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Research Article

# The role of the information environment during the first COVID-19 wave in Germany

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**ABSTRACT**

The COVID-19 pandemic has been accompanied by intense debates about the role of the information environment. On the one hand, citizens learn from public information campaigns and news coverage and supposedly adjust their behaviours accordingly; on the other, there are fears of widespread misinformation and its detrimental effects. Analyzing the posts of the most important German information providers published via Facebook, this paper first identifies a uniform salience of subtopics related to COVID-19 across different types of information sources that generally emphasized the threats to public health. Next, using a large survey conducted with German residents during the first COVID-19 wave in March 2020 we investigate how information exposure relates to perceptions, attitudes and behaviours concerning the pandemic. Regression analyses show that getting COVID-19-related information from a multitude of sources has a statistically significant and positive relationship with public health outcomes. These findings are consistent even across the ideological left/right spectrum and party preferences. These consistent correlational results demonstrate that during the first wave of COVID-19, a uniform information environment went hand in hand with a cautious public and widely accepted mitigation measures. Nonetheless, we discuss these findings against the backdrop of an increased politicization of public-health measures during later COVID-19 waves.

## Introduction

Lacking a vaccine and treatments against COVID-19, non-pharmaceutical interventions such as national lockdowns or encouragement of social distancing were the only available instruments for governments to contain the pandemic during its first wave in Spring 2020 (Flaxman et al. 2020). Still, substantial shares of citizens in developed democracies did not fully embrace the severity of the pandemic. Accordingly, already in the very early stages of the COVID-19 crisis, leading policy makers like the World Health Organization (WHO) and public actors used the term 'infodemic', suspecting people's information exposure as a

root cause for this negligence. Social media platforms such as Facebook were identified as the prime suspects, as they allow content from non-experts and unreliable sources to proliferate almost unchecked, independent of its trustworthiness or quality. However, it is still largely unclear how important social media were as pathways to COVID-19 related information in general. Moreover, during the early stages of the pandemic, elite discourses were consistently emphasizing the threats of the pandemic and the necessity of countermeasures by health and state authorities. In the absence of counterframes – at least in mainstream discourses – the early stage of the COVID-19 outbreak constituted a rare scenario when consistent messaging by elites in the political information environment might have had uniform effects on public opinion (Chong and Druckman 2007; Zaller 1992). Against the backdrop of these competing expectations, we investigate the role of information exposure during the first COVID-19 wave in March 2020 in Germany.

The study relies on two data sources. The first one is data from the GESIS Panel special survey on COVID-19 (GESIS Panel Team 2020). This large panel with more than 3,000 respondents represents the heterogeneity of the adult population in Germany. In addition to its sample size, this data source has the advantage of containing media exposure measures and a detailed breakdown of different outcomes related to COVID-19. As information exposure might have heterogeneous relations with different dimensions, we analyzed four different dependent variables: risk perceptions, perceptions of government measures, the attitudinal dimension of trust in relevant policy actors and the behavioural dimension of personal protection measures. The second data source is Facebook, the most widely used social media platform in Germany (Beisch and Schäfer 2020). To identify a potential heterogeneity in the overall information environment related to COVID-19, we use topic models to classify almost a million public Facebook posts by a heterogeneous set of actors that could be assigned to the information sources asked in the survey.

The quantitative text analysis of the most widely seen political messages on Facebook reveals that a homogeneous set of topics was salient in COVID-19-related information from different types of information providers. In contrast, there was almost no evidence for misinformation or doubts about the severity of the pandemic. Against the backdrop of this almost uniform coverage across information sources, our multiple regression models reveal a consistent statistically significant positive association between the number of information sources used and perceptions, attitudes and behaviours at the individual level that help mitigate the COVID-19 pandemic. Heterogeneity tests reveal that this positive relationship holds across variables that usually filter how citizens interpret media messages, political ideology and party preference. While the findings are of a correlational nature, the main results persist in additional model specifications, including tests for reversed causality. Nonetheless, we discuss these consistent findings regarding the role of the information environment during the first wave of COVID-19 against the backdrop of the increasing politicization of countermeasures and a more heterogeneous information environment in later COVID-19 waves.

## COVID-19 and information exposure

During the early stages of the COVID-19 pandemic in Spring 2020, robust scientific evidence on the severity of the pandemic and the effectiveness of measures taken against it by governments was still lacking. Questionable information and speculative takes

could not just be found on social media, but to a lesser extent also in more established sources of information. In early February already, the WHO was actively engaging with social media platforms to tackle what it called an 'infodemic' related to COVID-19.[1] Yet despite the widespread perception that COVID-19 information on social media lacked quality, it was still unclear how much citizens were exposed to COVID-19 information via social media vis-a-vis more established information sources such as news broadcasts and newspapers. In this paper, we pose four research questions that aim to shed light on the role of information exposure in the early stages of the pandemic in Germany and contribute to the body of research on COVID-19 in the social sciences.

An emerging body of research on the *supply side* of information on COVID-19 either concentrates on coverage by established news organizations or user-generated content on social media. While research from the U.S. has shown that news coverage on the COVID-19 pandemic was highly politicized and polarized (Hart, Chinn, and Soroka 2020), evidence from Germany found no evidence of major systemic failings in the Facebook messages of established news providers from January to March 2020 (Quandt et al. 2020). On the other hand, a similar content analysis of so-called 'alternative news media' revealed that COVID-19 was fed into the anti-systemic ideological frames that these pages typically promote (Boberg et al. 2020). Despite considerable public attention devoted to online misinformation, it is still not systematically clear what the topical focus of information providers was during the first wave of COVID-19, especially for the German case. On the one hand, there are well-known differences between information providers, say public broadcasters vs. the tabloid press, in their likelihood to promote different aspects of political topics (Aalberg, Van Aelst, and Curran 2010). On the other, especially in the context of an emerging topic such as COVID-19, there is also a tendency among journalists to rely on authoritative sources such as the WHO or national governments, which might result in a more homogeneous coverage than in the context of an established policy debate.

