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ORIGINAL PAPER

Association of personality traits and socio-environmental factors with COVID-19 pandemic-related conspiratorial thinking in the D-A-CH region

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Abstract

Misinformation, lack of trust, and uncertainty during the COVID-19 pandemic have fostered the emergence of new conspiracy theories. In August 2021, we examined the association of individual personality traits and socio-environmental factors with high belief in pandemic-related conspiracies through an online survey among 3,067 quota-sampled German-speaking adults residing in the D-A-CH region (Germany, Austria, Switzerland). In multivariable-adjusted regression models, pandemic-related conspiracy belief was, first, negatively associated with tertile (T) of complexity thinking, optimism, and higher level of education (complexity thinking, $OR_{T3vs.T1}$: 0.43, 95% CI 0.32–0.57, $P_{trend} < 0.01$; optimism, $OR_{T3vs.T1}$: 0.41, 95% CI: 0.30–0.56, $P_{trend} < 0.01$; higher education, $OR_{T3vs.\ T1}$: 0.67, 0.50-0.89; $P_{trend} <0.01$) and second, positively associated with regular participation in religious meetings, not having recently voted, unwillingness of oneself or one's close contacts to vaccinate, past COVID-19 infection and disapproval of COVID-19 mitigation measures. Our findings highlight the importance to foster complexity understanding through targeted interventions, such as in education settings, to help curb the spread of conspiracy theories. We conclude that**,** in order to effectively address the challenges posed by pandemic-related conspiracy theories, policymakers must acknowledge the impact of conspiracy beliefs on public health decisions while promoting transparent communication and interdisciplinary (between scientific disciplines) and transdisciplinary (between science and society) research, as well as science literacy and science diplomacy collaboration.

Keywords COVID-19 pandemic · Conspiracy belief · D-A-CH region · Complexity thinking

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Introduction

Statement of the problem

The outbreak of the SARS-CoV-2 pandemic in early 2020 presented societies all over the world with unprecedented challenges. These early stages of the pandemic were largely characterized by fear of infection, followed by critical discussions about transmission-reducing public health measures such as mask wearing, social distancing, and others. Subsequently, public discourse shifted to the promise of a vaccine that could help to enable a return to a pre-COVID "normal." Some scientists found such a promise overly ambitious given the limited knowledge of the COVID-19 virus and the plethora of previously known infectious diseases for which no effective vaccine exists. Yet, several COVID-19 vaccines became available within the first year of the pandemic (Fathizadeh et al. 2020). The fast pace of development and the size of the investment raised numerous questions. Confronted with the complexities and uncertainties of life in a global pandemic, many people became increasingly skeptical of these new vaccines and the ways they were produced and made available (Bussink-Voorend et al. 2022). In the D-A-CH region (Germany [Deutschland/D], Austria [A], and Switzerland [Confederatio Helvetica/CH]), skepticism built on sentiments of vaccine hesitancy that had been on the rise even before the pandemic, which for instance lead to measles outbreaks at schools in Germany or a slow uptake of human papilloma virus (HPV) vaccines (Karafillakis et al. 2019; Kennedy 2019). Hesitancy towards COVID-19 vaccines and consequent low vaccination rates were among the factors leading to early lockdown measures in the fall of 2021 (at some point targeting the unvaccinated in particular, such as in Austria) and to numerous challenges for health care systems in the region.

In preceding studies, we investigated the acceptance of COVID mitigation measures, first, limited to Austria as a model region (Schernhammer et al. 2022; Weitzer et al. 2021) and then expanding our focus to the D-A-CH region by focusing on drivers of COVID vaccination status, including beliefs in COVID-19 conspiracy theories (Weitzer et al. 2022). Our results were consistent with observations made, for instance, in the US (Franke and Elliott 2021; Wang and Liu 2022) reporting the emergence of new conspiracy theories within a short time after the first vaccines became available. One such theory postulated governmental control through microchips implanted via COVID-19 vaccination. Others were about how the virus was made up and supposedly not real (Förstl 2020). A common feature of these conspiracy theories was that their supporters held strongly to their own narratives (Flaherty et al. 2022). When confronted with facts, they did not reverse, but rather intensified their commitment to their ideas and world views (Roose 2020).

Significance of the problem

Thus, conspiracy theories in reaction to crises pose challenges that policy makers should be aware of and consider as a factor when making decisions. A factual and

logical statement may be misinterpreted and lead to the exact opposite effect and actions than originally intended, as was seen with regard to vaccination measures in general (Paul et al. 2021). During the COVID-19 pandemic, conspiracy theories have become even more problematic, as they have undermined trust in government and institutions, fostered social disconnection, spread misinformation, and posed threats to democratic principles (Allington et al. 2021; Jennings et al. 2021; Juanchich et al. 2021; Klösch et al. 2023; Oleksy et al. 2021; Sternisko et al. 2023). Therefore, it is crucial to discern the factors and preconditions related to heightened conspiracy belief in this case. Our study is the first large-scale report involving a quantitative analysis of conspiratorial thinking regarding the COVID-19 pandemic conducted within the D-A-CH region.

Theoretical groundwork

The next paragraphs will provide, a brief overview on conspiracy theories and the theoretical framework we use to understand them and the emergence of COVID-19 pandemic-related conspiracy theories and the conceptual background.

Conspiracy theories: definition and theoretical framework

In this paper the term "conspiracy theory" is understood as "the belief that two or more actors have coordinated in secret to achieve an outcome and that their conspiracy is of public interest but not public knowledge" (Douglas and Sutton 2023, p. 282). Four basic principles underlying this phenomenon have been described, which propose that conspiracy beliefs are consequential, universal, emotional, and social (van Prooijen and Douglas 2018). First, the consequential aspect means that even unlikely conspiracy theories impact health, relationships, and societal development. Second, conspiracy beliefs are universal, as they encompass all cultures and time periods worldwide in their different manifestations (Castanho Silva et al. 2017; Swami 2012). For example, conspiracy theories were prevalent in ancient civilizations and persist in modern times in both large- and small-scale environments (a whole nation or a local organization) (Brotherton 2015; Douglas and Leite 2017). Third, negative emotions, such as anxiety and lack of control, drive belief in conspiracy theories more than rational thinking. For instance, feelings of uncertainty have been described to increase susceptibility to conspiracy theories (Pertwee et al. 2022; van Prooijen and Douglas 2017). Fourth, conspiracy beliefs encompass the social aspects of intergroup conflict, driven by a strong ingroup identity and a sense of outgroup threat (van Prooijen and van Vugt 2018). Furthermore, three drivers of conspiracy theories have previously been identified, namely the desire to (1) understand one's environment; (2) feel safe and in control of one's environment; and, (3) have a positive image of oneself and one's social group (Douglas et al. 2017). Other factors which contribute to conspiracy thinking include epistemic and existential motivations, such as the desire for uniqueness or the need for meaning and purpose. Hence, a two-component model for conspiracy theory belief has been proposed, which highlights epistemic mistrust and further misinformation processing as key

characteristics of an individual's turning towards conspiracy theories as explanations for the happenings in the world (Pierre 2020). This coincides with the notion of "conspiracist ideation" (Swami et al. 2011), which describes the general inclination of a person to believe the conspiracist narrative rather than other rationalizations. Measuring the amount of conspiracy belief has been a challenge, although a 15-item Generic Conspiracist Beliefs (GCB) scale has been introduced to assess the general inclination towards conspiratorial thinking (Brotherton et al. 2013).

In summary, conspiracy beliefs exert substantial and wide-ranging impacts on individuals and societies. An in-depth understanding of their psychological, social, and circumstantial foundations is imperative for grasping the implications and potential ramifications of such beliefs.

COVID-specific conspiracy theories

The COVID-19 pandemic has been accompanied by a surge in conspiracy theories that have spread widely, in part due to increased time spent on social media platforms, while face-to-face interactions and group activities decreased because of social distancing. One prominent conspiracy theory claims that the virus was intentionally created and released from a laboratory with underlying political motives (Förstl 2020). Alternatively, another theory implies that COVID-19 is a bioweapon engineered to target specific populations (Islam et al. 2021). In contrast, some other conspiracy theories assert that COVID-19 is a hoax, with governments and other entities exaggerating its severity for undisclosed and potentially malicious reasons (Allington et al. 2021). Additionally, a theory linking 5G technology to the spread of COVID-19 has gained traction (Ahmed et al. 2020), despite lacking scientific evidence. Another widely circulated conspiracy theory alleges that Bill Gates is using COVID-19 vaccines to implant microchips in people for surveillance purposes; this theory was so prevalent that discussions about its (im)possibility were available on many mainstream media outlets (Saiful et al. 2021). Lastly, concerns about vaccine safety and hypothetical hidden agendas surrounding COVID-19 vaccines and pharmaceutical companies have led to skepticism and hesitancy towards vaccination efforts.

