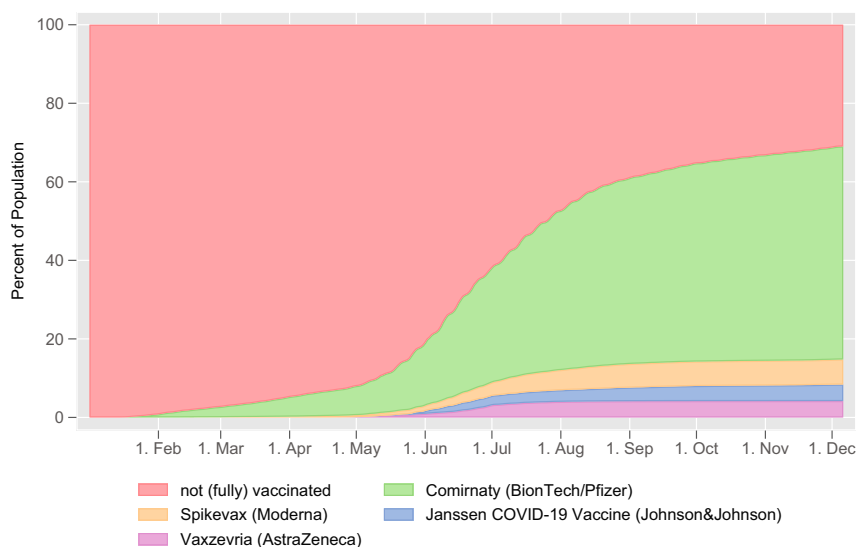


FIGURE 1 Individuals not, not fully and fully vaccinated against COVID-19 in Germany (2021). NB: It should be noted that the curve of those not fully vaccinated includes individuals who had already received the first vaccine dose or recovered from COVID-19, or for whom SARS-CoV-2 immunization had not (yet) been recommended.

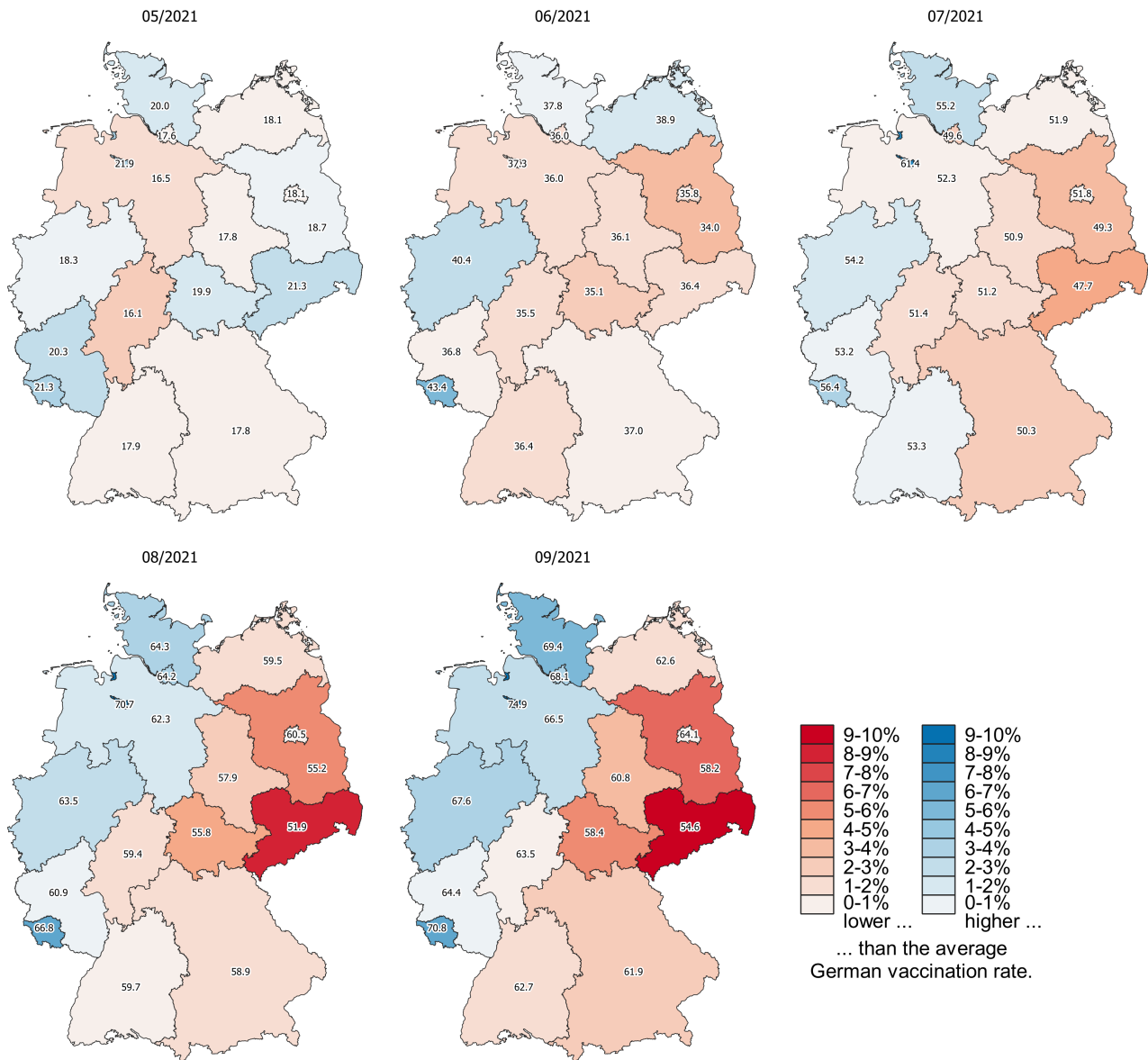


FIGURE 2 Regional development of vaccination rates in Germany (May–September 2021). Annotation: The digits represent the COVID-19 vaccination rates (in percent) in Germany's 16 federal states at the end of each respective month. The colours depict the deviation from the average German vaccination rate, see colour legend.

public health, epidemiology, sociology and psychology of health scholars. This has led to the development (and validation) of various vaccine hesitancy assessment models (Gilkey et al., 2016; Larson et al., 2016; Oduwole et al., 2019; Shapiro et al., 2018). In addition to standard sociodemographic data, common vaccine hesitancy-specific themes across these assessment models cover attitudes towards receiving a vaccine (or having one's child vaccinated), perceived benefit or harm of existing or novel vaccines under consideration, perceived trust in healthcare providers, vaccination programmes, authorities, etc.