Because the main analysis of the paper focuses on information exposure on the individual level, it is important to understand the nature of coverage on COVID-19 in the overall information environment. For instance, it should make a difference whether the public health dimension and the human toll of COVID-19 are salient in the news or restrictions of individual liberties. After all, which (sub)topic dimensions of an emerging issue the media focuses on affects attitudes and perceptions (Druckman et al. 2010). We therefore ask:

*RQ1* Did topic salience in coverage on COVID-19 diverge between information sources?

In parallel, researchers also investigated the *demand side* of COVID-19, i.e. citizens' information exposure. The primary focus was to find out what types of COVID-19 information citizens received. In cross-national surveys from March/April 2020, 65–70% of respondents reported getting COVID-19 information daily, mostly from major news organizations. At the same time, 60–70% of respondents worried about fake news about the pandemic or reported having seen at least some misinformation regarding COVID-19 on social media (Edelman 2020; Newman et al. 2020).

Some studies also focused on the relationship between information exposure and COVID-19 outcomes. Two quasi-experimental studies from the U.S. showed that exposure to the ambiguous coverage of Fox News during Spring 2020 reduced compliance with

countermeasures (Ash et al. 2020; Simonov et al. 2020). A country-comparative study including Germany found that perceptions of higher misinformation prevalence were related to more information seeking and more compliance with public health guidelines. In contrast, people who felt that they encountered intentionally wrong information were less likely to comply with mandated measures and were more likely to actively avoid COVID-19 information (Hameleers, van der Meer, and Brosius 2020). This was confirmed by Siebenhaar, Köther, and Alpers (2020) who found that German respondents who were distressed by information consequently avoided information on the pandemic and complied less with public health measures, and similarly, by Imhoff and Lamberty (2020) who revealed a lower compliance among people holding conspiracy beliefs about the virus.

While these findings suggest that, in principle, some information can be harmful in the fight against the pandemic, several studies also identified information exposure as a positive correlate of public-health compliant behaviours and attitudes. In a comparative study, citizens in six countries emphasized the gains in knowledge they acquired from news media coverage on the pandemic (Nielsen et al. 2020). Regression analyses confirmed that getting information from news organizations was associated with higher levels of factual knowledge about the virus. Importantly, relying on social media as an information source was not negatively associated with knowledge about COVID-19 (Nielsen et al. 2020). Rothmund et al. (2022) also showed that being exposed to public broadcasting news was the most important predictor of having knowledge about and evaluations of COVID-19 in line with scientific expert judgements.

More generally, beyond the context of the pandemic, there is no solid theoretical or empirical basis for expecting uniform negative effects of online media. Several analyses have shown that established media organizations still dominate the market for online news, whereas hyperpartisan or so-called 'fake' news providers only play marginal roles (Allen et al. 2020; Guess 2021; Guess, Nagler, and Tucker 2019; Stier et al. 2022). Oftentimes, users even stumble upon news they do not actively seek out on Facebook or other social media platforms (Scharkow et al. 2020).

To investigate the relationship between exposure to various sources of information and COVID-19-related attitudes, perceptions and behaviours, this paper jointly takes into account the demand and supply side of information. We couple high-quality survey data from around 3,000 respondents that included questions about information exposure and COVID-19 outcomes with an analysis of public Facebook posts during the first wave of COVID-19 in March 2020 in Germany. Most closely related to our research is the paper by Siebenhaar, Köther, and Alpers (2020) who studied the relationship between information avoidance and compliance with preventive measures. While providing important insights into information behaviour and its individual-level correlates, their study differs from ours in four main regards: (1) the convenience sample recruited from social media platforms and the university website was skewed in several regards (e.g. almost 80% female respondents); (2) only one outcome variable was analyzed: compliance with preventive measures; (3) information exposure was not used as a predictor, but only as an indirect measure of information avoidance; (4) there was no analysis of the actual content of coverage on COVID-19.

When it comes to outcomes related to COVID-19, most related research has not systematically distinguished various relevant dimensions. For instance, information exposure might be positively associated with public health attitudes without necessarily having any

relation with adhering to government measures. To arrive at a more nuanced understanding of the role of information exposure during the first wave of COVID-19, this paper distinguishes four different outcomes. The first two outcomes can be regarded as perceptions, more precisely (1) the perceived probability of risks to oneself and others and (2) the perceived effectiveness of government measures. We also take into account (3) relevant attitudes by capturing trust in persons and institutions that are responsible for dealing with the COVID-19 pandemic. Finally, given that non-pharmaceutical interventions were the only available means that could be taken in Spring 2020 (Flaxman et al. 2020), it is especially important to also investigate (4) (self-reported) compliance with public health measures and associated changes in behaviours. Integrating these different dimensions, we ask:

*RQ2* How was information exposure associated with perceptions, attitudes and behaviours related to COVID-19?

As in other policy fields, one important filter of how citizens interpret information on COVID-19 should be their political orientation and signals by party elites (Campbell et al. 1960; Zaller 1992). In fact, positions towards the role of the state in society (including public health) and trust in state authorities vary considerably along the ideological left-right spectrum as well as between party families. A voter with an orientation towards a liberal party that is usually advocating for individual liberties might come to different conclusions after getting exposed to information on COVID-19 compared with a Social Democratic party voter who might accept more wide-ranging government measures. Another confounding factor is whether a voters' preferred party forms part of the government (in March 2020 the CDU/CSU-SPD coalition led by Angela Merkel) or not.

In addition to long-established variations in policy platforms and ideological foundations of parties, conflict lines on COVID-19 policies and citizens' attitudes towards governmental counter measures might not primarily be structured along the left-right ideological divide but rather related to the unique role of the populist radical right in contemporary democratic party systems (Falkenbach and Greer 2021; Wondreys and Mudde 2020). In addition to the anti-elitist rhetoric of these parties, their supporters also start with lower levels of trust in experts, political authorities and the government to begin with (Van Hauwaert and Van Kessel 2018). Yet while right-wing politicians such as Donald Trump and Jair Bolsonaro have become the most well-known deniers of the lethality of COVID-19 over the course of the year 2020, at the beginning of the pandemic the signals of populist radical right parties were more ambiguous. That included the Alternative for Germany (AfD) whose leading politicians actually criticized the German government for not taking stricter measures against the pandemic.[2] Amid a lack of publicly visible counterframes and no noteworthy politicization of public-health measures, the early stage of the pandemic in Germany represented a rare instance (Chong and Druckman 2007) when the role of information exposure was potentially homogeneous across citizens, independent of their political orientation or party preferences.