Conceptual background

The growing prevalence of conspiracy beliefs, particularly during the COVID-19 pandemic, impacts public health, trust in organizations and political decision-making. Multiple independent variables can be considered to influence the susceptibility to conspiracy beliefs (Fig. 1). These encompass a range of factors, notably those belonging to the category of general demographic characteristics, socioeconomic status, personality traits and an individual's aptitude for complexity thinking. Furthermore, the experiences and dynamic changes of the COVID-19 pandemic have played a pivotal role in shaping perceptions and beliefs. These include past experiences with COVID-19 infection, vaccination behavior, and approval of the mitigation measures (Fig. 1).

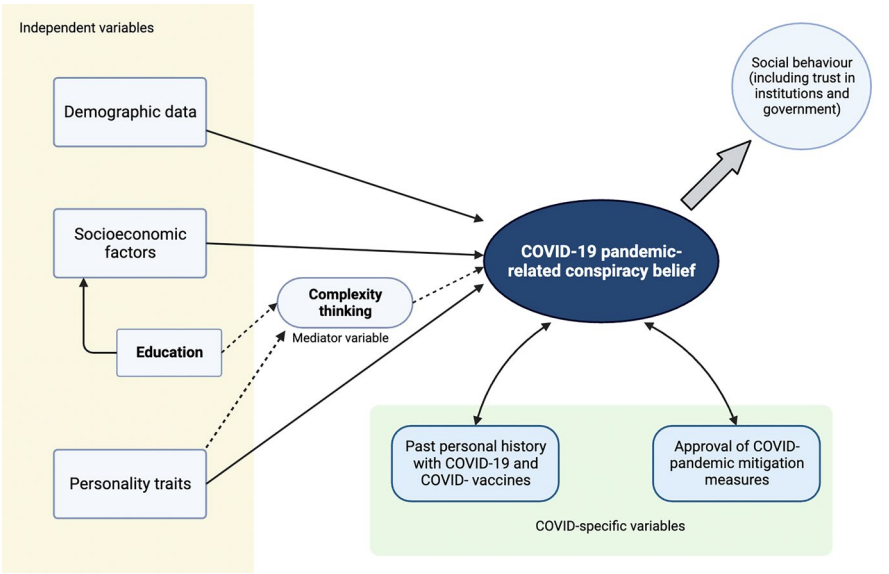

Fig. 1 Conceptual framework of COVID-19 pandemic related conspiracy belief. (Image created with BioRender.com)

Hypothesis, aim and research questions

In this study, we specifically examined complexity thinking, personality traits and environmental factors associated with conspiracy belief in the D-A-CH region. We hypothesized several factors to be significantly associated with higher conspiracy belief. The analysis reported herein aimed to contribute new insights and form a basis for effective public health policies and practices to mitigate the COVID-19 pandemic and future public health challenges. Thus, our research questions were:

1. What are the factors associated with pandemic-related conspiracy belief during the COVID-19 pandemic in the D-A-CH region?
2. How are education and socioeconomic factors linked to belief in pandemic-related conspiracy theories?
3. Could complexity thinking and specific personality traits be identified as "protective factors" against conspiracy beliefs?

Methods

Study design and study population

Data for this cross-sectional cohort study were collected between July 21, 2021 and August 8, 2021 via an online survey in the form of a structured questionnaire in German among 3,067 adults residing in the D-A-CH region using a non-probability

quota selection corresponding to the respective population distribution by age, gender, and region. The survey was designed by the authors of the publication and implemented by the market research institute INTERROGARE, Bielefeld, Germany, using online participant panels. The survey comprised 74 questions on lifestyle, health, and COVID-19-related mitigation measures and behaviors and took an average of 25 minutes to complete (Table S1). Participants' informed consent was inferred by completing the online survey. The study was exempt from Institutional Review Board approval according to Federal Regulations 45 CFR 46.10(b).

Variables

The survey included several demographic and socioeconomic variables, including those listed below:

Age	Marital status
Gender	Number of children younger than 16 years
Ethnicity	Political preference
Country of residence	Participation in religious meetings
Living area	Close contacts
Highest educational attainment	History of COVID-19 infection
Household income	Vaccination status of oneself and estimation whether their friends/acquaintances are vaccinated
Living arrangement	Approval of COVID-19 mitigation measures imposed by the government

Additionally, we assessed factors related to work [main job task, change in work situation, and work-life balance (Syrek et al. 2011)], health factors such as smoking status and chronic disease history, and several personality traits. The latter included optimism, which we measured via the validated Life-Orientation-Test revised (LOT-R) (Hinz et al. 2016); interpersonal trust, which we assessed using the validated "Kurzskala Interpersonales Vertrauen" (KUSIV3) (Beierlein et al. 2012); empathy and perspective taking, which capture a person's inclination and ability to view a matter with through another's eyes and which we measured with the "Fragebogen für Empathie und Perspektivenübernahme" (Maes et al. 1995); and, the "Big Five" personality traits, which include conscientiousness, extroversion, agreeableness, openness and neuroticism and were assessed using the validated Big-Five-Inventory-SOEP (BFI-S) (Gerlitz and Schupp 2014; McCrae and Costa Jr. 1999). A comprehensive list of all survey variables and the corresponding response categories can be found in the supplemental materials (Table S1).

Conspiracy belief and complexity thinking scores

Survey participants were asked to indicate on a 4-point Likert scale (disagree, rather disagree, rather agree, agree) how they perceived the positive impact of daily activities (such as eating less meat or walking/cycling more) on their health and the

environment/climate and their endorsement towards specific statements on climate change and regarding COVID-19-related conspiracy theories (Table S2). We used principal component analysis (PCA) to identify questions of this set to use for the development of (A) a score for belief in pandemic-related conspiracies (hereafter referred to as a 'conspiracy belief score') and (B) a score for the degree of complexity thinking (hereafter referred to as a 'complexity thinking score'). The scores have been previously utilized and published in detail by our group (Schernhammer et al. 2023). Briefly, all 12 questions showed reasonable factorability, with correlations of at least 0.3 with at least one other item (Fig. S1). Additionally, the Kaiser-Meyer-Olkin measure (Kaiser 1970) of sampling adequacy was 0.86, and Bartlett's test of sphericity (Bartlett 1937) was significant (χ^2 (66) = 13,143.96, $p < 0.05$). We therefore conducted the PCA using all 12 survey items (Table S3). The two-factor solution, which explained nearly 53% of the variance, was selected for its previous theoretical support (Brown 2009) and the observation of leveling of eigenvalues on the scree plot after two factors (Figs. S2, S3). We examined the internal consistency for each of the scales using Cronbach's alpha, which was moderate for the complexity thinking score at 0.69 and high for the conspiracy belief score at 0.87 (Table 1). We created composite scores for belief in conspiracy theories and complexity thinking, based on the sum of the respective items that had a factor loading of > 0.55 for the corresponding principal component (Table S3). Each score had possible values from 5 to 20; higher scores indicated more belief in conspiracy theories or more complex thinking. There were no missing data to account for, as responses were mandatory to all the questions included in the analysis.

Statistical methods

Frequencies were reported for categorical variables, while median and interquartile range (IQR) were given for continuous variables. Differences between groups stratified by conspiracy belief score were compared using chi-square or Kruskal-Wallis tests, depending on the variable type. Due to the non-normal distributions of derived conspiracy belief and complexity thinking scores (Shapiro Wilk's $p < 0.001$; Fig. 2), we classified participants into approximate tertiles (T) for each score and qualitatively interpreted the tertiles as 'low' (T1), 'medium' (T2) or 'high' (T3) for the

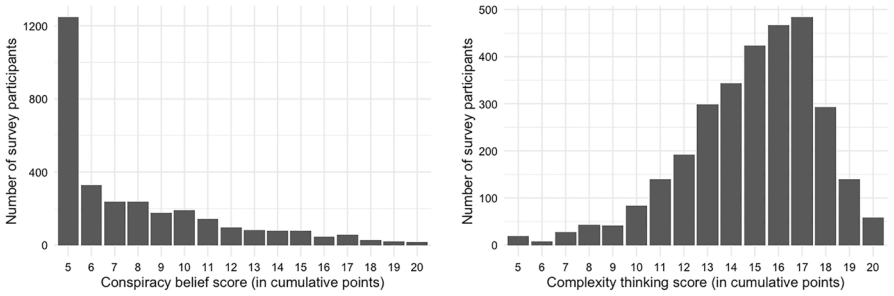

Fig. 2 Distribution of derived scores for belief in pandemic-related conspiracies and complexity thinking

Table 1 Descriptive statistics for the scores derived from principal component analysis of 12 survey items (N = 3067)

Score	No. of items	Mean (SD)	Skewness	Kurtosis	Cronbach's α
Conspiracy belief	5	7.91 (3.63)	1.27	0.80	0.87 (0.86–0.87)
Complexity thinking	5	14.88 (2.82)	− 0.77	0.64	0.69 (0.67–0.7)

respective score. To guide the analyses to identify factors associated with belief in pandemic-related conspiracies, we assessed multicollinearity with the variation inflation factor (VIF) and identified two variables, "empathy" and "main job task," with high collinearity with one or more other variables based on a VIF > 5.