All these assessment models have in common that individual political-ideology attitudes are not taken into account explicitly. In section *Contextual influences* of a more

extensive VacHes assessment model—the *Vaccine Hesitancy Determinants Matrix (VHDMx)*—*Politics/policies* is provided as item e, but the concept—or rather concept group—are not further defined (MacDonald and SAGE Working Group on Vaccine Hesitancy, 2015; Marti et al., 2017). It is unsurprising that various investigators utilizing the VHDMx have (i) failed to adequately or specifically operationalize the concept *Politics/policies* for, and include it explicitly, in their data collection instruments (e.g. Dinga et al., 2021; Erchick et al., 2022; Majee et al., 2022), (ii) drawn no, or no noteworthy, pertinent findings (e.g. ECDC, 2015; Kulkarni et al., 2021; Lane et al., 2018; Marti et al., 2017), or (iii) simply omitted the variable (e.g. Erchick et al., 2022; Soares et al., 2021). By the same token, studies using the VHDMx have

deductively captured rather different determinants for VacHes based on the *Politics/policies* item—rather than directed data collection based on a priori defined and validated (sub)items. Identified determinants range from the effects of vaccine mandates (Marti et al., 2017) over political unrest and conflict (Dubé et al., 2014) to, even, limited access to vaccines due to suboptimal publicly organized vaccine provision infrastructure, or lack thereof (Dubé et al., 2014). Limited access, arguably, might not per se cause VacHes but rather act as a barrier/deterrent and thereby serve as a source of frustration which, admittedly, can ultimately lead to VacHes. The inconsistency in the utilization of the *Politics/policies* item indicates that, currently, the item might not be sufficiently defined for proper operationalization and/or be perceived as a container variable for aspects that might be considered somewhat political and/or cannot be linked immediately to the remaining items. In consequence, these studies all miss to test the relationship between basic political attitudinal patterns and VacHes.

This appears even more incomprehensible when considering that, fueled by identity politics and over the past decade, the injection of traditionally apolitical issues, such as gender, climate change and vaccination, into political debates has led to a substantial increase in political polarization based on and around these issues—acutely SARS-CoV-2 immunization (Sharfstein et al., 2021). In turn, political ideology and party affiliation, and pertinent preferences, are being increasingly explored by political science and sociology scholars as determinants of VacHes (Aw et al., 2021; Jones & McDermott, 2022; Kirzinger et al., 2021; Stoeckel et al., 2022). Although these studies come to somewhat different conclusions regarding the effect magnitude of political ideology and party affiliation, and pertinent preferences, these factors can be considered important determinants of VacHes albeit with setting-dependent variable weighting.

In Germany, as alluded to in the introduction, the right-wing populist, anti-system party AfD and protest parties have unequivocally voiced their opposition to all government mandated SARS-CoV-2 containment measures, in particular vaccination, in an attempt to shift the “focus from a public health issue to a crisis of democracy itself”(Lewandowsky et al., 2022, p. 237). While at the beginning of the pandemic, the party's reaction was rather inconsistent, from autumn 2020 it focused on the COVID-19 crisis as the central topic for criticizing the government's actions in response to the pandemic (Lehmann & Zehnter, 2022). In this context, the AfD has repeatedly trivialized the disease course of COVID-19 and heavily relied on inflammatory and misleading rhetoric in order to discredit the government and other less radical political parties. Central narratives have centred around reframing the purported effects of SARS-CoV-2 containment measures as leading to the *collapse of the economy, withdrawal of constitutional rights and oppression of citizens* (Coenen

et al., 2022). To amplify their political narratives and further consolidate support for their anti-system attitudes, the AfD has, in addition, consistently, persistently and, arguably, successfully used social media (since their inception in 2017) and propagated misleading information and untruths which, in turn, has increasingly polarized their supporters, recently in particular on the issue of vaccination (Jungkunz, 2021; Pfeifer, 2021).

Moreover, our data show, stably across multiple surveys, substantial variation in the perceived trustworthiness of supporters of different parties regarding media/sources of information relating to SARS-CoV-2/COVID-19. Figure 3 shows that the perceived media trustworthiness of supporters of AfD and the protest parties is generally substantially lower than for those who support the other main parties. As the AfD and the newly founded protest parties focus on social media to connect with their supporters, and this is the most trustworthy source of information for many of the latter, echo-chamber effects, such as those similarly reported for closed Facebook groups (Sorell & Butler, 2022), result in dismissal of alternative, contradicting sources and re-enforcement of long-held viewpoints and beliefs. This dynamic further solidifies political polarization and the amalgamation of political ideology and party affiliation with topics, such as vaccination, and, in extension vaccine hesitancy.

Hypotheses

The elaborations above lead us to formulate the following hypotheses regarding political-ideological attitudes in general and party affiliation in particular:

H1. *The further politically-ideologically right an individual identifies, the higher their degree of VacHes is.*

H2a. *Supporters of right-wing populist AfD and the newly formed COVID-19 protest parties have the highest degree of VacHes.*

H2b. *Supporters of left-wing Linke (Left party) and liberal FDP (Free Democratic Party) show a significantly higher degree of VacHes compared with supporters of social democratic SPD (Social Democratic Party of Germany), christian-democratic CDU/CSU (Christian Democratic Union/Christian Social Union) and Greens, but not as high as those of AfD or protest parties.*

Our data show that vaccination rates are evidently lower in Eastern and also in Southern Germany (Figure 2). In addition, ECDC (European Centre for Disease Prevention and Control) data show that the further East a country is located in Europe, the lower their