Against the backdrop of the well-known heterogeneity in the interpretation of media messages by citizens depending on their political leanings, it is intriguing to investigate whether these established findings differ in a political environment when citizens were encountering mostly uniform messages from political elites.

*RQ3a*  Did the role of information exposure differ depending on the political ideology of
        citizens?
*RQ3b*  Did the role of information exposure differ depending on the party preferences of
        citizens?

## Research design

Our research relies on high-quality survey data from a large survey and Facebook data col-
lected during the first wave of COVID-19 in March 2020 in Germany.

### Survey data

*Sample.* For the survey-based analyses, we utilize data from the GESIS Panel, a probability-
based mixed-mode access panel that comprises about 5,000 active panellists. Each wave
of the panel is conducted in a self-administered mixed-mode design, i.e. as an online or
paper-based survey (Bosnjak et al. 2018). The 'GESIS Panel Special Survey on the Corona-
virus SARS-CoV-2 Outbreak in Germany' (GESIS Panel Team 2020) was conducted between
March 17 and March 29, 2020.[3] Since the survey had to be conducted in a timely manner,
the invitations were limited to the online subsample of the GESIS Panel.

Overall, $N = 3,765$ respondents were invited to participate, $N = 3,176$ of whom com-
pleted the survey, resulting in a completion rate of 84.36%. For the analyses in this paper,
the data was linked to the cumulative GESIS Panel Standard Edition (GESIS 2020b) as well
as the Extended Edition (GESIS 2020a). Due to item nonresponse for about 7% of cases,
the final sample size is approximately $N \sim 2,940$, with slight differences across the four
dependent variables.

Since respondents in the GESIS Panel were allowed to self-select into the respective
survey modes for participating in the COVID-19 special survey (i.e. online- or paper-
based surveys), the current sample cannot be considered a probability sample (for a dis-
cussion of selection bias in the context of COVID-19 online surveys, see Schaurer and Weiß
2020). Therefore, especially the descriptive results cannot be generalized to a broader
population. A comparison of the sample with population margins can be found in
Online Appendix, Section 1. The questionnaire of the GESIS Panel Special Survey is the
result of joint work in the Open Probability-based Panel Association,[4] the Department
of Economics of the University of Bonn as well as the German Research Institute of the
Federal Employment Agency. Experts in scale development and on substantive consider-
ations about how people react to pandemics guided the selection of items (see also
Rammstedt, Lechner, and Weiß 2021).

*Dependent variables.* First, risk perceptions were measured with five items on the like-
lihood that within the next two months, (a) respondents will get infected with COVID-19,
(b) someone from their immediate social surroundings will get infected, (c) respondents
will need hospital treatment, (d) respondents will have to be quarantined, (e) respondents
will get infected and spread the virus to other people. Response options for all of these
items ranged from 1 – not likely at all to 7 – absolutely likely, with an option to indicate
that this had already happened. The latter response category was treated as a missing
value for the analysis of perceived risk. These items were combined into a single mean

score (Cronbach's $\alpha = 0.82$). Second, respondents were asked about how they perceive the effectiveness of seven different measures for containing the pandemic (e.g. closing kindergartens and schools), with response options ranging from 1 – not effective at all to 7 – very effective. The combined mean score has a Cronbach's $\alpha$ of 0.87. Third, trust was assessed by asking participants how much they trusted nine different actors or institutions in dealing with the pandemic (e.g. the federal government, the WHO or scientists). Response options for these items ranged from 1 – don't trust at all to 5 – entirely trust. Cronbach's $\alpha$ for the mean scale is 0.89. Fourth, respondents where asked whether they engage in a set of ten different prevention behaviours (e.g. washing their hands more often or reducing social contacts), with the option of also naming additional behaviours. These eleven binary items were combined into a single sum score.

All four dependent variables were rescaled to a range of 0 to 100 to facilitate interpretation. The complete item wording and descriptive statistics of all variables can be found in Sections A2 and A3 of the Online Appendix.

*Independent and control variables.* The survey contained self-report items of media exposure asking respondents about their use of information sources for getting COVID-19 information. The items included the higher-level, dichotomous categories *public broadcasting* and *commercial broadcasting*, both in their national and local/regional variants, national and local *newspapers*, *Facebook*, *other social media* and *personal conversations*. Respondents were asked to report usage independent of the channel where they received the information (online, offline, apps). While more detailed ways of measuring the intensity of media exposure (e.g. in usage days per week for each source) exist, the simpler technique of counting sources suffices to assess aggregate levels of exposure (Andersen, Vreese, and Albæk 2016). For the regression models, we construct a variable *number of COVID-19 information sources* as an additive index of used information sources, ranging from 0 to 10 ($M = 3.89$, SD $= 1.57$).

A relevant confounder is *satisfaction with democracy* with a scale of 0 – extremely dissatisfied to 10 – extremely satisfied ($M = 6.08$, SD $= 2.30$). We also control for *political interest* on a 5-point scale ranging from 1 – not at all to 5 – very strong ($M = 3.28$, SD $= 0.89$). In order to account for the role of respondents' *political ideology*, we include a variable ranging from 0 – left to 10 – right ($M = 4.65$, SD $= 1.87$). For the interaction models used in the heterogeneity analyses, we grouped respondents' political ideology into three terciles (0–3 left, 4–6 moderate, 7–10 right). Additionally, respondents were asked about their *voting intention* ('Sonntagsfrage') if the federal elections were held next Sunday, with the following response categories: AfD (8%), CDU/CSU (22%), SPD (11%), FDP (7%), DIE LINKE (9%), BÜNDNIS 90/DIE GRÜNEN (23%), other party or don't know (21%).[5]

The regression models also include demographic variables. The share of *females* in the sample is 49%. *Education* was trichotomised into the categories 'low', 'medium' and 'high'. There is a pronounced over-representation of highly educated respondents (see Table A1 in the Online Appendix), i.e. 58% of respondents reported a 'high' educational attainment, whereas in the Microcensus 2017 this group has a share of about one third. Finally, *household size* is measured as a categorical variable with three categories (1 person, 2 persons, 3 and more persons). The proportion of single-person households is 11%, two-person households have a share of 48%, and about 40% of respondents live in a household with 3 or more persons.