We used multivariable adjusted multinomial logistic regression models to calculate odds ratios (OR) and 95% confidence intervals (CI) for the association between each potential risk factor and belief in COVID-19 pandemic-related conspiracy theories. To develop a final multivariable model, we randomly subdivided the data into a training (70%) and replication dataset (30%). First, we examined a full model with the training data set that included all 32 variables. We then established a reduced model by excluding the two highly collinear variables noted above and other variables that did not improve the model. We then identified the final, most parsimonious model as the subset of variables that minimized the Akaike Information Criterion (AIC; Table S4). Sensitivity analysis was done by three repeated 10-fold cross validation We conducted additional analyses with the final models stratified by a joint classification of participants' and their close contacts' vaccination status to examine potential effect modification by one's social network of associations of other variables with belief in conspiracy theories. We also considered potential effect modification by age, gender, country of residence and type of residential area (urban vs. rural) by conducting additional analyses stratified (separately) by each of those variables.

A two-sided p-value of 0.05 or lower was considered statistically significant. Data analyses were performed using R, version 4.0.5 (R Foundation for Statistical Computing, Vienna, Austria) and SPSS (IBM SPSS Statistics 26.0).

Results

Participant characteristics

In total 3067 survey participants were included in the analyses. Overall, the study participants ranged between 18 and 90 years of age (median: 48 years, interquartile range [IQR]: 34–62), and 48.8% were men (Table 2). Participant responses to the items used to derive the complexity thinking and conspiracy belief scores did not vary markedly by country of residence (Table S2).

The median complexity thinking score was 15 (range 5–20, IQR 13–17), while the median conspiracy belief score was 6 (range 5–20, IQR 5–10). The two scores were modestly inversely correlated (Spearman *r*: − 0.199; $p < 0.001$). Accordingly, participants with a low conspiracy belief score tended to be higher on the complexity thinking scale (Figs. 2 and S4). Cross validation showed a kappa of 0.35, which represents fair agreement. The confusion matrix findings indicated 39.80% overall tertile misclassification and only 23.64% misclassification for the low conspiracy belief tertile (Table S5).

Most sociodemographic and personality characteristics had similar distributions across tertiles of conspiracy belief score (Table 2) and complexity thinking score (Table S6), including when stratified by gender (Table S7), age (Table S8), country of residence (Table S9) or type of residential area (Table S10). Non-White survey participants appeared to be more likely to score in the medium and high tertiles for conspiracy belief than those of White ethnicity, as did those with children younger than age 16 (vs. those with no younger children), whereas participants reporting higher educational attainment and higher household income had comparatively lower conspiracy belief scores (Table 2). For almost all the survey items, the directions of associations with the complexity thinking score were inverse to the directions of their associations with the conspiracy belief score. The few exceptions included living alone, not being married/in a partnership, and not having a chronic disease, which were more prevalent among the participants in the highest tertile for each of the two scores (Table 2).

Characteristics cross-sectionally associated with belief in pandemic-related conspiracies in the D-A-CH region

The factors most strongly associated with an increased likelihood of belief in conspiracies included the joint classification of participant and close contacts' COVID vaccination status; participants reporting that neither they nor their close contacts were vaccinated were 10 times more likely to have a conspiracy belief score in the high tertile ($OR_{T3\ vs.\ T1}$: 10.05, 95% CI 6.88–16.00; $P_{trend} < 0.01$) and four times more likely to score in the medium conspiracy belief tertile ($OR_{T3\ vs.\ T1}$: 4.13, 95% CI 2.78–6.14; $P_{trend} < 0.01$) than participants reporting that both they and their close contacts were vaccinated (Table 3). Individually, the vaccination statuses of participants and of their close contacts were similarly associated with the conspiracy belief score; those not vaccinated were more likely to have higher conspiracy belief scores than those who were vaccinated, and those whose close contacts were not vaccinated had higher conspiracy belief scores than those whose close contacts were vaccinated. Participants reporting a larger number of close contacts also appeared to have lower conspiracy belief scores than participants with smaller numbers of close contacts (Table 3). Additionally, participants who reported regular (at least monthly) attendance at religious meetings were six times more likely to score in the high conspiracy belief tertile ($OR_{T3\ vs.\ T1}$: 6.13, 95% CI 4.35–8.63; $P_{trend} < 0.01$) and ~60% more likely to score in the medium conspiracy belief tertile ($OR_{T3\ vs.\ T1}$: 1.56, 95% CI 1.13–2.17; $P_{trend} = 0.01$) than those who reported never attending religious meetings. Survey participants who did not vote at all or voted for the

Table 2 Characteristics of study population overall and by tertile of derived scores for conspiracy belief

	Overall (N = 3067)	Tertile of conspiracy belief score		
		Low (5 points; N = 1248)	Medium (6–9 points; N = 982)	High (10–20 points; N = 837)
Conspiracy belief score				
Median [IQR]	6.00 [5.00; 10.0]	5.00 [5.00; 5.00]	7.00 [6.00; 8.00]	12.0 [11.0; 15.0]
Complexity thinking score				
Median [IQR]	15.0 [13.0; 17.0]	16.0 [14.0; 17.0]	16.0 [13.0; 17.0]	14.0 [12.0; 16.0]
Age				
Median [IQR]	48.0 [34.0; 62.0]	53.0 [38.0; 64.0]	49.0 [36.0; 62.0]	41.0 [29.0; 54.0]
Gender				
Women	1567 (51.1%)	603 (48.3%)	521 (53.1%)	443 (52.9%)
Men	1498 (48.8%)	645 (51.7%)	460 (46.8%)	393 (47.0%)
Diverse	2 (0.1%)	0 (0%)	1 (0.1%)	1 (0.1%)
Ethnicity				
White	2806 (91.5%)	1180 (94.6%)	888 (90.4%)	738 (88.2%)
Non-White	261 (8.5%)	68 (5.4%)	94 (9.6%)	99 (11.8%)
Migration history				
More than second generation/none	1937 (63.2%)	829 (66.4%)	652 (66.4%)	456 (54.5%)
Second generation	297 (9.7%)	105 (8.4%)	85 (8.7%)	107 (12.8%)
First generation	833 (27.2%)	314 (25.2%)	245 (24.9%)	274 (32.7%)
Country				
Germany	1025 (33.4%)	430 (34.5%)	294 (29.9%)	301 (36.0%)
Austria	1019 (33.2%)	424 (34.0%)	357 (36.4%)	238 (28.4%)
Switzerland	1023 (33.4%)	394 (31.6%)	331 (33.7%)	298 (35.6%)
Living area				

Table 2 (continued)

	Overall (N = 3067)	Tertile of conspiracy belief score		
		Low (5 points; N = 1248)	Medium (6–9 points; N = 982)	High (10–20 points; N = 837)
Urban	1658 (54.1%)	708 (56.7%)	502 (51.1%)	448 (53.5%)
Rural	1409 (45.9%)	540 (43.3%)	480 (48.9%)	389 (46.5%)
Highest educational attainment				
Highschool degree or lower	2337 (76.2%)	872 (69.9%)	775 (78.9%)	690 (82.4%)
University degree	730 (23.8%)	376 (30.1%)	207 (21.1%)	147 (17.6%)
Household income				
Low tertile	1141 (37.2%)	366 (29.3%)	397 (40.4%)	378 (45.2%)
Medium tertile	787 (25.7%)	329 (26.4%)	243 (24.7%)	215 (25.7%)
High tertile	1139 (37.1%)	553 (44.3%)	342 (34.8%)	244 (29.2%)
Living situation				
Alone	952 (31.0%)	356 (28.5%)	306 (31.2%)	290 (34.6%)
Not alone	2115 (69.0%)	892 (71.5%)	676 (68.8%)	547 (65.4%)
Marital status				
Single	913 (29.8%)	340 (27.2%)	297 (30.2%)	276 (33.0%)
Married	1730 (56.4%)	734 (58.8%)	540 (55.0%)	456 (54.5%)
Divorced	333 (10.9%)	132 (10.6%)	113 (11.5%)	88 (10.5%)
Widowed	91 (3.0%)	42 (3.4%)	32 (3.3%)	17 (2.0%)
Number of children under 16 years				
No child that age	2404 (78.4%)	1056 (84.6%)	787 (80.1%)	561 (67.0%)
1 child	368 (12.0%)	118 (9.5%)	99 (10.1%)	151 (18.0%)
2 or more children	295 (9.6%)	74 (5.9%)	96 (9.8%)	125 (14.9%)
Voting behavior (last election)				