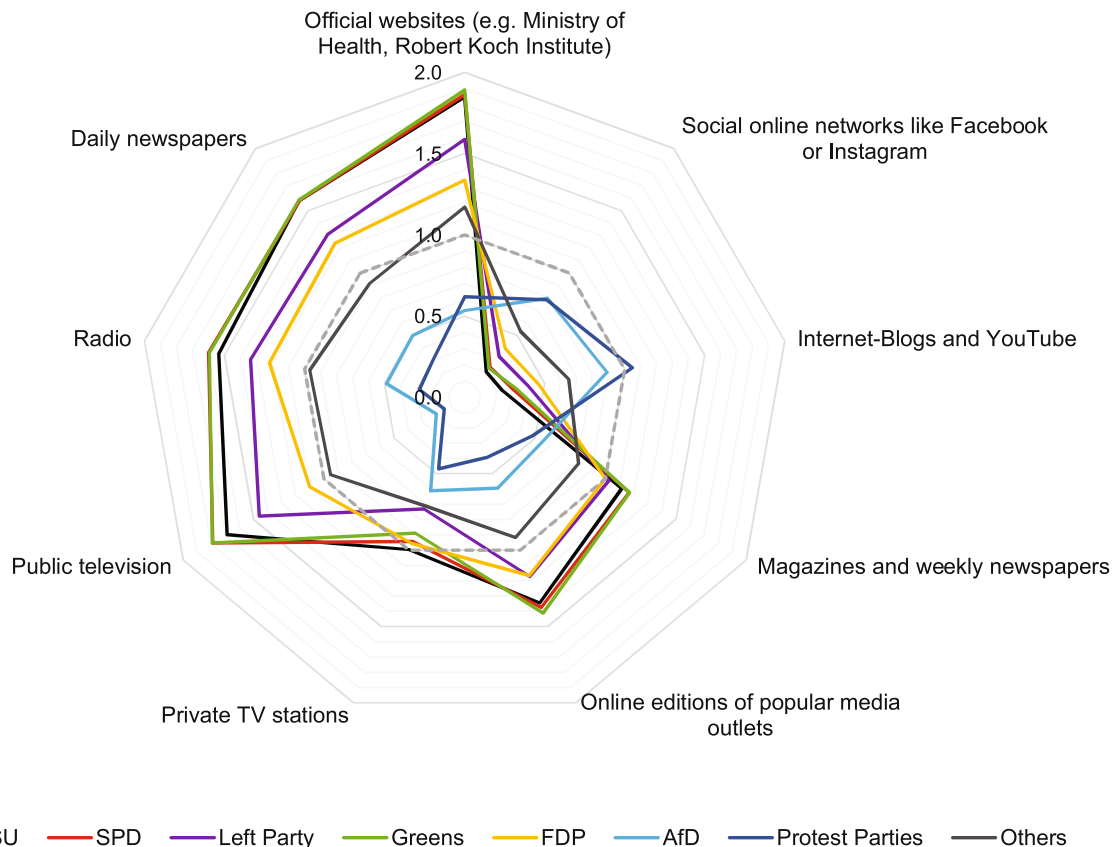


FIGURE 3 Trust in different media/sources of information relating to SARS-CoV-2/COVID-19. Annotation: The mean value is shown according to voting preference (Sunday poll); 0 = not trustworthy; 2 = trustworthy. Positions inside the dashed line indicate rather no trust in the respective medium, positions outside indicate that the party's supporters rather trust the medium. Survey period: 04–15. February 2021. $N = 5355$ (excluding non-voters and ineligible voters), weighted by age, gender and residency in West or East Germany.

national vaccination rate tends to be (ECDC, 2022). While political-ideological attitudes differ significantly between East and West Germany, we conceive region of residency to be a proxy for more than only political positions. These socio-cultural differences between the German regions could also have an impact on VacHes. Therefore, beyond political-ideological differences, we expect systematic differences in VacHes by region:

H3. *Individuals living in the north-western regions of Germany have a lower VacHes than those living in the southern and eastern regions.*

Since social media is more widespread among younger people, because for these cohorts social media platforms became important sources of information also on COVID-19, and populist parties in particular have made intensive use of the COVID-19 issue on social media to mobilize their electorate, we can formulate the following hypothesis:

H4. *The effect of political ideology on VacHes should be stronger in younger cohorts.*

We furthermore test to what extent the effect of political-ideological position is moderated by region of residency and two socio-demographic variables that have often been applied as explanations for VacHes: age and gender. The models additionally control for highest educational attainment.

As previous studies indicate that, in Germany, incidence and mortality rates as well as physical proximity to COVID-19 hot-spots have no impact on attitudes towards SARS-CoV-2 containment measures and trust in public bodies (Jäckle et al., 2022; Jäckle & Wagschal, 2022), we do not postulate pertinent hypotheses for these factors.

METHODS

The following analysis is based on empirical data from four iterations (S1–S4) of the *Politikpanel Deutschland* (<https://www.politikpanel.uni-freiburg.de/>), a German online survey series that were conducted between February and October 2021 among a total of more than 30,000 respondents (field time: S1 Feb. 2021; S2 Apr./May 2021; S3 Jul./Aug. 2021; S4 Sep./Oct.

2021). Participants for this self-selecting survey were recruited via a pool of respondents from former surveys. The survey iterations were additionally advertised via social media, but also via local and regional newspapers. As with all self-selecting online surveys, our sample is not representative of the general public. Yet, due to different recruitment channels, the distribution of participants in terms of socio-demographic characteristics is relatively close to the overall population (see Jäckle et al., 2022 for a detailed comparison between the sample and the overall German population with respect to gender, age, education and party affiliation). Dropout in all surveys was comparatively low (S1: 7.5%; S2: 22.4%; S3: 12.1%; S4: 4.2%). The surveys focused on various topics related to social and political phenomena, but in all four surveys information on VacHes and political attitudes was asked.

VacHes as the dependent variable of this analysis is operationalized as a combination of the two questions 'Have you been vaccinated against COVID-19' and 'Are you planning to get vaccinated against COVID-19'. The scale ranges from 1 'yes for sure/I have already received at least one dose' to 5 'no, definitely not'. High values thus represent a high VacHes. The main independent variables measure political ideology in terms of party affiliation—applying the standard question in German electoral surveys 'If there were a federal election next Sunday, which party would you vote for?'—and the general left–right self-rating (0: left; 1: right). The sociodemographic variables age, gender, highest educational attainment and place of residence (by state) have been asked in all waves. Additionally, information on further variables potentially relevant for VacHes such as income or immigrant status was asked not in all but in some of the survey waves.

RESULTS

Replication data and Stata-Do-Files for all subsequent analyses can be reviewed at Harvard Dataverse (Jäckle & Timmis, 2022).

Models M1–M4 (Appendix: Table A1) show the extent to which *political-ideological attitudes* affect VacHes—for each of our four surveys (S1–S4). Model M1 builds on the corresponding survey data from S1, M2 on S2 etc. With respect to H1, we found a significant effect regarding left–right position in the second and third surveys. As expected, the effect is positive overall, that is, the more rightwing an individual's political position is, the higher their VacHes tends to be—the exception is supporters of Linke (see below). M1–M4 control for *party affiliation* (see below) and, therefore, captures political ideological positions in a more concrete manner. Bearing this in mind, the effect found for the left–right-variable has to be regarded as solid. In models not controlling for party affiliation (see Table S1), left–right

position shows highly significant positive effects in all four models. In addition, the effect is comparatively strong. *Ceteris paribus*, in the July/August survey (S3), individuals with a robust rightwing political position have an estimated VacHes value that is 0.47 points higher (on a 1–5 scale) than their leftwing counterparts. This effect is noticeably larger than the effects of the other control variables, such as self-identified gender. In the third survey wave, women only had a 0.13 point higher VacHes score (estimated) than males.

Regarding *party affiliation*, we found the biggest effects are present for supporters of AfD and the recently established protest parties. Individuals with these party affiliations had a significantly higher VacHes score than supporters of the other (main) parties, namely 1.6–2.4 points higher for AfD supporters and 3.2–3.7 points higher for the supporters of the protest parties compared with the reference CDU/CSU. Supporters of the CDU/CSU, SPD and Greens are the least SARS-CoV-2 vaccine hesitant—a relationship that remains highly stable across all four surveys. There are no detectable differences between individuals identifying with the three major political parties. Supporters of the two remaining parties position themselves somewhere in between the two political poles, liberal FDP and socialist Linke. Compared to the reference category (CDU/CSU) and particularly in the first two surveys, supporters of FDP and Linke were more vaccine hesitant (0.8 for FDP and 0.5 for Linke in S1). Also, the evolution of VacHes positions across the surveyed time period is striking: while supporters of the CDU/CSU, SPD and Greens had relatively positive positions towards vaccination from the beginning of the immunization campaign (February 2021) and did not change their view through the end of the survey period in October 2021, the supporters of AfD, FDP, Linke showed a steady decline in VacHes. Only individuals supporting the protest parties remained extremely negative with respect to SARS-CoV-2 vaccination.