## Facebook data and topic model

*Data.* For the text analysis, we retrieved Facebook data from CrowdTangle, a data insights tool owned by Facebook that tracks the content of and interactions with public posts on Facebook pages (CrowdTangle Team 2020).[6] Our data collection covers the period from December 1, 2019 to March 29 2020, which corresponds to the last day of the GESIS Panel Survey. Specifically, we retrieved all COVID-19-related posts during this period by German public Facebook pages.[7] We used a comprehensive query expansion strategy: Initially, we crawled all posts including one of the terms `corona` or `covid`, gathering $N = 701,877$ unique posts by public pages. We then applied the following regular expression to filter out the most common COVID-19-related terms in a semi-inductive approach:     `corona.*|ncov.*|.*cov-2.*|covid.*|quarant.*|` `#.*virus.*|#.*bleib.*`. From the list of resulting terms, we removed `corona` and `covid` since they were already included in our initial query set.[8] Next, we used the top 30 terms from the remaining list to query CrowdTangle again for the same period.[9] Our final Facebook data set consists of 855,516 unique posts created by 181,894 different public Facebook pages.

Engagement is heavily skewed: the top 1,000 pages ranked by the number of interactions (the aggregated number of reactions, comments and shares) capture 58% of all interactions. We therefore restricted our analysis to these top 1,000 pages, in order to then manually map them to the information sources present in the GESIS Panel Survey. Our sample of pages therefore captures the most popular, and by extension, the likely most seen public content on COVID-19 among German Facebook users. As the country-of-origin information for pages was imprecise, we also coded 296 pages in the top 1,000 that are primarily posting in English and removed these and their 4,749 posts from our dataset. We then utilized Google's Compact Language Detector v3 (CLD3)[10] to remove all remaining non-German posts.

*Topic model.* To gain a more structured view of the Facebook data, we applied a topic model to all posts made by the top 1,000 pages. Concretely, we implemented a *biterm topic model* (BTM) (Yan et al. 2013) that is particularly suited to uncovering topics in short texts. We utilized the library *spaCy* for stopword removal and lemmatization (see for more details Online Appendix Section A4). This left us with $N = 77,152$ valid posts and an average post length of 12.81 tokens, posted by 629 distinct Facebook pages. To find the optimal hyper-parameters for the BTM, we computed topic *coherence scores* as defined by Röder, Both, and Hinneburg (2015) using the *Gensim* library. Overall, our tuning procedure comprised a total of 200 distinct parameter combinations. After optimizing the model parameters based on coherence scores,[11] we arrived at 20 topics and the hyper-parameters $\alpha = 4.1$ and $\beta = 0.61$ (see Online Appendix Figure A4).

## Results

### Did topic salience in coverage on COVID-19 diverge between information sources?

We first turn to *RQ1* to investigate the salience of different topics within information on COVID-19 by using Facebook data.[12] Relying on Facebook data holds several methodological and substantive advantages for our study. First, whereas transcripts of TV shows

and texts of newspaper articles are not easily available for researchers at a large scale, all mainstream media organizations publish contents on Facebook. Second, the consistent textual format in the form of posts allows for analyzing and comparing the topical focus of COVID-19 across information sources (e.g. coverage of public broadcasters vs. local newspapers). Third, thanks to the wide use of Facebook by political elites, we do not just capture communication on COVID-19 by mainstream media but also from myriad other actors such as politicians, civil society organizations or public health institutions.

To map the Facebook data to our survey-based research questions, we assigned the top coded 1,000 Facebook pages to the information sources present in the GESIS Panel survey (e.g. the category 'national public broadcasting' consisted of accounts like https://www.facebook.com/tagesschau). To approximate the COVID-19 information exposure via Facebook that respondents were asked about in the survey, we constructed the category 'Other sources' which contained posts by a wide range of different actors, including comedians and celebrities, politicians (especially from the AfD), so-called 'alternative media' (such as RT Deutsch), government accounts and even German-speaking foreign actors (e.g. Austrian Chancellor Sebastian Kurz). The top 40 pages ranked by the number of interactions their COVID-19 posts received can be found in Online Appendix Section A4.

\Running the topic model on the Facebook data produced semantically coherent topics that could be substantially interpreted. However, (short) social media texts from heterogeneous sources contain more peculiar and less structured language compared to the traditionally used newspaper corpora. Therefore, the topic model also identified some small and inconsistent topics, mostly shaped by idiosyncratic wording or repeated hashtag use by one or two particular pages. We therefore selected only the most empirically relevant topics for further analysis, concretely, all topics with a mean probability of at least 0.01, averaged across all documents. To identify and label relevant topics, three authors independently conducted an extensive manual inspection of the remaining 13 (out of 20) topics based on the most predictive terms (see Table 1 including English translations) and a manual inspection of a large random sample of Facebook posts with a high probability for each topic (see systematically drawn examples in Table A5 in the Online Appendix). The blind coding process resulted in similar topic labels that were then consolidated by the three authors. The probabilities of each topic were aggregated for each information source for the following analysis.

Figure 1 shows the prevalence of the 13 topics across information sources. Some deviations can be found, e.g. local outlets focused more on concrete implemented measures that differed considerably between regions in Germany, while national media were over-proportionally reporting on the early outbreak and international developments. Overall, there slight variations in topic salience. Nonetheless, each information source devoted a decent share of its attention to each topic, with at least similar topic proportions. This is true even for the category 'Other sources' that represents a great variety of actors posting on COVID-19 on Facebook. In addition, the keyword lists in Table 1 and sampled example posts in Table A5 show that even across the identified topics, the unifying themes are the threats posed by the novel virus and measures taken by the authorities.