Table 2 (continued)

	Overall (N = 3067)	Tertile of conspiracy belief score		
		Low (5 points; N = 1248)	Medium (6–9 points; N = 982)	High (10–20 points; N = 837)
Government party	1416 (46.2%)	671 (53.8%)	425 (43.3%)	320 (38.2%)
Opposition party	775 (25.3%)	324 (26.0%)	261 (26.6%)	190 (22.7%)
Did not vote	876 (28.6%)	253 (20.3%)	296 (30.1%)	327 (39.1%)
Participation at religious meetings				
Never or almost never	2182 (71.1%)	989 (79.2%)	713 (72.6%)	480 (57.3%)
Less than once a month	470 (15.3%)	159 (12.7%)	179 (18.2%)	132 (15.8%)
At least once a month	415 (13.5%)	100 (8.0%)	90 (9.2%)	225 (26.9%)
Work status				
Employed (full/part time)	1603 (52.3%)	601 (48.2%)	496 (50.5%)	506 (60.5%)
Self-employed (full/part time)	194 (6.3%)	83 (6.7%)	65 (6.6%)	46 (5.5%)
Retired	748 (24.4%)	361 (28.9%)	252 (25.7%)	135 (16.1%)
Unemployed	153 (5.0%)	43 (3.4%)	58 (5.9%)	52 (6.2%)
Student/in training	175 (5.7%)	91 (7.3%)	54 (5.5%)	30 (3.6%)
Household	137 (4.5%)	47 (3.8%)	44 (4.5%)	46 (5.5%)
Temporary contract	57 (1.9%)	22 (1.8%)	13 (1.3%)	22 (2.6%)
Main job task				
Physical work, manual labor	510 (16.6%)	125 (10.0%)	160 (16.3%)	225 (26.9%)
Mental work	791 (25.8%)	345 (27.6%)	240 (24.4%)	206 (24.6%)
Social contact, communication with others	678 (22.1%)	296 (23.7%)	221 (22.5%)	161 (19.2%)
Other or no work	1088 (35.5%)	482 (38.6%)	361 (36.8%)	245 (29.3%)
Change in work status				
No change in occupation (but possible change to home-office)	1904 (62.1%)	833 (66.7%)	603 (61.4%)	468 (55.9%)

Table 2 (continued)

	Overall (N = 3067)	Tertile of conspiracy belief score		
		Low (5 points; N = 1248)	Medium (6–9 points; N = 982)	High (10–20 points; N = 837)
Changed to short-time work	293 (9.6%)	76 (6.1%)	104 (10.6%)	113 (13.5%)
Became unemployed	156 (5.1%)	41 (3.3%)	52 (5.3%)	63 (7.5%)
Changed jobs	146 (4.8%)	48 (3.8%)	46 (4.7%)	52 (6.2%)
Mostly charity work	115 (3.7%)	55 (4.4%)	38 (3.9%)	22 (2.6%)
Not employed pre-pandemic, still unemployed	398 (13.0%)	181 (14.5%)	123 (12.5%)	94 (11.2%)
Not employed pre-pandemic, now with job	55 (1.8%)	14 (1.1%)	16 (1.6%)	25 (3.0%)
Contact with a close person (except children) that I can talk to				
Daily	2194 (71.5%)	958 (76.8%)	723 (73.6%)	513 (61.3%)
At least once a week	565 (18.4%)	212 (17.0%)	189 (19.2%)	164 (19.6%)
At least once a month	163 (5.3%)	41 (3.3%)	36 (3.7%)	86 (10.3%)
At least once a year	42 (1.4%)	6 (0.5%)	11 (1.1%)	25 (3.0%)
I do not have anyone to talk to	103 (3.4%)	31 (2.5%)	23 (2.3%)	49 (5.9%)
How many people would you count as your close contacts (family and friends)?				
Median [IQR]	5.00 [3.00; 10.0]	6.00 [4.00; 10.0]	6.00 [4.00; 10.0]	5.00 [2.00; 9.00]
Smoking status				
Never	1284 (41.9%)	566 (45.4%)	390 (39.7%)	328 (39.2%)
Former	839 (27.4%)	359 (28.8%)	277 (28.2%)	203 (24.3%)
Current	944 (30.8%)	323 (25.9%)	315 (32.1%)	306 (36.6%)
Chronic disease				
No	1824 (59.5%)	707 (56.7%)	587 (59.8%)	530 (63.3%)
Yes	1243 (40.5%)	541 (43.3%)	395 (40.2%)	307 (36.7%)
Tested positive for COVID-19				

Table 2 (continued)

	Overall (N = 3067)	Tertile of conspiracy belief score		
		Low (5 points; N = 1248)	Medium (6–9 points; N = 982)	High (10–20 points; N = 837)
No	2850 (92.9%)	1187 (95.1%)	920 (93.7%)	743 (88.8%)
Yes	217 (7.1%)	61 (4.9%)	62 (6.3%)	94 (11.2%)
Approval of the COVID-19 measures implemented by the government				
Yes, fully or mostly	1570 (51.2%)	884 (70.8%)	451 (45.9%)	235 (28.1%)
Yes, partially	1077 (35.1%)	316 (25.3%)	404 (41.1%)	357 (42.7%)
No, they were unnecessary/unjustified	420 (13.7%)	48 (3.8%)	127 (12.9%)	245 (29.3%)
Interpersonal trust				
Low	710 (23.1%)	228 (18.3%)	260 (26.5%)	222 (26.5%)
Medium	1695 (55.3%)	620 (49.7%)	534 (54.4%)	541 (64.6%)
High	662 (21.6%)	400 (32.1%)	188 (19.1%)	74 (8.8%)
Optimism				
Low	1150 (37.5%)	359 (28.8%)	349 (35.5%)	442 (52.8%)
Medium	819 (26.7%)	294 (23.6%)	299 (30.4%)	226 (27.0%)
High	1098 (35.8%)	595 (47.7%)	334 (34.0%)	169 (20.2%)
Perspective taking				
Low	1003 (32.7%)	392 (31.4%)	293 (29.8%)	318 (38.0%)
Medium	810 (26.4%)	315 (25.2%)	278 (28.3%)	217 (25.9%)
High	1254 (40.9%)	541 (43.3%)	411 (41.9%)	302 (36.1%)
Work–life balance				
Low	991 (32.3%)	359 (28.8%)	292 (29.7%)	340 (40.6%)
Medium	976 (31.8%)	329 (26.4%)	346 (35.2%)	301 (36.0%)
High	1100 (35.9%)	560 (44.9%)	344 (35.0%)	196 (23.4%)

Table 2 (continued)

	Overall (N = 3067)	Tertile of conspiracy belief score		
		Low (5 points; N = 1248)	Medium (6–9 points; N = 982)	High (10–20 points; N = 837)
Conscientiousness				
Low	1068 (34.8%)	363 (29.1%)	275 (28.0%)	430 (51.4%)
Medium	896 (29.2%)	385 (30.8%)	308 (31.4%)	203 (24.3%)
High	1103 (36.0%)	500 (40.1%)	399 (40.6%)	204 (24.4%)
Extroversion				
Low	917 (29.9%)	396 (31.7%)	324 (33.0%)	197 (23.5%)
Medium	1079 (35.2%)	390 (31.3%)	311 (31.7%)	378 (45.2%)
High	1071 (34.9%)	462 (37.0%)	347 (35.3%)	262 (31.3%)
Agreeableness				
Low	1115 (36.4%)	386 (30.9%)	323 (32.9%)	406 (48.5%)
Medium	1025 (33.4%)	411 (32.9%)	333 (33.9%)	281 (33.6%)
High	927 (30.2%)	451 (36.1%)	326 (33.2%)	150 (17.9%)
Openness				
Low	1133 (36.9%)	467 (37.4%)	353 (35.9%)	313 (37.4%)
Medium	896 (29.2%)	346 (27.7%)	313 (31.9%)	237 (28.3%)
High	1038 (33.8%)	435 (34.9%)	316 (32.2%)	287 (34.3%)
Neuroticism				
Low	921 (30.0%)	448 (35.9%)	307 (31.3%)	166 (19.8%)
Medium	543 (17.7%)	233 (18.7%)	154 (15.7%)	156 (18.6%)
High	1603 (52.3%)	567 (45.4%)	521 (53.1%)	515 (61.5%)
Cross-classification of participant and close contacts vaccination status				
Self-vaccinated and friends vaccinated	1852 (60.4%)	951 (76.2%)	566 (57.6%)	335 (40.0%)

Table 2 (continued)

