INFORMATION, COMMUNICATION & SOCIETY
2023, VOL. 26, NO. 16, 3133–3156
https://doi.org/10.1080/1369118X.2022.2146983

Routledge
Taylor & Francis Group

Perceived prevalence of misinformation fuels worries about COVID-19: a cross-country, multi-method investigation

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ABSTRACT

Data suggests that the majority of citizens in various countries came across 'fake news' during the COVID-19 pandemic. We test the relationship between perceived prevalence of misinformation and people's worries about COVID-19. In Study 1, analyses of a survey across 17 countries indicate a positive association: perceptions of high prevalence of misinformation are correlated with high worries about COVID-19. However, the relationship is weaker in countries with higher levels of case-fatality ratios, and independent from the actual amount of misinformation per country. Study 2 replicates the relationship using experimental data. Furthermore, Study 2 demonstrates the underlying mechanism, that is, perceived prevalence of misinformation fosters the belief that COVID-19 is spiralling out of control, which in turn, increases worries. Our findings suggest that perceived prevalence of misinformation can have significant psychological effects, even though audience members reject the information as being false.

ARTICLE HISTORY
Received 22 December 2021
Accepted 16 October 2022

KEYWORDS
COVID-19; misinformation; worry; trust

In December 2019, first reports about a novel coronavirus, later entitled SARS-CoV-2, emerged in Wuhan, China. Within a few months, the virus reached virtually all parts of the world leading to a global pandemic with more than 3,000,000 deaths as of April 2021. Governments and political leaders around the world have attempted to reduce the spreading of the virus by introducing drastic measures, such as lockdowns, curfews,

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and more recently, rapid vaccinations. The success of those measures crucially depends on the information environment, and most importantly, the spread of misinformation about COVID-19. Misinformation, defined as misleading or false information (Fletcher, 2018), ranged from questioning the existence of COVID-19, providing alternative but false health advice to prevent infections (i.e., injecting disinfectants) to blatant conspiracy theories (Ali, 2020; Humprecht, 2019). Such misinformation has prompted the World Health Organization to warn of an ongoing 'infodemic' (World Health Organization, 2020). In fact, recent data suggest that the majority of citizens in various countries believe that they have been exposed to 'fake news' during the crisis (Nielsen et al., 2020). Perceived prevalence of misinformation may have significant psychological consequences, such as worries about the pandemic. Yet, the implications of perceived misinformation for dealing with COVID-19 remain underexplored.

As one important outcome, reactions related to COVID-19, such as worries about getting infected, or about personal and country-wide economic consequences, may shape citizens' behaviours during the crisis, including the willingness to comply with restrictions or vaccine hesitancy. Furthermore, such worries may have detrimental health effects, such as sleep problems, depressive tendencies, or psychotic disorders (see Fitzpatrick et al., 2020; Yue et al., 2021; Yue et al., 2022). Against this background, examining people's worries about the pandemic might help to understand some of the roots of the negative implications of the pandemic. In this paper, we therefore asked in a general research question how online perceived misinformation influences people's worries about the pandemic.

We theorize that perceived exposure to misinformation may increase worries. We test this relationship using a unique cross-national survey tapping the perceived prevalence of misinformation by more than 28,000 individuals across 17 countries. Besides estimating the effects of perceived misinformation on worries, we also explore two specific research questions the influence of macro-level factors such as the cross-country variation in misinformation prevalence (Gallotti et al., 2020) and COVID-19 related case-fatality ratios. Since the cross-national survey data do not allow causal conclusions, we apply propensity score matching to test the robustness of our findings and to test against selection effects (Rubin & Thomas, 2000). To further validate the survey findings, we conducted an experimental study, directly manipulating perceived prevalence of misinformation and measuring the underlying mechanism, the belief that COVID-19 is spiralling out of control when misinformation prevails.