**Table 1.** Top terms per topic (German/English) and description.

| Topic | Top 10 terms | Description |
|---|---|---|
| Early outbreak & uncertainty | welt, infizieren, wichtig, menschen, fragen, deutschland, china, virus, zeigen, aktuell*world, infect, important, people, questions, germany, china, virus, show, current* | Information about the early outbreak and reduction of uncertainty regarding the virus |
| Government measures | bleiben, maßnahmen, stadt, gelten, schulen, schließen, ausbreitung, aktuell, menschen, öffentlich*stay, measures, city, apply, schools, close, spread, current, people, public* | Policy measures, their impact on daily life and their effectiveness |
| Health care system | kontakt, versorgung, patienten, alt, menschen, schützen, personal, krankenhäuser, medizinisch, ärzte*contact, care, patients, old, people, protect, staff, hospitals, medical, doctors* | Preparedness of the health care system, at-risk-groups, personal hygiene |
| Impact on economy | deutsch, folgen, milliarden, geld, prozent, wirtschaft, euro, krise, unternehmen, wirtschaftlich*german, follow, billions, money, percent, economy, euro, crisis, businesses, economic* | Impact of COVID-19 on the national and international economy |
| Local & personal stories | bestätigen, infizieren, menschen, kreis, positiv, frau, testen, personen, häuslich, mann*confirm, infect, people, circle, positive, woman, test, people, domestic, man* | Local impact with strong focus on individual infections or clusters |
| Local information West Germany | aachen, krisenstäbe, städteregion, stadt, lage, koblenz, märz, insgesamt, aktuell*aachen, crisis staffs, city, situation, koblenz, march, total, current* | Local COVID-19 news, very similar to 'Practical local information' |
| Media events | dr, erklären, sprechen, fragen, kommentare, live, interview, beantworten, pressekonferenz, prof*dr, explain, talk, questions, comments, live, interview, answer, press conference, prof* | Announcements (or results) of discussion rounds, expert opinions, press briefings and TV shows |
| National political actors | kanzlerin, deutsch, grenzen, regierung, spahn, angela, deutschland, bundesregierung, cdu, merkel*chancellor, germany, borders, government, spahn, angela, germany, federal government, cdu, merkel* | Speeches and nation-wide decision making |
| Postponement of events | aufgrund, stattfinden, geplant, finden, märz, foto, april, verschieben, absagen, veranstaltungen*due to, take place, planned, find, march, photo, april, postpone, cancel, events* | Cancellation and postponement of events in sports, culture, leisure, entertainment |
| Practical local information | thema, informationen, bitte, hotline, kreis, fragen, direkt, wichtig, finden, aktuell*topic, information, please, hotline, district, questions, direct, important, find, current* | Practical information and where to turn for help for residents of specific regions |
| Solidarity & encouragement | bleiben, helfen, zeiten, menschen, einfach, leben, hause, mein, halten, mal*stay, help, times, people, simple, life, home, my, hold, once* | Moral appeals, empathy, community hashtag campaigns |
| Supplies & shortages | supermärkten, kaufen, polizei, desinfektionsmittel, leeren, lebensmittel, toilettenpapier, kunden, hamsterkäufe, regale*supermarkets, buy, police, disinfectant, empty, food, toilet paper, customers, hoarding, shelves* | Supplies and their shortage, including hoarding; also includes warnings about scams |
| Travel & international developments | zahl, deutsch, infizieren, menschen, italien, wuhan, deutschland, china, virus, fällen*number, german, infect, people, italy, wuhan, germany, china, virus, cases* | Developments in other countries; travel restrictions |

Of course, homogeneity on the level of topics still masks more nuanced latent dimensions such as the framing or valence of coverage on COVID-19. For instance, topics with a pronounced anti-establishment perspective were prominent in the specifically tailored corpus of Boberg et al. (2020) where alternative media were over-sampled compared to the broader and more 'mainstream' set of pages we analyzed here. Among our sample of the most prominent public pages on Facebook, a
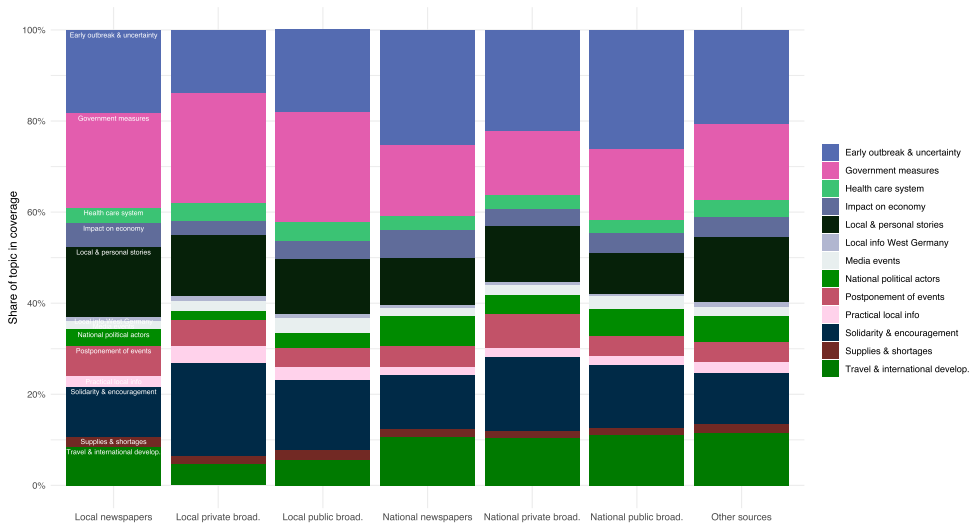
**Figure 1.** Mean topic probabilities per information source.

topical cluster of posts that would question the severity of the pandemic could not be found. Additionally, we manually searched for slanted terms such as `*lüge*`, `Wahrheit`, `*fakten*`, `Realität`, `*gates*` or `*querdenken` in the posts of *Other sources*, yet found no noteworthy instances of misinformation or disinformation. We also conducted a sentiment analysis and reran the topic model with different parameters. Both analyses revealed only marginal differences between information sources (Online Appendix Section A4).