	Overall (N = 3067)	Tertile of conspiracy belief score		
		Low (5 points; N = 1248)	Medium (6–9 points; N = 982)	High (10–20 points; N = 837)
Self-vaccinated and friends unvaccinated	628 (20.5%)	230 (18.4%)	216 (22.0%)	182 (21.7%)
Self-unvaccinated and friends vaccinated	164 (5.3%)	28 (2.2%)	53 (5.4%)	83 (9.9%)
Self-unvaccinated and friends unvaccinated	423 (13.8%)	39 (3.1%)	147 (15.0%)	237 (28.3%)

Table 3 Final multinomial logistic regression model for factors associated with tertile of derived conspiracy belief score

Characteristic	Response frequency distributions			Associations with tertile of conspiracy belief score					
	Low conspiracy belief	Medium conspiracy belief	High conspiracy belief	Medium conspiracy belief			High conspiracy belief		
	N = 1248	N = 981	N = 836	OR	95% CI	p value	OR	95% CI	p value
Complexity thinking score									
Low	384 (31%)	367 (37%)	447 (53%)	–	–		–	–	–
Medium	386 (31%)	286 (29%)	219 (26%)	0.84	0.67, 1.06	0.15	0.53	0.40, 0.71	**< 0.01**
High	478 (38%)	328 (33%)	170 (20%)	0.84	0.67, 1.06	0.14	0.43	0.32, 0.57	**< 0.01**
Age									
≤ 25	115 (9.2%)	91 (9.3%)	132 (16%)	–	–		–	–	
26–35	143 (11%)	150 (15%)	184 (22%)	1.32	0.89, 1.96	0.17	0.99	0.64, 1.53	0.96
36–45	207 (17%)	181 (18%)	181 (22%)	1.12	0.76, 1.65	0.57	0.69	0.45, 1.07	0.10
46–55	227 (18%)	181 (18%)	147 (18%)	1.19	0.82, 1.74	0.37	0.77	0.50, 1.19	0.23
56–65	293 (23%)	194 (20%)	109 (13%)	1.11	0.76, 1.63	0.58	0.68	0.43, 1.07	0.09
> 65	263 (21%)	184 (19%)	83 (9.9%)	1.51	1.02, 2.23	**0.04**	0.91	0.56, 1.47	0.70
Gender									
Women	603 (48%)	521 (53%)	443 (53%)	–	–		–	–	
Men	645 (52%)	460 (47%)	393 (47%)	0.97	0.80, 1.18	0.77	1.00	0.79, 1.28	0.97
Ethnicity									
White	1180 (95%)	887 (90%)	737 (88%)	–	–		–	–	
Non-White	68 (5.4%)	94 (9.6%)	99 (12%)	1.62	1.14, 2.30	**< 0.01**	1.82	1.21, 2.73	**< 0.01**
Highest educational attainment									
Highschool degree or lower	872 (70%)	775 (79%)	689 (82%)	–	–		–	–	
University degree	376 (30%)	206 (21%)	147 (18%)	0.75	0.60, 0.94	**0.01**	0.67	0.50, 0.89	**< 0.01**
Household income									

Table 3 (continued)

Characteristic	Response frequency distributions			Associations with tertile of conspiracy belief score					
	Low conspiracy belief	Medium conspiracy belief	High conspiracy belief	Medium conspiracy belief			High conspiracy belief		
	N = 1248	N = 981	N = 836	OR	95% CI	p value	OR	95% CI	p value
Low tertile	366 (29%)	397 (40%)	378 (45%)	–	–		–	–	
Medium tertile	329 (26%)	242 (25%)	215 (26%)	0.71	0.56, 0.90	**< 0.01**	0.77	0.58, 1.03	0.08
High tertile	553 (44%)	342 (35%)	243 (29%)	0.69	0.55, 0.87	**< 0.01**	0.59	0.44, 0.79	**< 0.01**
Number of children under 16 years									
No child that age	1056 (85%)	786 (80%)	561 (67%)	–	–		–	–	
1 child	118 (9.5%)	99 (10%)	150 (18%)	1.01	0.73, 1.40	0.95	1.81	1.26, 2.60	**< 0.01**
2 or more children	74 (5.9%)	96 (9.8%)	125 (15%)	1.51	1.04, 2.20	**0.03**	2.79	1.84, 4.24	**< 0.01**
Voting behavior (last election)									
Government party	671 (54%)	424 (43%)	319 (38%)	–	–		–	–	
Opposition party	324 (26%)	261 (27%)	190 (23%)	1.08	0.86, 1.35	0.52	0.85	0.64, 1.14	0.28
Did not vote	253 (20%)	296 (30%)	327 (39%)	1.27	1.00, 1.61	**0.05**	1.47	1.11, 1.95	0.008
Participation at religious meetings									
Never or almost never	989 (79%)	713 (73%)	480 (57%)	–	–		–	–	
Less than once a month	159 (13%)	179 (18%)	132 (16%)	1.65	1.28, 2.14	**< 0.01**	2.20	1.60, 3.02	**< 0.01**
At least once a month	100 (8.0%)	89 (9.1%)	224 (27%)	1.56	1.13, 2.17	**< 0.01**	6.13	4.35, 8.63	**< 0.01**
How many people would you count as your close contacts (family and friends)?									
No close contacts	182 (15%)	149 (15%)	213 (25%)	–	–		–	–	
Less than 5 close contacts	210 (17%)	169 (17%)	204 (24%)	0.97	0.70, 1.34	0.85	0.67	0.47, 0.96	**0.03**
5–6 close contacts	265 (21%)	214 (22%)	158 (19%)	1.06	0.77, 1.43	0.78	0.47	0.33, 0.68	**< 0.01**
7–10 close contacts	348 (28%)	269 (27%)	145 (17%)	1.01	0.75, 1.36	0.95	0.38	0.26, 0.54	**< 0.01**

Table 3 (continued)

Characteristic	Response frequency distributions			Associations with tertile of conspiracy belief score					
	Low conspiracy belief	Medium conspiracy belief	High conspiracy belief	Medium conspiracy belief			High conspiracy belief		
	N = 1248	N = 981	N = 836	OR	95% CI	p value	OR	95% CI	p value
More than 11 close contacts	243 (19%)	180 (18%)	116 (14%)	1.08	0.78, 1.50	0.63	0.55	0.37, 0.81	**< 0.01**
Smoking status									
Never	566 (45%)	389 (40%)	327 (39%)	–	–		–	–	
Former	359 (29%)	277 (28%)	203 (24%)	1.19	0.95, 1.50	0.13	1.26	0.95, 1.69	0.11
Current	323 (26%)	315 (32%)	306 (37%)	1.35	1.08, 1.70	**< 0.01**	1.68	1.27, 2.21	**< 0.01**
Tested positive for COVID-19									
No	1187 (95%)	920 (94%)	742 (89%)	–	–		–	–	
Yes	61 (4.9%)	61 (6.2%)	94 (11%)	1.20	0.81, 1.79	0.37	1.85	1.20, 2.86	**< 0.01**
Approval of the COVID-19 measures implemented by the government									
Yes, fully or mostly	884 (71%)	451 (46%)	234 (28%)	–	–		–	–	
Yes, partially	316 (25%)	403 (41%)	357 (43%)	2.14	1.74, 2.62	**< 0.01**	3.12	2.41, 4.03	**< 0.01**
No, they were unnecessary/unjustified	48 (3.8%)	127 (13%)	245 (29%)	3.67	2.48, 5.41	**< 0.01**	10.02	6.74, 15.5	**< 0.01**
Interpersonal trust									
Low	228 (18%)	260 (27%)	221 (26%)	–	–		–	–	
Medium	620 (50%)	534 (54%)	541 (65%)	0.89	0.70, 1.13	0.32	1.25	0.94, 1.68	0.12
High	400 (32%)	187 (19%)	74 (8.9%)	0.59	0.43, 0.79	**< 0.01**	0.49	0.32, 0.75	**< 0.01**
Optimism									
Low	359 (29%)	348 (35%)	441 (53%)	–	–		–	–	
Medium	294 (24%)	299 (30%)	226 (27%)	1.14	0.90, 1.46	0.28	0.72	0.54, 0.96	**0.02**

Table 3 (continued)