The models also indicate that *geographic differences* play an important role for VacHes. As hypothesized, survey participants from East German states tend to be substantially more vaccine hesitant than those from the majority of North/West German states. While participants from Saxony are particularly vaccine hesitant, significant positive effects can be observed in various other East German states, such as Thuringia and Saxony-Anhalt (at least in some models). However, also in the southern states of Bavaria and Baden-Wuerttemberg participants are significantly less positive towards vaccination. In large parts of North/West Germany, but also in Brandenburg or Berlin, we found no significantly different VacHes rates compared with the reference state of North Rhine-Westphalia.

To explore the potential association between VacHes scores (declared vaccination intentions) and de facto vaccination rates, we also explored, across

federal states, how well percentages of individuals considered vaccine hesitant in our first survey (February 2021) corresponded with percentages of individuals who, in December 2021, had not received the recommended basic course of SARS-CoV-2 vaccine (henceforth: unvaccinated), see Figure 4. Unsurprisingly, most East German states and Baden Wuerttemberg (South) had higher than expected percentages of unvaccinated individuals when compared with expected values based on the average percentage of those considered vaccine hesitant (average across states: blue line—this does not imply that 10% vaccine hesitant translates to 10% unvaccinated). However, there exist some striking outliers: on one hand, the East German state of Saxony-Anhalt, which had—across our entire sample—the by far largest percentage of individuals considered vaccine hesitant in February (~35%), had a lower than expected percentage of unvaccinated individuals in December (~34%). Saxony, on the other, which—compared with Saxony-Anhalt—had a lower percentage of individuals considered vaccine hesitant in February (30%), had—again across the entire sample—the highest rate of unvaccinated individuals by far in December (42%). The reverse is true for states, such as Bremen and Saarland, where the percentage of unvaccinated individuals is significantly lower than expected. By the same token, Thuringia and Brandenburg

had a significantly higher than expected percentage of unvaccinated individuals—Saxony-Anhalt is the only East German state that had a lower than expected percentage of unvaccinated individuals in December.

Additional interaction models show that the degree of VacHes is, in some cases, determined by a combination of party affiliation and region, see Figure 5. Individuals based in East Germany and identifying with the AfD (light blue) tend to be more vaccine hesitant than their likeminded peers in other parts of Germany. Similarly, individuals based in South Germany and identifying with protest parties (brown) tend to be more vaccine hesitant than their equivalents overall. For the FDP (yellow) and ‘Other’ group of parties (dark green), their supporters in East and South Germany tend to be more vaccine hesitant than their peers in North/West Germany. However, for supporters of the FDP these differences vanish entirely at the end of the observation period.

With respect to the further control variables, the models show that in the first two surveys, younger survey participants were significantly more SARS-CoV-2 vaccine hesitant than older participants (yet the effect is not very large). For example, for our second survey, M2 indicates that a difference of 50 years between two participants merely translates into a difference in the VacHes score of 0.15 points—less than half of the

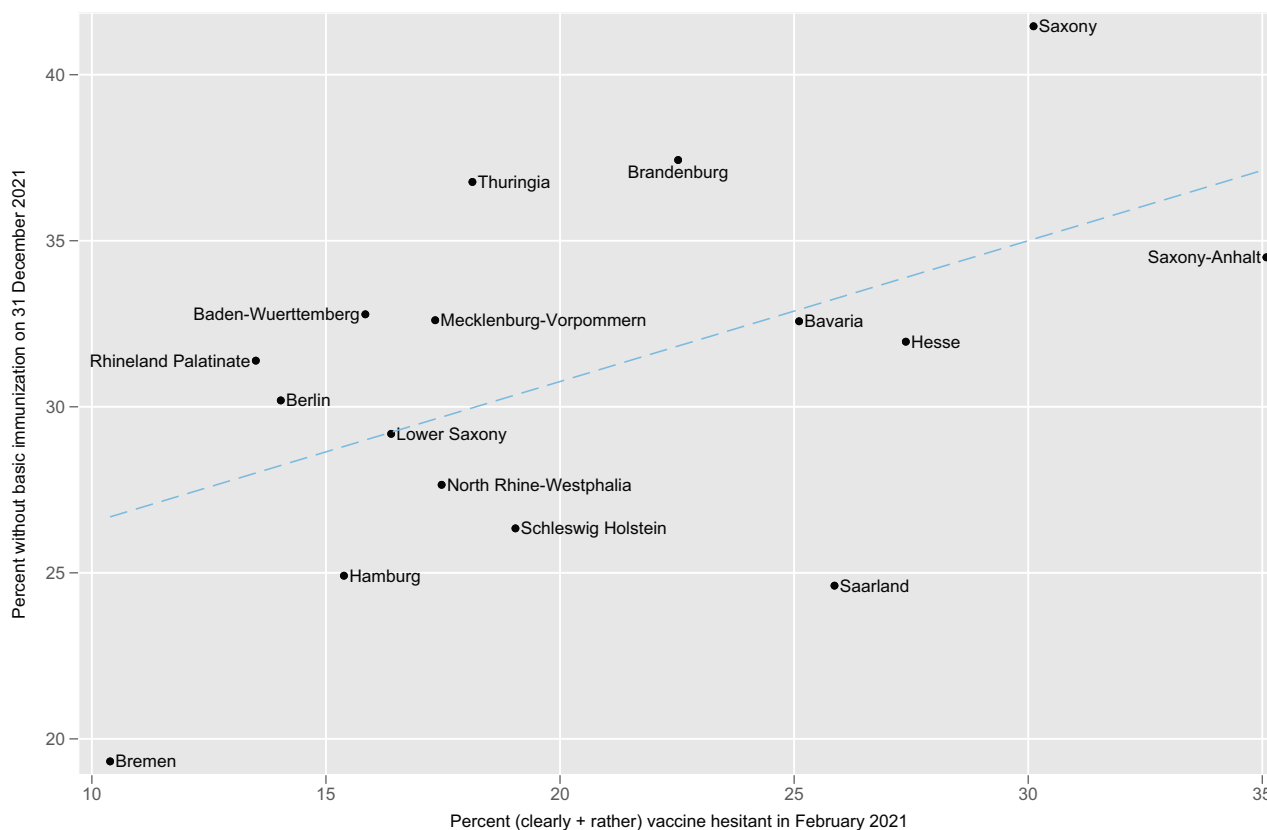


FIGURE 4 Percent of vaccine hesitant individuals (February 2021) plotted against percent of individuals without basic vaccination (December 2021) per federal state.