Misinformation and COVID-19

The term disinformation is often used interchangeably with the term misinformation, or the colloquial term 'fake news'. Misinformation, however, is not the same as disinformation. Misinformation can be understood as 'information that is false, but not created with the intention of causing harm' (Wardle & Derakhshan, 2017, p. 20). By contrast, disinformation can be defined as 'false, inaccurate, or misleading information designed, presented and promoted to intentionally cause public harm or for profit' (High Level Experts Group, 2018, p. 10). Since, in this study, we cannot make claims about the intentions behind the falsified information, we use the term misinformation. As recommended by Wardle and Derakhshan (2017), we furthermore

refrain from the polarized and imprecise term 'fake news'. We are also not using the terms conspiracy theory or conspiracy beliefs, which refer to the belief in secret plots by powerful individuals or organizations (Douglas et al., 2019). We generally focus on perception of information veracity, no matter the intent or nature of the belief, and therefore use the term misinformation.

Studies indicate that misinformation has been quite prevalent during the COVID-19 crisis. For instance, a recent study suggests that people in the United States and United Kingdom believed several falsehoods that were spread on social media (Geldsetzer, 2020). According to Li et al. (2020), 25% of the most viewed COVID-19 related YouTube videos contained misleading information, totalling 62 million views worldwide. Typical misinformation included stories about the alternative cures such as the use of chloroquine, vulnerability based on ethnicity, the intentional use of the virus as a secret Chinese bioweapon, low mortality numbers, or the statement that COVID-19 is not more dangerous than a typical flu, just to name a few (e.g., Evanega et al., 2020).

When looking at the effects of exposure to misinformation more generally, there are two different research logics. Following an *attitudinal logic*, the key interest is to understand who actually believes in misinformation (Hameleers & van der Meer, 2019; Walter & Murphy, 2018; Zerback et al., 2020). Here, the theory is that misinformation spreads and impacts attitudes due to its psychological appeal (Zerback et al., 2020). There is a flourishing literature building on psychological mechanisms trying to explain how and why people are affected by misinformation (or disinformation), mostly stemming from the idea that people are 'cognitive misers', using heuristics in decision-making (Tversky & Kahneman, 1974). The self-confirmation heuristic (Metzger et al., 2010), for instance, makes people evaluate information as credible when it confirms their prior beliefs. This heuristic is another way of interpreting the confirmation bias (Nickerson, 1998), which explains why people tend to believe information that confirms their existing beliefs. Once established, misinformation is hard to correct, even when people learn that the information was false (Huang & Wang, 2020). In the last years, research has shown that effects of misinformation could take many forms, from individual level behaviours, such as engagement with questionable information (Corbu et al., 2020; Glenski et al., 2020), resistance to correction efforts (Hameleers & van der Meer, 2019; Walter & Murphy, 2018), persuasive effects (Zerback et al., 2020), contextual behavioural effects, such as vaccine hesitancy (Wilson & Wiysonge, 2020) or societal effects (McKay & Tenove, 2020). Additionally, recent studies looked into possible measures to limit such effects (Hameleers, 2020; Vraga & Tully, 2021)

Following a *perception logic*, individuals can have the impression that misinformation is prevalent in online information environments, even *though they do not accept and/or believe in it*. That is, this line of research deals with consequences of perceived misinformation. Studies using the perception logic are scarce to date (Jones-Jang et al., 2020; Van Duyn & Collier, 2019). They build on the distinction between 'fake news' as a genre and as a label (Egelhofer & Lecheler, 2019) and investigate effects of elites' discourse about 'fake news' on media trust (Van Duyn & Collier, 2019) or effects of perceptions about mis- and disinformation on political cynicism (Jones-Jang et al., 2020). More specifically, whenever scholars ask respondents whether or not they have seen or heard false information, we can speak of a perception logic. That is, the attitudinal logic studies those individuals who actually believe in the misinformation. The perception logic, by contrast,

is concerned with the much larger (and in previous research largely ignored) group, *those who do not believe in the misinformation*. A perception logic is important because the perception of widespread misinformation can affect individual attitudes and behaviours. This paper follows the perception approach. We study the psychological consequences of citizens' perception that there is frequent misinformation. By definition, when citizens characterize information as misinformation (and share that impression in a survey), they do not accept that information and regard it as false. Thus, we study the *effects of the impression that misinformation is generally prevalent*.