Characteristic	Response frequency distributions			Associations with tertile of conspiracy belief score					
	Low conspiracy belief	Medium conspiracy belief	High conspiracy belief	Medium conspiracy belief			High conspiracy belief		
	N = 1248	N = 981	N = 836	OR	95% CI	p value	OR	95% CI	p value
High	595 (48%)	334 (34%)	169 (20%)	0.71	0.55, 0.92	**< 0.01**	0.41	0.30, 0.56	**< 0.01**
Perspective taking									
Low	392 (31%)	292 (30%)	317 (38%)	–	–		–	–	
Medium	315 (25%)	278 (28%)	217 (26%)	1.29	1.00, 1.65	**0.05**	1.18	0.87, 1.61	0.28
High	541 (43%)	411 (42%)	302 (36%)	1.33	1.03, 1.71	**0.03**	1.21	0.89, 1.66	0.23
Work life balance									
Low	359 (29%)	292 (30%)	339 (41%)	–	–		–	–	
Medium	329 (26%)	345 (35%)	301 (36%)	1.46	1.15, 1.86	**< 0.01**	1.39	1.05, 1.86	**0.02**
High	560 (45%)	344 (35%)	196 (23%)	0.92	0.72, 1.19	0.54	0.89	0.65, 1.23	0.50
Conscientiousness									
Low	363 (29%)	275 (28%)	429 (51%)	–	–		–	–	
Medium	385 (31%)	307 (31%)	203 (24%)	1.12	0.88, 1.44	0.36	0.67	0.50, 0.91	**< 0.01**
High	500 (40%)	399 (41%)	204 (24%)	1.30	1.01, 1.68	**0.04**	0.73	0.53, 1.01	0.06
Extroversion									
Low	396 (32%)	324 (33%)	196 (23%)	–	–		–	–	
Medium	390 (31%)	311 (32%)	378 (45%)	0.93	0.74, 1.17	0.54	1.99	1.49, 2.67	**< 0.01**
High	462 (37%)	346 (35%)	262 (31%)	0.91	0.71, 1.15	0.42	1.71	1.24, 2.35	**< 0.01**
Agreeableness									
Low	386 (31%)	322 (33%)	405 (48%)	–	–		–	–	
Medium	411 (33%)	333 (34%)	281 (34%)	1.08	0.85, 1.37	0.53	1.01	0.76, 1.34	0.97

Table 3 (continued)

Characteristic	Response frequency distributions			Associations with tertile of conspiracy belief score					
	Low conspiracy belief	Medium conspiracy belief	High conspiracy belief	Medium conspiracy belief			High conspiracy belief		
	N = 1248	N = 981	N = 836	OR	95% CI	p value	OR	95% CI	p value
High	451 (36%)	326 (33%)	150 (18%)	0.95	0.73, 1.23	0.68	0.59	0.42, 0.83	**< 0.01**
Openness									
Low	467 (37%)	352 (36%)	313 (37%)	–	–		–	–	
Medium	346 (28%)	313 (32%)	237 (28%)	1.26	1.00, 1.58	0.06	1.23	0.92, 1.64	0.17
High	435 (35%)	316 (32%)	286 (34%)	1.03	0.81, 1.31	0.81	1.42	1.05, 1.93	**0.02**
Cross-classification of participant and close contacts vaccination status									
Self-vaccinated and friends vaccinated	951 (76%)	566 (58%)	334 (40%)	–	–		–	–	
Self-vaccinated and friends unvaccinated	230 (18%)	216 (22%)	182 (22%)	1.27	1.00, 1.60	**0.05**	1.37	1.02, 1.82	**0.03**
Self-unvaccinated and friends vaccinated	28 (2.2%)	53 (5.4%)	83 (9.9%)	2.26	1.37, 3.72	**< 0.01**	6.03	3.55, 10.3	**< 0.01**
Self-unvaccinated and friends unvaccinated	39 (3.1%)	146 (15%)	237 (28%)	4.13	2.78, 6.14	**< 0.01**	10.05	6.88, 16.0	**< 0.01**

OR odds ratio, *CI* confidence interval. Bold p values are statistically significant

opposing party in the last elections were also more likely to score in the high tertile for conspiracy belief than those who voted for a governing party, as were current smokers compared to past or never smokers, participants with a history of a positive COVID test (vs. no history) and those reporting partial or non-approval of government measures to mitigate the pandemic (vs. approval). Participants with higher extroversion also had higher conspiracy belief scores than those with lesser extroversion (Table 3).

Figure 3 shows a visualization of the most important risk and protective factors for COVID-19 pandemic-related conspiracy belief.

For the characteristics that were cross-sectionally associated with belief in pandemic-related conspiracies, subgroup analyses were performed stratified by gender (Table S11), age (Tables S12, S13), country of residence (Table S14) and type of residential area (Table S15). Across all subgroups, individuals who were unvaccinated themselves and had unvaccinated close contacts exhibited the strongest association with higher conspiracy belief scores. Further analyses exploring potential effect modification by age showed that not voting at the last respective national elections ($OR_{T3\ vs.\ T1}$: 3.08, 1.16–8.18; $P_{trend} = 0.02$) and at least monthly participation at religious meetings ($OR_{T3\ vs.\ T1}$: 21.09, 6.43–74.30; $P_{trend} < 0.01$) were each positively associated with belief in conspiracies among participants aged 18 to 25 years (Tables S12, S13). Additionally, having one ($OR_{T3\ vs.\ T1}$: 3.63, 1.43–9.19; $P_{trend} < 0.01$) or more children ($OR_{T3\ vs.\ T1}$: 5.17, 1.71–15.70; $P_{trend} < 0.01$) under 16 years old was only associated with higher conspiracy belief score for participants aged 26–35 years (Table S12). Furthermore, in the subgroup analysis by country of residence, the association between testing positive for COVID-19 and higher conspiracy belief scores was observed only among participants residing in Austria ($OR_{T3\ vs.\ T1}$: 2.67, 1.26–5.68; $P_{trend} < 0.01$) (Table S14).

Education and socioeconomic factors inversely associated with belief in pandemic-related conspiracy theories

In survey participants who had a university degree, belonging to the group with high conspiracy belief scores was 33% less likely ($OR_{T3\ vs.\ T1}$: 0.67, 0.50–0.89; $P_{trend} < 0.01$), and having a medium conspiracy belief score was 25% less likely ($OR_{T2\ vs.\ T1}$: 0.75, 0.60–0.94; $P_{trend} < 0.01$), compared to high school graduates or equivalents. When stratified by gender, the inverse association between higher education and conspiracy belief was statistically significant for men but not women ($OR_{T3\ vs.\ T1}$: 0.61, 0.40–0.93; $P_{trend} = 0.02$ and $OR_{T2\ vs.\ T1}$: 0.68, 0.49–0.93; $P_{trend} = 0.02$) (Table S11). University graduates from Austria and Switzerland were 48% less likely to be in the high conspiracy belief tertile than in the low tertile ($P_{trend} = 0.03$; Table S14), while this association was not observed in the study participants from Germany. In subgroup analyses conducted to examine the potential influence of urban and rural residence, the observed association of higher education with lower conspiracy belief scores appeared for participants living in rural areas ($OR_{T3\ vs.\ T1}$: 0.56, 0.35–0.92; $P_{trend} = 0.02$) and not for those living in urban areas (Table S15).