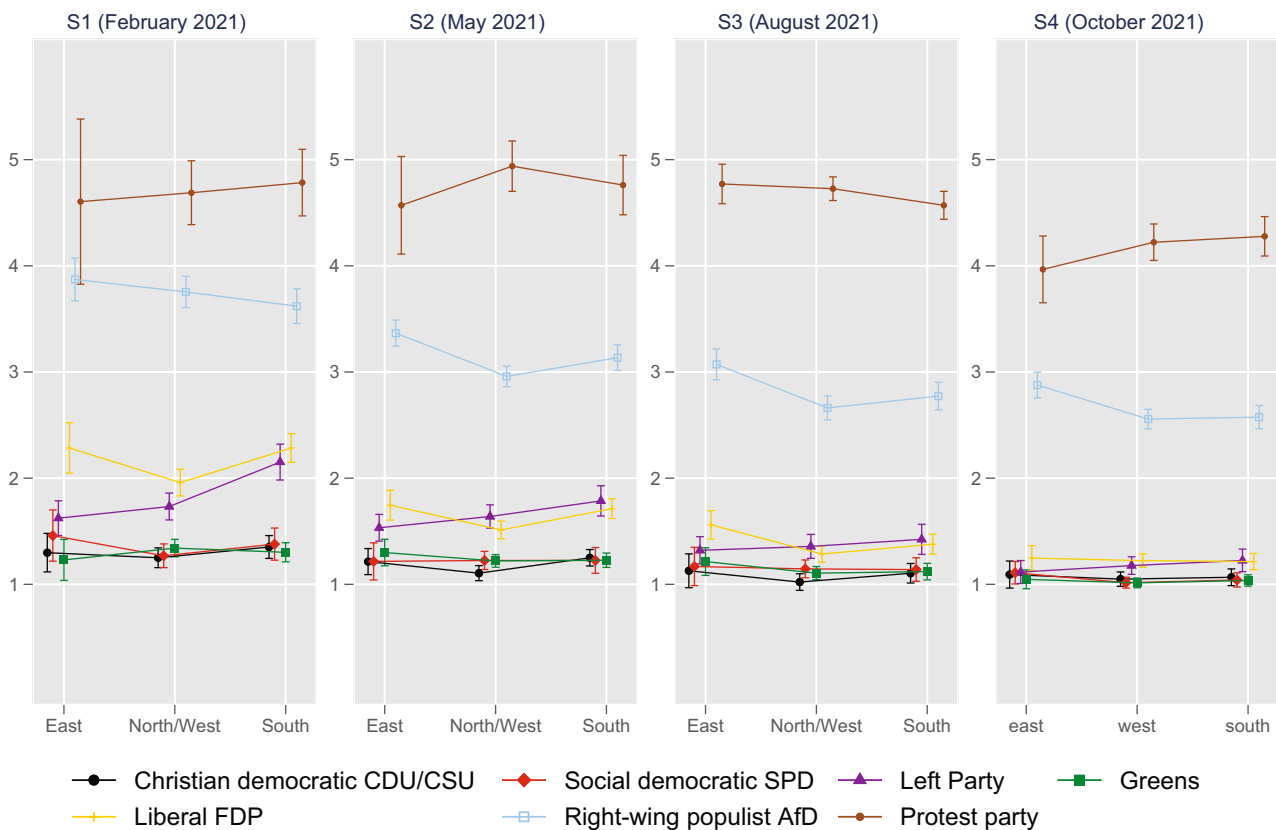


FIGURE 5 Estimated VacHes scores by *party affiliation* and *German region* (+95% CI). Annotation: East = Berlin, Brandenburg, Mecklenburg-Vorpommern, Saxony, Saxony-Anhalt, Thuringia; North/West: Bremen, Hamburg, Hesse, Lower Saxony, North Rhine-Westphalia, Rhineland Palatinate, Saarland, Schleswig Holstein; South: Baden-Wuerttemberg, Bavaria. Graphs based on interaction models presented in [Table S9](#).

effect that left–right position has on VacHes (0.39). Additional analysis indicated that the age effect is not linear, as assumed in M1–M4 (see [Table S2](#)), but rather a U-shaped correlation exists between age and VacHes. Using age groups we found, in the first two surveys, that especially elderly participants (>64 years) were significantly less hesitant than younger age groups. Particularly in the latter surveys (M3 & M4), our data indicate that individuals in their 30s, 40s and 50s are more vaccine hesitant than the youngest participant group (<25 years). While the youngest and oldest age groups tended to have lower VacHes values, interestingly, in the middle age groups hesitancy increased over the observation period. VacHes is also related to the educational background (see [Table A1](#)). Particularly those participants with a university degree are less vaccine hesitant. Interestingly, these educational differences were not present in the first survey in February and only emerged later on.

In addition, a range of further control variables, for which data were not always available for all surveys, was investigated (see [Tables S3–S6](#)). Participants who consider it difficult to cope with their income tend to be significantly more hesitant (M1, M3, and M4), while in the second survey individuals with an immigrant

background were substantially more hesitant—these differences decreased in M3 and were not significant in M4. Furthermore, we found that, at least in the first survey(s), individuals with better perceived general health status tend to be more hesitant and that individuals who follow the other government measures/advice to prevent virus transmission (wearing masks and using the COVID-19 tracing app) are less hesitant regarding SARS-CoV-2 immunization.

In order to test whether the ideological effects found in M1–M4 exist in all groups in the same way, or whether ideological positions influence VacHes differently in certain groups of people (see H4), we estimated models including interactions between (i) *left_right* and *agegroup* as well as between (ii) *party-affiliation*, *agegroup* and *gender*.

[Figure 6](#) shows the marginal effect of left–right-position depending on the age group. It is evident that the effect of the ideological position is not age independent. For younger participants the positive effect is stronger and significant in most survey waves, that is, the more rightwing a young individual is, the more they are hesitant towards the COVID-19 vaccination. By the same token, for older individuals, especially the oldest category (>64 years), the left–right position either has