### How did information exposure relate to COVID-19 outcomes?

Before we turn to the survey analysis, we first zoom in on the descriptive relevance of information sources during the first COVID-19 wave in Germany (see Online Appendix Figure A1). In total, public broadcasting radio or television, either national or local, were used by 92% of respondents. 67% of respondents got information from newspapers, when taking together local and national papers. 56% of respondents also reported receiving information about COVID-19 from personal conversations and a total of 45% received such information from commercial broadcasters (national or local). Compared with these channels, social media were mentioned as far less frequent sources of COVID-19 information. Facebook was used by 19% of respondents, while 15% got COVID-19 information on other social media. 14% reported using additional sources, while only 0.3% of respondents reported not getting any COVID-19 information at all.

Taken together, the previous analyses showed that (1) nearly all German residents were exposed to information on COVID-19 in March 2020 and (2) across information sources, they were facing an almost uniform coverage that emphasized the national and international threats of the pandemic and legitimized the installation of countermeasures. Consequently, we make the assumption that being confronted with similar topics on

each possible channel should add up to positive relations between the number of COVID-19 information sources and COVID-19 attitudes, perceptions and behaviours. While previous research has shown that more detailed exposure measures can reveal even stronger media effects, overall, there is a stable correspondence between the number of sources used, the overall amount of news exposure and media effects (Andersen, Vreese, and Albæk 2016).

Equipped with this descriptive evidence, we investigate *RQ2* by using multiple regressions with the number of information sources used for getting information on COVID-19 as the main explanatory variable, a set of control variables and perceptions, attitudes and self-reported behaviours related to the pandemic as dependent variables. The results in Table 2 show that even after controlling for a host of confounders, getting information from more sources had a statistically significant positive association with COVID-19 outcomes ($p<0.001$). This relationship was consistent across all four dependent variables. Moving from 0 to 10 sources of COVID-19 information would be associated with an increase of risk and effectiveness perceptions by 11.7% and 10.3% respectively; an increase of trust in actors by 8.7% and an increase in self-reported behavioural measures taken by 13.5%.

To answer *RQ3a* on a potential heterogeneity across different ideological leanings, we interacted our main explanatory variable information exposure with a variable that divided respondents into three groups along the left/right spectrum. Figure 2 demonstrates that the relationships between the number of sources used and the four COVID-19 outcomes were similar in direction and magnitude across respondents with a left, moderate and right-leaning ideology.

To investigate the moderating role of party preferences (*RQ3b*), we interacted respondents' voting intention with the information exposure variable. Figure 3 shows the predicted values for these models. There are some apparent differences between parties in the baseline levels, e.g. people with an AfD preference had the lowest levels of trust in the actors shaping COVID-19 policy. Party differences were most pronounced when it comes to the perceived risk of infection. Yet the slopes are mostly running in parallel and in a positive direction. The only stark difference is visible for people with an SPD voting intention who were less likely to take personal measures against COVID-19 with an increasing information exposure. Nonetheless, the main finding is that party preference played a minimal moderating role, even in the group of respondents who intended to vote for the AfD.

Taken together, even for different subgroups for which the established political science literature would predict substantial variation, the statistically positive relationship between the number of COVID-19 information sources used and the four outcomes persists.

We conducted an extensive set of robustness tests whose results are presented in Online Appendix Section A5. First, to get a better sense of the mechanisms at play and the interrelationships between the four outcomes, we ran two additional sets of regressions including (1) perceived risk of infection as an additional predictor to explain the other three outcomes (Table A9); and (2) both perceptions of the effectiveness of measures and the risks of infection included as predictors to explain measures taken against COVID-19 (Table A10). The results are as theoretically expected: risk perceptions positively predict the perceptions of the effectiveness of measures as well as

**Table 2.** Information exposure and COVID-19 outcomes.

| | Perceptions | | Attitudes | Behaviours |
|---|---|---|---|---|
| | Risk of infection | Effectiv. of measures | Trust in actors | Measures taken |
| Number of COVID-19 info. sources | 1.17*** | 1.03*** | 0.87*** | 1.35*** |
| | (0.20) | (0.20) | (0.18) | (0.18) |
| Political ideology (left/right) | −0.06 | −0.03 | −0.51** | 0.04 |
| | (0.20) | (0.20) | (0.19) | (0.19) |
| Political interest | 0.84* | 0.26 | 0.14 | 0.73 |
| | (0.40) | (0.40) | (0.38) | (0.37) |
| Satisfaction with democracy | 0.28 | 0.67*** | 2.31*** | 0.50*** |
| | (0.15) | (0.15) | (0.14) | (0.14) |
| CDU/CSU | −1.50 | 1.11 | 9.38*** | −1.00 |
| | (1.40) | (1.39) | (1.31) | (1.31) |
| FDP | −1.98 | −1.47 | 5.68*** | −1.41 |
| | (1.64) | (1.62) | (1.53) | (1.52) |
| Grüne | −0.43 | 0.50 | 6.68*** | −0.60 |
| | (1.50) | (1.49) | (1.40) | (1.40) |
| Linke | −3.07 | −3.64* | 3.38* | −4.74** |
| | (1.73) | (1.71) | (1.61) | (1.61) |
| SPD | −1.89 | −0.73 | 8.28*** | −3.43* |
| | (1.60) | (1.58) | (1.49) | (1.49) |
| Other party or don't know | −0.94 | −1.97 | 4.62*** | −3.06* |
| | (1.37) | (1.36) | (1.28) | (1.27) |
| Household: 2 persons | 1.18 | 1.59 | −1.02 | 2.12* |
| | (1.01) | (1.00) | (0.95) | (0.94) |
| Household: 3+ persons | 2.32* | 2.04 | −1.51 | 4.85*** |
| | (1.06) | (1.05) | (0.99) | (0.99) |
| Age | −0.27*** | −0.02 | 0.10*** | −0.03 |
| | (0.03) | (0.03) | (0.02) | (0.02) |
| Female | −0.11 | 4.04*** | 2.21*** | 3.45*** |
| | (0.66) | (0.65) | (0.61) | (0.61) |
| Medium education | 1.56 | 1.11 | 0.03 | 1.45 |
| | (1.09) | (1.08) | (1.02) | (1.02) |
| High education | 1.92 | −1.20 | −1.83 | 2.93** |
| | (1.08) | (1.07) | (1.00) | (1.00) |
| $R^2$ | 0.07 | 0.05 | 0.20 | 0.07 |
| Adj. $R^2$ | 0.07 | 0.04 | 0.19 | 0.07 |
| Num. obs. | 2943 | 2949 | 2940 | 2949 |