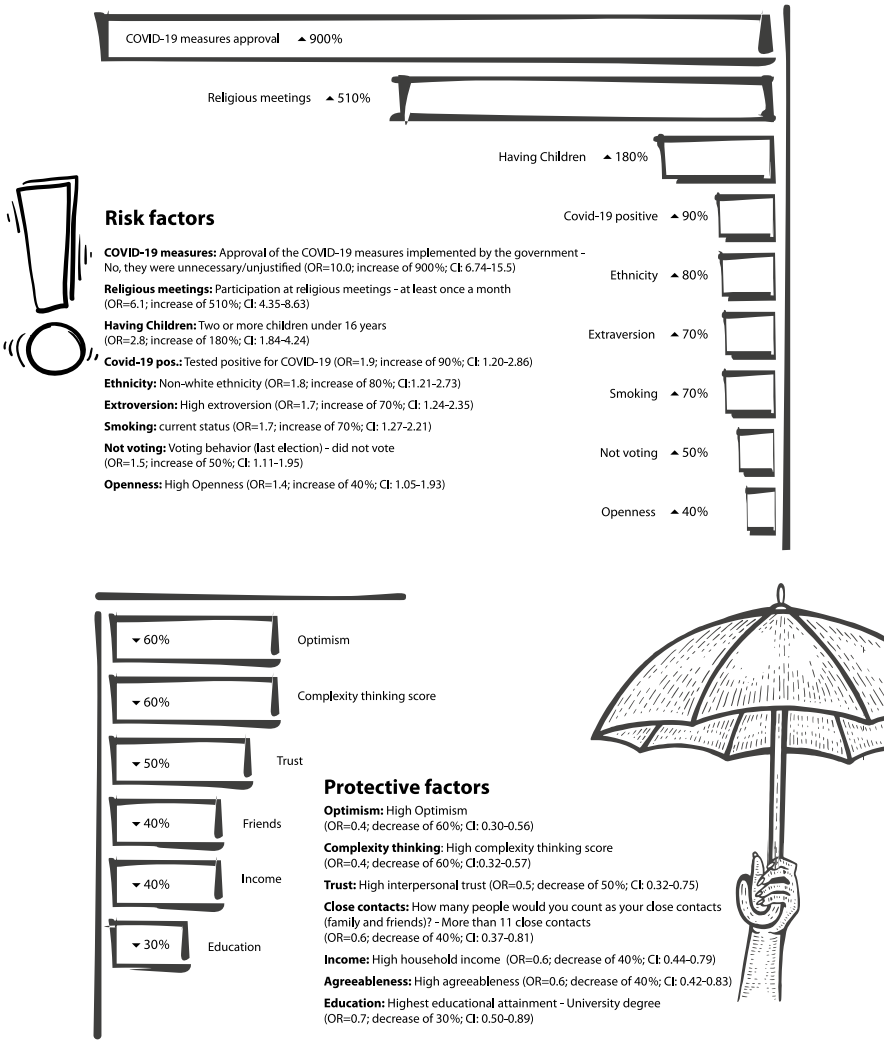

Fig. 3 Main risk and protective factors associated with high belief in pandemic-related conspiracies. The size of the bars relates to the magnitude of the calculated odds ratio (OR). OR > 1 indicates a positive association (i.e., risk factors; e.g., OR = 10 signifies a 10-times higher odds of high belief in pandemic-related conspiracies or an increase of about 900%); OR < 1 indicates an inverse association (i.e., protective factors; e.g., OR = 0.50 signifies half the odds of high belief in pandemic-related conspiracies, or a decrease of about 50%)

Complexity thinking and interpersonal trust associated with lower conspiracy belief scores

Factors that were inversely associated with the conspiracy belief score included the derived complexity thinking score, optimism, and trust. Participants with a complexity thinking score in the highest tertile were 57% less likely ($OR_{T3\ vs.\ T1}$: 0.43, 95% CI 0.32–0.57; $P_{trend} < 0.01$) and those with medium complexity thinking scores 47% less likely to have high conspiracy belief scores ($OR_{T3\ vs.\ T1}$: 0.53, 95% CI 0.40–0.71; $P_{trend} < 0.01$) compared to participants scoring lower for complexity thinking. Further, participants in the high tertile for optimism were 59% less likely than those in the low tertile to have high conspiracy belief scores ($OR_{T3\ vs.\ T1}$: 0.41, 95% CI 0.30–0.56, $P_{trend} < 0.01$). Similarly, participants in the high tertile for trust were 51% less likely than those in the low tertile to have high conspiracy belief scores ($OR_{T3\ vs.\ T1}$: 0.49, 0.32–0.75, $P_{trend} < 0.01$) (Table 3).

Stratification by gender showed an inverse association between a higher compared to a lower complexity thinking score for both women ($OR_{T3\ vs.\ T1}$: 0.32, 0.21–0.49; $P_{trend} < 0.01$) and men ($OR_{T3\ vs.\ T1}$: 0.52, 0.34–0.80; $P_{trend} < 0.01$) (Table S11). Similarly, trust and optimism were both inversely associated with high conspiracy belief across both genders (Table S11). In participants residing in an urban area, interpersonal trust ($OR_{T3\ vs.\ T1}$: 0.45, 0.25–0.81; $P_{trend} < 0.01$) was inversely associated with the conspiracy belief score (Table S15).

Discussion

In our study, we aimed to identify factors associated with higher belief in COVID-19 conspiracy theories and observed that belief in pandemic-related conspiracies was inversely related to complexity thinking. We found further inverse associations between conspiracy belief and optimism and trust, as well as positive associations with being unvaccinated (particularly when the respondents had unvaccinated close contacts), regular participation in religious meetings, not having voted for the current governing party in the last elections, current smoking, a prior positive test for COVID-19, limited approval of COVID-19 mitigation measures, and extroversion. Overall, our data suggest that the persons at the greatest risk of believing in COVID-19 conspiracy theories are those with low optimism, low complexity thinking, a low level of education, with one or more children younger than 16 years, and those with fewer direct social contacts, as well as those who were less interested in participating in the political discourse, more unlikely to get vaccinated and more likely to attend religious events at least monthly. Of note, simultaneously, persons with a high conspiracy belief score tended also to self-report as more extroverted and open. In the next paragraphs, we discuss some specific points that emerge from our study and that contribute to a more nuanced understanding of factors and associations underpinning people's belief in conspiracy theories related to the COVID-19 pandemic.

COVID-mitigation measures, politics and vaccine hesitancy

It is important to note the time at which the survey was conducted: hopefulness and optimism could be assumed to have been fairly high during the summer of 2021, given the gradual easing of COVID-19 restrictions and a general expectation that the pandemic may already be over. This observation is even more compelling in hindsight, as the COVID wave with the delta variant, which led to another uptick in numbers of more severe cases, which had not hit the D-A-CH region yet at that time. The three countries in the D-A-CH region had similar COVID mitigation strategies with high-volume tests and contact tracing, lockdowns (nationwide or by federal state/canton) and restrictions on gatherings. Thus, the resulting lack of social interactions due to pandemic mitigation policies as well as the increased levels of uncertainty dominating political life have previously been identified as important factors contributing to an increase in belief in conspiracy theory (Bierwiaczonek et al. 2020). Furthermore, in the US, the belief in conspiracies was shown to be widespread across the entire political spectrum, which may illustrate a reduced willingness to engage in complexity-based and nuanced explanations of events due also to sensationalized news coverage (Oliver and Wood 2014). Even more so, digital media consumption and frequent exposure to politicians were both associated with a higher likelihood of conspiracy belief (De Coninck et al. 2021; Konstantinou et al. 2021).

Mistrust in the government is known to have many real-world implications, one of them manifesting as vaccine hesitancy during the COVID-19 pandemic (Colautti et al. 2022). Vaccine hesitancy, which may be a result of intentional or accidental misinformation, is damaging to confidence in forthcoming health policies (Lebernegg and Eberl 2021). At the time of our survey the inoculation rate picked up speed, as the previous prioritization of who received a dose of the vaccine was lifted. So, participants with low approval of the COVID-19 measures and being unvaccinated could be ascertained to have a more adverse attitude towards the COVID vaccine. However, our survey did not have a question to directly measure the degree of vaccine hesitancy of the participants, rather only the current vaccination status of the participants themselves and their close contacts.

While vaccine hesitancy was present before this latest pandemic, its potential to polarize society increased manyfold during discussions surrounding COVID-19 vaccine mandates (Hirsch and Kotkamp 2021). This raised several human rights concerns, such as freedom of opinion and expression and the right to life and liberty, impacting both proponents and opponents of vaccination. It has been suggested that political biases, frequency of social contact with other people, economic status, and level of trust in scientists influenced the willingness for vaccine uptake (Hao and Shao 2022; Mascia et al. 2020; Stoler et al. 2022). Interestingly, in a data analysis across 23 countries in 2021 assessing COVID-19 vaccine hesitancy, Germany was among the countries with the lowest support of vaccine mandates (Lazarus et al. 2022). Conversely, just a year later the German federal constitutional court ruled on the legality of a different vaccination, namely for measles, to ensure an adequate degree of herd immunity (BVerfG, Beschluss des Ersten Senats vom 21. Juli 2022). Across the border, however, the Austrian government suspended the proposed COVID-19 vaccine mandate only four months after announcing it and before

it came to fruition. While a scientific basis to support the mandate was lacking and thus driving its suspension, the backlash due to the fear of disproportionate governmental control and its consequences were also important factors. Public trust and trust in the government play an important role in this regard, and trust in different institutions may vary depending on the perceptions of their response to the pandemic (Reid et al. 2023). Likewise, in the case of perceived outgroup threats, which play important factor in conspiracy theories, the likelihood to support stricter immigration control measures were associated with the belief that the virus was leaked from China (Kim and Park 2023). Another study found a link between conspiracy thinking and the preference for direct rather than representative democracy, feelings of societal marginalization, and heightened dissent (Pantazi et al. 2022), the latter factors being also relevant in relation to criminal justice and crime prevention measures. Thus, conspiracy belief during the pandemic does not merely have implications for support of public health measures but also involves aspects of security and democracy.

Complexity thinking and psychological factors in pandemic-related conspiracy beliefs

Most of the COVID-19 conspiracy theories have several factors in common: they envision a purpose and specific rationale for why the pandemic occurred, who is responsible, and how and by what means the virus is being intentionally spread (van Mulukom et al. 2022). While many people consider these theories far-fetched, numerous others feel vindicated and agree with these statements. A 2014 study found that the feeling of powerlessness and refuge-seeking behavior in conspiracy thoughts may come as negative consequences of social and political disengagement (Jolley and Douglas 2014). People's denial of scientific findings may be a consequence of the thought process leading them to escape uncertainty during the COVID-19 pandemic by holding on to information from unvalidated sources (Allington et al. 2021).