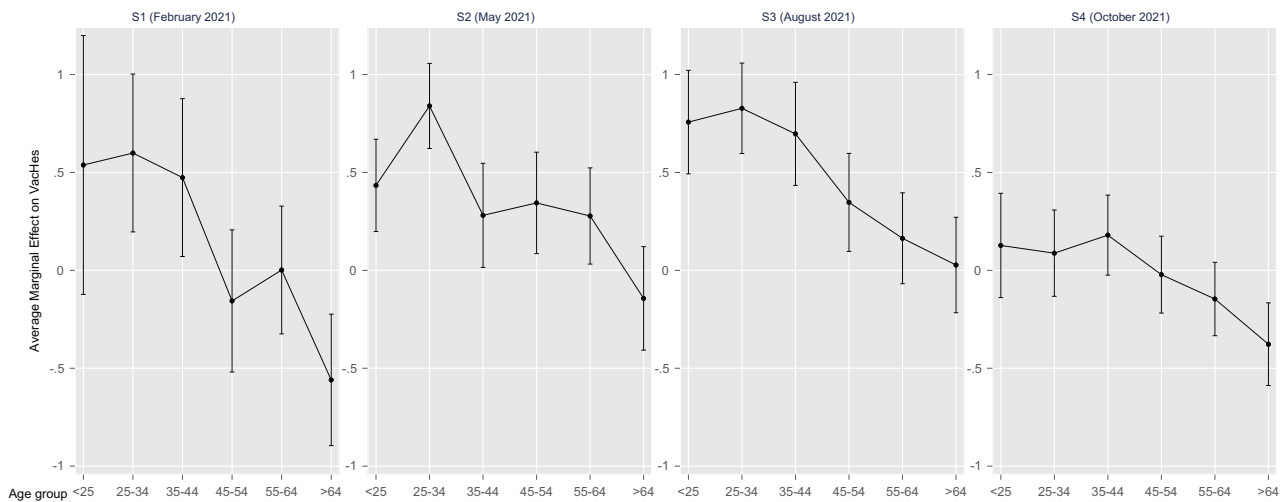


FIGURE 6 Average marginal effects (AME) for *left–right position* on VacHes by *agegroup* +95% CI. Graphs based on interaction models presented in Table S7. The AME gives the effect of left–right position (switching from very left-wing to very right-wing) on the VacHes score for different age groups. Reading example: While the model for S1 estimates no significant effect of left–right-position for the youngest age group (the confidence interval includes zero), being more right wing significantly increases VacHes for the age groups 25–34 and 35–44 while it significantly decreases VacHes for the oldest age group (>64 years).

no significant effect or, as in waves 1 and 4, the effect is even negative. This indicates for these group of individuals that those leaning towards leftwing affiliations are more hesitant.

Figure 7 shows the predicted values of VacHes from regression models including the three-way interaction (age group × party affiliation × gender). Three findings are worth mentioning: (1) the AfD and the protest parties clearly stand out compared with all other parties, (2) women with party affiliation AfD and FDP are more vaccine hesitant than men with the identical party affiliation, and (3) the overall variance reduces over time. We see that, initially, especially supporters of FDP and Linke are relatively hesitant. In the last survey, however, there exist no significant detectable differences vis-à-vis CDU/CSU, SPD and Greens. Even for supporters of the AfD, the degree of VacHes decreases. This might be due to the fact that for some people vaccination was quasi obligatory (due to vocational requirements), even if they were against vaccination at the beginning and, as described above, the VacHes score treats those who had been vaccinated the same way as those who indicate to definitely get vaccinated.

DISCUSSION

This study explored the effect of various sociopolitical/ideological and geographical factors on the degree of VacHes among a German national cohort across four surveys (S1–S4) conducted between February and October 2021. In Germany, an individual's party affiliation is, by an inordinate margin, the strongest indicator for the degree of their VacHes—stronger than gender or educational background. Interestingly, this effect steadily

decreased for supporters of all major parties over the course of the vaccination campaign. Similarly, regional differences have a marked effect on VacHes: many East German states are more vaccine hesitant while North/West German states tend to be less vaccine hesitant. It is striking that, although the degree of VacHes, in most cases, fluctuated marginally over time or returned to the levels at baseline (S1), the discrepancy of vaccination rates between East German (least vaccinated) and other German states increased steadily through S4. Regarding the effect of left–right position on VacHes, we found that in the middle of the immunization campaign (S2, S3), the further rightwing an individual identified themselves, the more vaccine hesitant they tended to be. However, this effect had vanished in S4. Furthermore, interaction models show that age has an influence on the effect of left–right position on VacHes with more leftwing oriented older persons being more VacHes, while for younger persons a more rightwing political orientation correlates with a higher VacHes. Other factors, such as gender, perceived income adequacy, migration background and perceived health status did not have explanatory value regarding the degree of VacHes across all surveys.

Party affiliation and ideological left–right position

As alluded to in the introduction, Stoeckel et al. (2022) come to the conclusion that—across a European cohort—VacHes is likely not driven by populist parties. However, for Germany this is not the case. Our data show that supporters of right-wing populist AfD and protest parties are more vaccine hesitant than supporters of other parties by an inordinate margin, which is

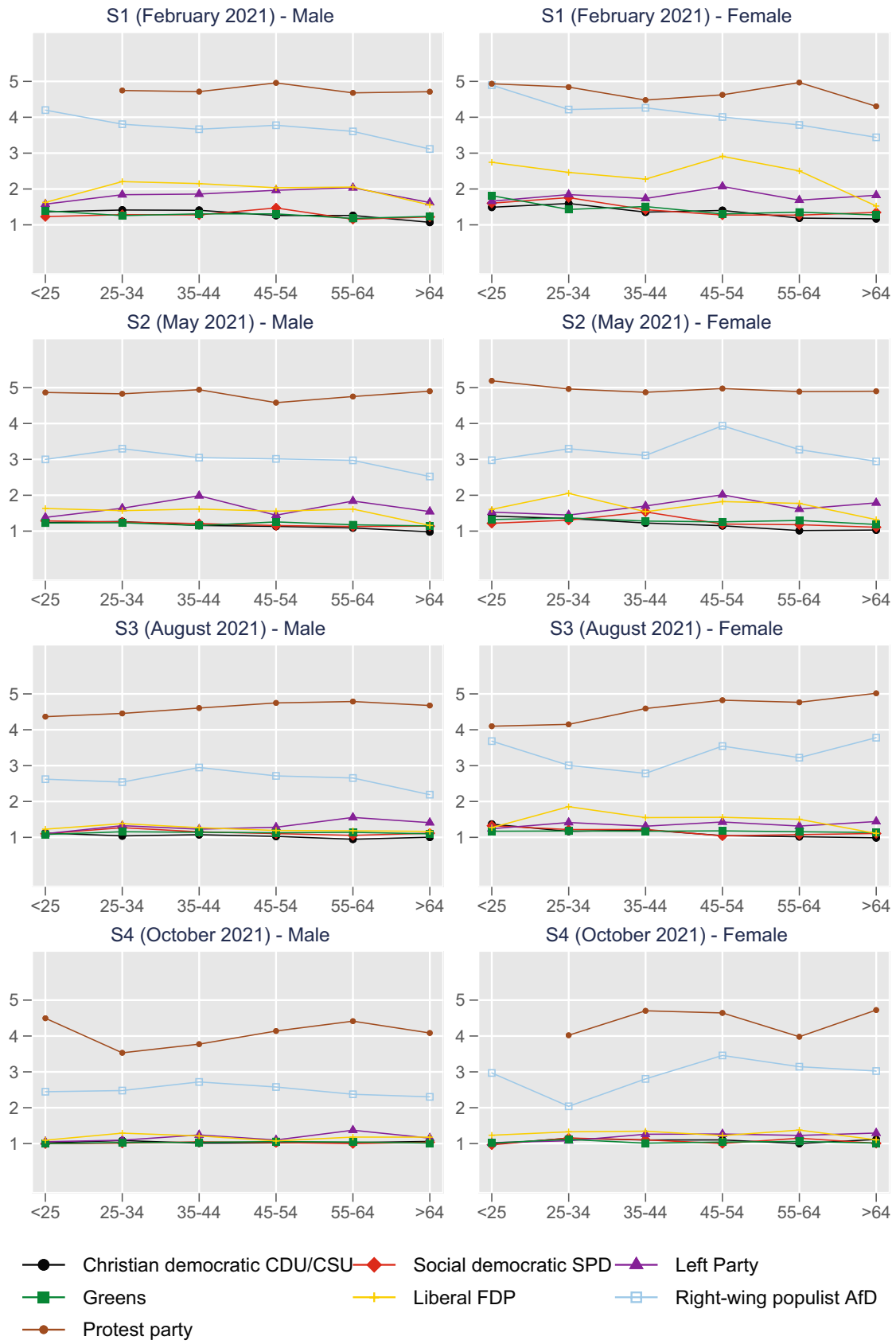


FIGURE 7 Estimated VacHes scores by party affiliation, agegroup and gender. Graphs based on interaction models presented in Table S8.

closely aligned with other authors' findings, namely that partisanship in the US, but also in Europe, is, although not always overtly, a solid indicator for VacHes (Jones & McDermott, 2022; Kirzinger et al., 2021; Sorell & Butler, 2022).