Note: Coefficients and standard errors from OLS Regressions. 'AfD' is the reference category for the dummy variables identifying voting intention for political parties. 'Household: 1 person' is the reference category for household size. 'Low education' is the reference category for education. ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

the number of reported measures taken against COVID-19, while not being significantly related to trust in actors. Both, the perceived risks and the perceived effectiveness of measures positively predict the measures taken. Importantly, in all of these model specifications the coefficient of the number of information sources remains stable, i.e. a significant and substantively relevant positive predictor of all COVID-19 outcomes.

We also show results disaggregated by information source in Table A12. For all different information sources, the effects were consistently positive (and oftentimes statistically significant), with a negative effect of personal conversations on the evaluation of government measures being the lone exception. In none of these models did more exposure to COVID-19 on social media (or in Table A13, only Facebook) have statistically significant negative effects on the outcome variables. The coefficients of information exposure are overall very stable in these models, indicating that it is not merely a proxy for other confounding processes.
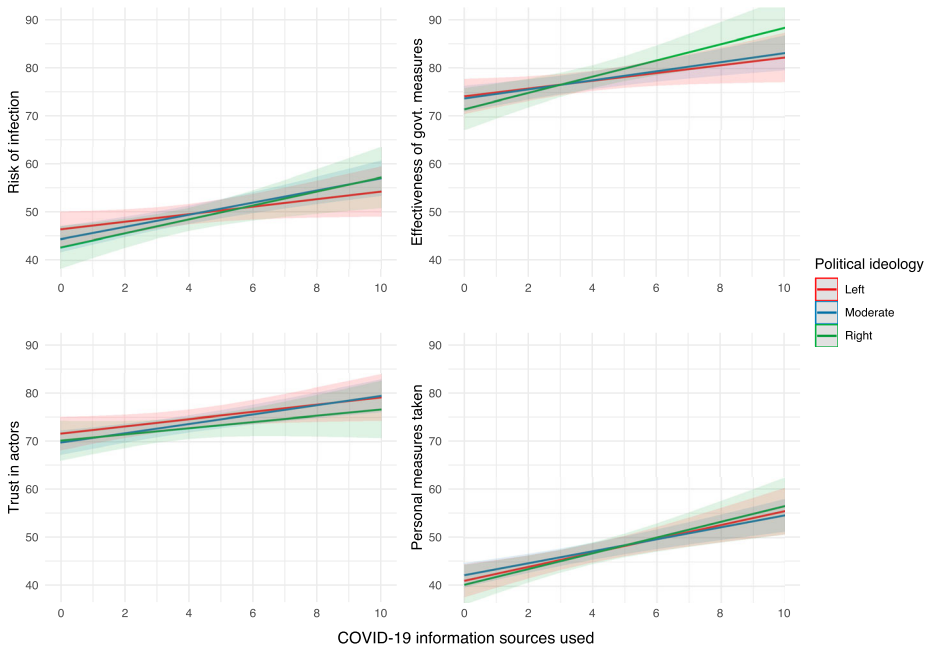
**Figure 2.** Predicted values with 95% confidence intervals. Predictions were taken from the interaction effect of a political ideology variable divided into terciles and the number of COVID-19 information sources used (full model in Online Appendix Table A7). All other variables were held constant, or in the case of discrete variables such as education, at their proportions.



**Figure 3.** Predicted values with 95% confidence intervals. Predictions were taken from the interaction effect of voting intention and the number of COVID-19 information sources used (full model in Online Appendix Table A8). All other variables were held constant, or in the case of discrete variables such as education, at their proportions.
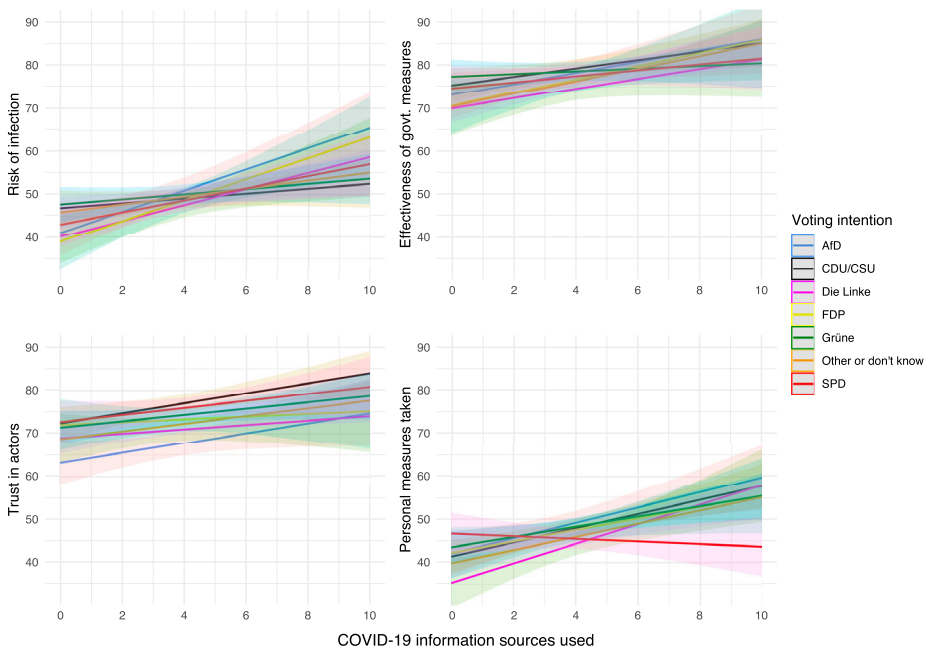
## Conclusion