The results of our study suggest that people with a higher score in complexity thinking are not as likely to believe in these oversimplified conspiracy theories and are better equipped to live with uncertainty and adjust to the related dynamic changes. Likewise, in a study with mostly British participants, self-identified rational thinkers were less likely to endorse conspiracy beliefs compared to people more disposed to intuitive or emotional thinking (Jones et al. 2023). We identified higher levels of trust and optimism as inversely associated with pandemic-related conspiracy belief, which is in line with results from other studies (Allington et al. 2021; Sturgis et al. 2021; Walter and Drochon 2022).

Additionally, in our analyses, extroversion was associated with the top tertile of pandemic-related conspiracy belief. However, individual personality factors from the "Big Five" were not found to be associated with conspiracy beliefs in a large meta-analysis (Goreis and Voracek 2019). Furthermore, prior literature associated belief in COVID-19 conspiracies with less institutional trust, less support for governmental regulations, and thus, to an extent, also less adoption of physical

distancing, which all have relevant societal implications (Pummerer et al. 2022). Unfortunately, loss of confidence and optimism can occur quickly, in contrast to the process of rectifying distrust, which takes time and effort. Therefore, rebuilding social trust and establishing effective communication strategies will be essential in any future pandemics (Svoboda 2022). Moreover, data from a cross-nationality study showed that deliberative and more analytical thinking was less associated with COVID-19 conspiracy beliefs (Kantorowicz-Reznichenko et al. 2022). This is supported by our finding of higher complexity thinking being associated with less conspiracy belief, and thus, encouragement of people to become more reflective in their thought process may reduce their susceptibility to conspiracy belief.

Promotion of education and science diplomacy

In our survey data, across different subgroup analyses, educational attainment was inversely associated with conspiracy belief. Education is an important factor that can increase cognitive capacity for complexity by teaching people to think analytically and to become accustomed to recognizing the nuances of various complex situations rather than oversimplifying them (Uscinski 2018). As science is a dynamic process of continual change informed by the newest discoveries, people with lower education might not be accustomed to dealing with this process (Sturgis et al. 2021). Thus, they tend to hold tightly to their beliefs while not being open to discussing their reasonings or sources of information. Yet, having achieved a higher degree of formal education does not necessarily mean a greater complexity understanding but only a higher likelihood of being classified as higher for both factors. More importantly, mistrust in scientific information and COVID-19 conspiracy beliefs were closely linked to reduced willingness to accept and follow recommended preventive measures (Hartmann and Müller 2023). Misinformation can easily be spread throughout social media, garnering attention through internet celebrities, who can use their influence and authority within their following by disseminating harmful and scientifically false advice (Baker 2022). When people feel at ease in environments that resemble an echo chamber and the setting affirms their fears or skepticism, they are more likely to turn towards conspiracy theories as they do not comprehend the scientific discourse and lose trust in the mainstream recommendations (Walter and Drochon 2022). Therefore, focusing on education on complexity thinking could represent a valuable long-term strategy for reducing the likelihood of conspiracy belief. Studies with more detailed assessment of education and validated scales for complexity thinking are needed in this regard. A proposed theoretical framework for cognitive styles based on a nested model of analytic reasoning, critical thinking and scientific reasoning (Gjoneska 2021) could be integrated for further study of complexity thinking. Similarly, science diplomacy, here defined as diplomacy for science (i.e. by negotiation of research and development agreements to facilitate international scientific collaborations), has been a key factor in dealing with the pandemic (Royal Society (The) 2010). The publication of the genetic code of the novel SARS-CoV-2 in early January of 2020 to download easily and further research on is a prime example of the positive impact of science diplomacy

(Mesot 2022). Diplomatic actions and negotiations can lead to agreements on data sharing, joint research initiatives, and the coordinated distribution research materials and methods. By prioritizing diplomacy for science, nations can collectively work to combat misinformation and ensure that more accurate information reaches the population. Furthermore, science diplomacy will be important for future complex societal challenges, such as the climate crisis or scarcity of resource supplies.

Strengths and limitations

Strengths of our study include its large sample size, unique set of questions surveyed, and the representativeness of our findings as far as the German speaking D-A-CH region is concerned. Comparable data sets from three different countries allowed for comparison across countries. The main limitations of this study include its cross-sectional nature and reliance on self-report for many variables, which may introduce response bias and non-response bias. The results of this study may not be generalizable to a global scale, because all participants resided in similar Central European, German-speaking countries with a more or less comparable approach of the government to contain the spread of the SARS-CoV-2 virus. Also noteworthy is the timing of the survey, which was just a few months after vaccines became available to all and before there were studies showing that booster vaccinations were becoming necessary. The degree of prior or general belief in conspiracy theories for the study population was not established, thus the extent of conspiracy belief linked specifically to the pandemic is not clear. However, the conspiracy belief scale introduced in this study categorized participants into low, medium and high tertile of conspiracy belief, which allowed for classification on an ordinal scale. The survey did not gather data on preferred type of media consumption, which was shown to influence the type of information people choose to believe (Dow et al. 2021; Jennings et al. 2021). Furthermore, generalizability to the whole population within the D-A-CH region may be limited by the characteristics of an online survey, which may underrepresent people beyond the age of 70 due to their lesser use of digital media; further, the study did not address non-German speaking citizens of the surveyed regions. Another limitation pertains to the tools we developed to assess pandemic-related conspiracy belief and complexity thinking in our participants. No validated tools existed at the time of survey conception, and we developed our own scales based on plausible questions to elicit the propensity for conspiratorial as well as complexity thinking. Obviously, these tools would require more formal validation for further use, but given the plausible associations we could show, we believe that they likely depict relevant characteristics. A validated general conspiracy belief score had been created but was focused more on general conspiracy belief than on pandemic-related conspiracies (Brotherton et al. 2013). Nevertheless, our survey questions and items assessing pandemic-related conspiracies were formulated in a similar way in their wording and were examined for internal reliability, collinearity and cross validation.

Conclusion

This study aimed to identify factors associated with increased pandemic-related conspiracy theories in the D-A-CH region using a newly developed conspiracy belief score. It is encouraging to note that forty percent of the studied population did not endorse any of the conspiracy theories surrounding the COVID-19 pandemic. At the same time, it is concerning that a small but notable number of individuals displayed a high level of conspiracy belief, which was found to be strongly linked to a reduced likelihood of endorsing vaccination for themselves or others.

Future real-world implication

Thus, the data obtained from this survey holds valuable insights that can contribute to informed discussions in inter- and transdisciplinary discourses and at the international level, particularly, in science diplomacy forums. The consideration of potential conspiracy beliefs in decision-making processes is important in international cooperation as well: Here, the utilization of scientific collaboration and findings such as those in our study can be essential for diplomatic relations that aim to address global challenges such as viral threats. Therefore, the interplay between scientists, diplomats, and policymakers as part of an interdisciplinary discourse is of key importance as a countermeasure to conspiracy thinking as it facilitates trust-based mutual learning and dialogue.

To counteract the proliferation of misinformation and thus improve public health strategies, it is critical to address the groups identified with characteristics that correlate with high conspiracy belief scores. One potential approach is through targeted interventions aimed at fostering complexity thinking during early schooling. By equipping the younger generations with critical thinking skills and strengthening the mutual learning between science and society (i.e., transdisciplinarity, see, e.g., Scholz and Steiner 2015; Steiner and Laws 2006), resilience against a tendency to believe conspiracy narratives can be increased.

Beyond educational institutions, it is crucial to recognize the non-negotiable impact of conspiracy beliefs on policy-making and "One Health" initiatives. These beliefs can influence decision-making processes and hinder the implementation of evidence-based public health measures. Therefore, policymakers and health authorities must be aware of these dynamics and work to build trust and communicate transparently with the public. Yet, the criminal justice system and legislative government bodies should not discriminate against individuals according to their tendency to believe in one conspiracy theory or another. Moreover, by engaging in open dialogue, we can collectively address the root causes of conspiracy beliefs and develop comprehensive strategies to combat misinformation effectively.

In light of the complexity and sensitivity of the issue, we would caution against inferring direct policy recommendations based on our survey findings. Instead, we propose that the data and discussion points be used both for developing inter- and transdisciplinary approaches and for crafting evidence-based policies and interventions, such as in educational settings. Our study focusing on the

DACH region suggests that, by nurturing critical thinking and fostering science diplomacy, we can support more informed and resilient ways to address complex societal challenges of our times.

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Data availability All data generated or analysed during this study are included in this published article and its supplementary information files.

Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical approval The study was exempt from Institutional Review Board approval according to Federal Regulations 45 CFR 46.10(b).

Informed consent Informed consent was not required, as the participation in the questionnaire indicated voluntary contribution.

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