Regarding the effects of ideological left–right position: Stoeckel et al. found that this had no significant impact on VacHes. Our results instead show that, when tested as the only political-ideological factor, the left–right position is significant in all models, with a more rightwing political orientation being associated with a higher degree of VacHes. Even when we control for party affiliation as a more concrete realization of political ideology, the left–right position remains significant in the April/May and July/August surveys. Our findings thus support earlier studies that showed the close association of anti-vaccine sentiment with rightwing and extremist ideologies (including radical left views) (Sorell & Butler, 2022). According to McCarthy et al. (2022), this is because pertinent individuals are frequently faced with *inter alia* perceived or *de facto* anomie: the disconnect between personal (values) and social norms, leading to disorientation and distrust in governmental entities. This leads to such individuals becoming increasingly receptive for conspiracy theories, which, in turn, re-enforce anomie. We did not collect data on inclination towards conspiracy theories in our surveys; however, McCarthy et al. found that individuals with a higher degree of VacHes in Australia tended to, among other factors, feel confronted more strongly with anomie and, importantly, have a more rightwing political ideology (McCarthy et al., 2022). Therefore, political ideology might be a more important determinant of VacHes, even if viewed as a proxy measure, than we were able to demonstrate in this study.

Regional differences

Although party affiliation and political ideology are important determinants that also explain federal state level differences in VacHes and vaccine uptake, wider regional differences, that is, based on the above mentioned federal state cluster (East, South or West Germany), might be determined by externalities: as alluded to above, according to data collated by the European Centre for Disease Prevention and Control (ECDC) and the Federal Office of Public Health (Switzerland) as of September 2022, Eastern EU member states (and Switzerland) tended to have a lower vaccine uptake (full course) than their Southern, Western or Northern counterparts (ECDC, 2022; Federal Office of Public Health (Switzerland), 2022). Together with our finding that parts of Germany cluster into VacHes regions, this suggests that 'VacHes clusters' might exist across national borders.

Strengths and limitations

In contrast to many studies on VacHes that focus primarily on psychological concepts and socio-demographic factors, this study shows that both political ideology and party affiliation are very relevant indicators of VacHes. The study is based on four large surveys with a total of more than 30,000 participants, including all political ideological orientations from all over Germany, which enables us to additionally test whether regional differences play a role. Albeit the study uses data from surveys conducted between February and October 2021, the models are cross-sectional analyses. Changes over time can thus only be traced in the aggregate. In order to investigate which factors lead individuals to change their opinion on vaccination over the course of the pandemic, a longitudinal panel would be necessary. In addition, relating changes in the aggregate VacHes scores to certain events (e.g. vaccination campaigns, or the non-pharmaceutical measures taken by the German states) would also be a very interesting research topic for future studies. In any case, in order to further expand the evidence base, future studies should test further potential determinants for VacHes and check whether the political-ideological attitudinal patterns that proved in this study to be a central explanatory factor for VacHes in Germany also apply to other countries.

Implications for practice and policy

A very important point for VacHes might also be the question to what extent politics is fueling exaggerated expectations with regard to vaccination. At the start of the vaccination campaign, German politicians often argued that the vaccination would reduce the probability of getting infected. Yet, at the latest since the SARS-CoV-2 Omicron variant emerged (at first in South Africa in November 21), it has become clear that while currently available SARS-CoV-2 vaccines are good at preventing serious morbidity of fully immunized individuals, they do not perform well in preventing transmission of Omicron between infected and not currently infected individuals. In addition, COVID-19 infections based on the Omicron variant are widely reported to have a comparatively mild diseases course. Together, these characteristics have also served, for certain parts of populations, as perceived evidence that current vaccines are ineffective and, in turn, fortified beliefs among individuals and groups thereof that immunization is not necessary, not worth the risk, or even generally harmful. If certain statements made by policy makers regarding vaccination ultimately turn out to be exaggerated or even false, then the entire vaccination campaign may suffer credibility damage. With the observation period of our study ending in October

21, we were not able to test this assumption empirically. However, future studies should, in any case, investigate the relationship between politically induced excessive expectancies and VacHes.

Regarding the measurement of vaccine hesitancy, based on contemporary evidence—namely that individual political and ideological attitude (and region of residency) are important drivers of VacHes—it is conceivable that the *Politics/policies* item of the *Vaccine Hesitancy Determinants Matrix* (VHDMx) might, ideally, be re-conceptualized as a variable measuring political ideology, party affiliation and pertinent preferences of individuals. It might even make good sense to separate *Politics/policies* into two items, with *politics* covering political procedures but also the de facto individual political factors we investigated, while the *policies* item would focus on the impact of concrete political action. It is even conceivable that *Influential leaders* and *anti- or pro-vaccination lobbies* (concepts in item *b* in section *Contextual influences* of the VHDMx) might become (political) items in their own right. Naturally, to be relevant, acceptable, accountable and sustainable, augmentation of the items of the VHDMx, and other VacHes measurement instruments for that matter, will require sound reasoning and justification, proper stakeholder consultation and alignment on the specific concepts to be measured, and judicial item validation (Timmis, Black, & Rappuoli, 2017; Timmis, Rigat, & Rappuoli, 2017). Furthermore, our VacHes score might be well suited for broader interpretation, regarding for instance trust in policy makers, government and public health institutions, health system experts, and other entities. Thus, VacHes may serve as a more general indicator important for the overall health system. Therefore, it could make sense to include VacHes in general health surveys, since it is one of the most controversial issues today that clusters society into distinct groups.

Based on our data, we are not able to provide concrete suggestions on how future immunization campaigns or pertinent political messaging should be designed specifically to resonate with certain vaccine hesitant individuals and groups thereof. This is chiefly due to this group being highly diverse regarding inter alia worldviews, and, in turn, underlying values, motives and reasoning for being vaccine hesitant. However, our study reveals which subsets of the (German) population are more (or less) likely to follow official advice and have the SARS-CoV-2 vaccine, and, therefore, might be approached differentially. For instance, Hornsey and Fielding (2017) provide an insightful analysis on how individuals and groups thereof, who—based on their *attitude roots* (the authors mention a range of attitude roots including values and beliefs)—reject contemporary scientific evidence on specific issues or issue clusters (Hornsey & Fielding, 2017). Hornsey and Fielding suggest that public/official narratives can be more effective if these link desired behaviours to beneficial outcomes

that relate to subjective attitude roots of certain cohorts rather than simply provide broader arguments based on pre-dominantly scientific terms. Naturally, the challenges are to (i) elicit underlying values and norms, (ii) ensure that narratives remain evidence-based and (iii) establish and, importantly, preserve trust in public health authorities by the majority of the population.