This paper investigated the role of information exposure during the first wave of COVID-19 in Germany in March 2020. First, an automated analysis of more than 800,000 German Facebook posts on COVID-19 by the most popular public pages showed that coverage was almost uniformly emphasizing the dangers posed by the novel virus and legitimizing public health countermeasures. At least on this scale of data collection and analysis, we could not find noteworthy traces of misinformation. Second, using high-quality survey data from the GESIS Panel, we descriptively showed that established sources such as public broadcasters were the primary pathways for getting COVID-19 information, albeit a much less pronounced use of social media. Third, in line with consistent messages by the media and political elites dominating the political information environment, we found a robust statistical relationship between the number of information sources used and positive public health outcomes; concretely, more pronounced perceptions of risks amid considerable uncertainty, more trust in central actors and the effectiveness of government measures and ultimately, a more stringent (self-reported) compliance with countermeasures. In addition, neither were there indications for negative effects of using social media or Facebook nor a heterogeneity depending on the political ideology or party preference of respondents. Taken together, the findings suggest that a uniform information environment went hand in hand with a cautious public and widely accepted mitigation measures during the first wave of COVID-19 in Germany.

Our analysis has several limitations. Most importantly, even consistent statistical findings from cross-sectional survey data cannot causally establish that information exposure improved public health outcomes. In addition to possible confounders which we could not include or that generally cannot be measured with self-reports, there is also the issue of reversed causality. Someone with high risk perceptions should also be more likely to search for COVID-19 information. At the same time, the relationship between self-reported behaviours and information exposure is robust to inclusion of risk perceptions in the models. We also acknowledge limitations in measurements, as self-reports of media exposure have a limited validity (Scharkow 2016). Additionally, the measures we used did not allow for assessing the (daily, weekly) intensity of exposure. One promising research design to mitigate these measurement limitations is to link surveys and direct measures of (digital) behavioural data collected for the same set of individuals (Stier et al. 2020). Finally, whereas Facebook data served our comparative purposes well as many different media outlets also publish news on the social network site, this data source only captures parts of the overall amount of information that reaches citizens via diverse distribution channels such as television, print newspapers, or venues such as Telegram groups.

The final note of caution pertains to the nature of the specific case and time period under study. There was almost no politicization of COVID-19 and the government measures taken in Germany during March 2020. The homogeneous information environment constituted a unique communication constellation when counterframes to uniform elite messages (Chong and Druckman 2007) were nearly absent. In that regard, our findings are fully consistent with well-established theories about the impact of elite-driven communication on public opinion (Zaller 1992). In contrast, the negative social and economic effects of lockdowns have been much more prominently featured in

public debates since the first wave of the pandemic. In addition, a host of political actors such as the AfD and the 'Querdenken' movement have downplayed the threats posed by the virus and mobilized against government measures. With these shifts in media coverage and political actors' stances, the signals related to COVID-19 in the information environment have become more ambiguous. As a consequence, how information exposure relates to COVID-19 perceptions, attitudes and behaviours has likely become more contingent on political predispositions (such as being a supporter of a populist radical right party) and individual characteristics. Therefore, the character and correlates of COVID-19 information exposure remain important subjects to study.

## Notes

1. https://www.nytimes.com/2020/02/06/health/coronavirus-misinformation-social-media.html
2. For instance, in this tweet by the AfD's parliamentary leader Alice Weidel: https://twitter.com/Alice_Weidel/status/1242457063743160322
3. The data from the 'GESIS Panel Special Survey on the Coronavirus SARS-CoV-2 Outbreak in Germany' is available as a public use file (PUF; see GESIS Panel Team 2020). In addition, the PUF has been included in the cumulative scientific use file of the GESIS Panel (GESIS 2020b).
4. https://openpanelalliance.org
5. This question was asked in an earlier wave of the GESIS panel in Spring 2019.
6. CrowdTangle is accessible after a per-user authorization given by Facebook to academic researchers. The tool does not provide insights into private user information, the identity of users or comments by individuals.
7. CrowdTangle assigns pages to countries based on various pieces of information such as the location of page administrators and their popularity among users of a given country.
8. Additionally, we dropped all terms that contained either of the sub-strings `bier`, `flasche`, or `brauerei` to exclude contents referring to the Corona beer brand.
9. `coronavirus`, `#corona`, `#coronavirus`, `quarantäne`, `#covid19`, `cov`, `coronakrise`, `#wirbleibenzuhause`, `covid19`, `#virus`, `#bleibtgesund`, `#coronakrise`, `#covid_19`, `#bleibtzuhause`, `coronaviren`, `#covid`, `coronafälle`, `#gemeinsamgegencorona`, `#quarantäne`, `2019-ncov`, `#coronavirusde`, `#wirvsvirus`, `quarantänemaßnahmen`, `coronafall`, `#coronacare`, `#bleibzuhause`, `#covid19de`, `#covid2019`, `#zuhausebleiben`, `quarantän`
10. https://github.com/google/cld3
11. According to the most reliable coherence scores $C_V$ as per Röder, Both, and Hinneburg (2015) and manual comparison to a model fitted at optimal $C_{UMass}$ settings.
12. Our analyses were performed in *R*, version 4.1.1 and Python, version 3.5.2.

## Data availability statement

Replication materials including R and Python scripts that support the findings of this study are available on OSF: https://doi.org/10.17605/OSF.IO/4AZ8V The survey data can be obtained by creating an account on the GESIS Data Archive. Please note: The 'GESIS Panel – Extended Edition' can only be accessed at the GESIS Secure Data Center in Cologne. Due to proprietary restrictions, the raw Facebook data cannot be shared but can be reconstructed using CrowdTangle.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

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