Finally, we believe that the implications of our work are transferrable—in principle—to other important, yet traditionally apolitical topics that are relevant to microbial biotechnology applications, such as technologies addressing climate change, microbiome-based (or targeting) therapeutics, utilization of genetically modified organisms and crops, and so on.

AUTHOR CONTRIBUTIONS

Sebastian Jäckle: Conceptualization (supporting); data curation (lead); formal analysis (lead); investigation (equal); methodology (lead); project administration (equal); visualization (lead); writing – original draft (equal); writing – review and editing (equal). **James K. Timmis:** Conceptualization (lead); data curation (supporting); investigation (equal); project administration (equal); writing – original draft (equal); writing – review and editing (equal).

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CONFLICT OF INTEREST

None to declare.

DATA AVAILABILITY STATEMENT

Replication data and Stata-Do-Files available at Harvard Dataverse. DOI: <https://doi.org/10.7910/DVN/JKI7IR>.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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APPENDIX

TABLE A1 Main models explaining vaccine hesitancy (VacHes) for four survey iterations.

	M1	M2	M3	M4
	Feb 2021	Apr/May 2021	Jul/Aug 2021	Sep/Oct 2021
H1: Left–right position (left = 0; right = 1)	0.0516 (0.49)	0.392*** (5.69)	0.478*** (7.44)	−0.0298 (−0.51)
H2a & H2b: Party affiliation (reference: CDU/CSU)				
SPD	0.0365 (0.62)	0.0530 (1.21)	0.0867 (1.95)	−0.0192 (−0.58)
Left Party	0.522*** (8.02)	0.459*** (9.15)	0.279*** (5.40)	0.111* (2.55)
Greens	0.0163 (0.33)	0.0558 (1.54)	0.0716 (1.81)	−0.0319 (−0.96)
FDP	0.825*** (15.21)	0.439*** (11.66)	0.289*** (7.34)	0.159*** (4.91)
AfD	2.435*** (41.58)	1.935*** (47.18)	1.717*** (36.59)	1.565*** (41.06)
Protest party	3.423*** (30.33)	3.665*** (40.88)	3.636*** (73.51)	3.161*** (48.60)
Others	1.393*** (19.88)	0.589*** (12.25)	0.458*** (11.14)	0.352*** (8.69)
Will not vote	2.100*** (25.02)	^a	0.969*** (11.86)	1.142*** (8.55)
Not eligible to vote	1.143*** (4.67)	^a	0.265* (2.48)	−0.112 (−0.32)
H3: State + region: East; North/West; South (reference: North Rhine-Westphalia (North/West))				
Baden-Wuerttemberg (South)	0.112* (2.48)	0.162*** (4.72)	0.0332 (1.00)	0.0316 (1.19)
Bavaria (South)	0.158** (2.99)	0.148*** (4.12)	0.121*** (3.37)	0.0430 (1.51)
Berlin (East)	−0.0690 (−0.87)	0.0533 (0.91)	0.0601 (1.10)	0.0240 (0.54)
Brandenburg (East)	0.162 (1.47)	0.150 (1.95)	0.0849 (1.18)	0.0294 (0.48)
Bremen (North/West)	−0.0301 (−0.49)	0.0558 (0.98)	−0.0536 (−1.00)	−0.0349 (−0.79)
Hamburg (North/West)	−0.335* (−2.39)	−0.0857 (−0.98)	−0.122 (−1.40)	−0.0982 (−1.57)
Hesse (North/West)	0.142 (1.85)	−0.0435 (−0.84)	0.0384 (0.76)	0.0137 (0.36)
Mecklenburg-Vorpommern (East)	0.0429 (0.34)	0.0328 (0.39)	0.195* (2.31)	−0.0979 (−1.33)
Lower Saxony (North/West)	0.0766 (1.33)	0.108** (2.61)	0.0676 (1.67)	0.0364 (1.09)
Rhineland Palatinate (North/West)	−0.105 (−1.35)	0.133* (2.38)	0.0734 (1.32)	0.0105 (0.23)
Saarland (North/West)	0.203 (1.38)	0.179 (1.62)	0.0746 (0.77)	−0.0659 (−0.77)
Saxony (East)	0.232** (2.63)	0.335*** (5.83)	0.392*** (6.66)	0.226*** (4.90)
Saxony-Anhalt (East)	0.178 (1.21)	0.212* (2.39)	0.182 (1.93)	0.212** (2.81)
Schleswig Holstein (North/West)	0.0716 (0.78)	0.177** (2.79)	0.0394 (0.67)	−0.0228 (−0.46)
Thuringia (East)	−0.0602 (−0.67)	0.165** (2.68)	0.174** (2.77)	0.0406 (0.74)

TABLE A1 (Continued).

	M1	M2	M3	M4
	Feb 2021	Apr/May 2021	Jul/Aug 2021	Sep/Oct 2021
Gender (reference: male)				
Female	0.172*** (5.70)	0.119*** (5.24)	0.132*** (6.12)	0.101*** (5.71)
Non-binary	0.550 (1.95)	0.00573 (0.03)	-0.00352 (-0.02)	0.0419 (0.32)
Age	-0.00507*** (-5.23)	-0.00294*** (-4.43)	-0.000492 (-0.75)	0.000116 (0.21)
Highest educational attainment (reference: School dropout/secondary school graduation (ISCED 2))				
Secondary school leaving certificate (ISCED 2)	0.140 (1.88)	-0.0524 (-0.82)	-0.144* (-2.08)	-0.111 (-1.71)
Advanced technical college certificate (ISCED 3)	0.136 (1.71)	0.0452 (0.41)	-0.145 (-1.15)	-0.148 (-1.26)
General university entrance certificate (ISCED 3)	-0.0341 (-0.44)	-0.0935 (-1.41)	-0.156* (-2.17)	-0.132* (-1.99)
University degree (ISCED 5a)	-0.0951 (-1.36)	-0.172** (-2.70)	-0.226** (-3.29)	-0.190** (-2.98)
Constant	1.404*** (12.23)	1.089*** (12.99)	0.951*** (10.68)	1.162*** (14.28)
Observations	5373	8411	8789	8925

Note: Presented are *b*-coefficients from OLS-regression, *t* statistics in parentheses; **p*<0.05, ***p*<0.01, ****p*<0.001; the dependent variable is vaccine hesitancy, VacHes, measured on a ratio scale from 1 to 5.

^aThe April/May survey did not ask for "will not vote" and "not eligible to vote".