Misinformation and Worries about COVID-19

Worries about one's personal, social and economic environment have been documented to highly increase in times of crisis, such as the COVID-19 pandemic (Barber & Kim, 2021; Dryhurst et al., 2020; Taylor et al., 2020). Worry is not an emotion, but can be defined as a cognitive activity that involves negative thoughts about an ambiguous or uncertain issue (Jensen et al., 2010). Since the pandemic is characterized by enormous uncertainties, worry is an important cognitive activity, potentially driving behaviours (Coifman et al., 2021). More specifically, studies investigating worries during the COVID-19 crisis have looked into both personal fears, such as perceived risks for self and loved ones (Coifman et al., 2021; He et al., 2021), economic worries (Mann et al., 2020), or both (Bareket-Bojmel et al., 2020). To date, there is an increasing body of knowledge investigating consequences of worries in times of crisis (including health crises) (e.g., de Bruin & Bennett, 2020; Fitzpatrick et al., 2020; Wong & Jensen, 2020). Studies considering worries related to COVID-19 as a dependent variable have found correlations with personal experience with the virus, preventive health behaviours (Dryhurst et al., 2020), or news consumption (He et al., 2021).

There is no research, to the best of our knowledge, investigating how the perceived prevalence of misinformation affects worries about the pandemic. In particular, we theorize that frequent exposure to misinformation fuels worries related to the pandemic. We use the term worries instead of anxiety or fear because we construe worries as negative cognitions in light of uncertainty and ambiguity. The terms fear and anxiety refer to psychological affects, they are much stronger and can also be irrational and highly subjective (Coifman et al., 2021).

Why then should the perception of misinformation raise such worries? The reason, we theorize, lies in the *impression of uncontrollability*. The notion of controllability can be traced back to the Transactional Theory of Stress by Lazarus and Folkman (1984). According to this theory, individuals continuously evaluate their environment and form an impression whether or not they have sufficient resources to deal with potentially challenging situations, such as a pandemic (Zacher & Rudolph, 2021). These appraisals can also refer to the level of controllability of a stressor and more specifically, whether a situation is controllable by oneself or by others. In a recent study, Zacher and Rudolph (2021), for instance, found that the perception that the pandemic is controllable leads to higher subjective wellbeing.

Translated to the present paper, when citizens perceive that misinformation is out there, this perception implies that others also are exposed to (and affected by) this misinformation. That is, individuals may come to believe that a certain share of other people

may actually believe in the erroneous information, ultimately guiding the behaviours of others. This theoretical explanation is build on the Influence of Presumed Media Influence model (IPMI, Gunther & Storey, 2003). The IPMI model holds that individuals implicitly assume an influence of the media on others, which in turn, can lead to cognitive and affective reactions and guide their own behaviours (Hong, 2021). In contrast to a 'third person' effect logic (Davison, 1983), the IPMI only looks at the perceived effect on others. The third-person-effect, however, takes the gap between the perceived media effects on oneself vs. others as the independent variable (Liu & Huang, 2020). The IPMI model would predict that an perceived impact on others may affect individuals' impression about the crisis and how it can be handled.

Connecting the IPMI model with the Transactional Theory of Stress and its notion of (un)controllability, we can theorize a three-step process: First, individuals perceive a prevalence of misinformation about COVID-19. Second, they assume that such misinformation can have an impact on others, that is, others are likely to believe in this misinformation (see Cheng & Chen, 2020). Third, this presumed influence on others will foster the perception of uncontrollability of the pandemic. That is, when misinformation prevails, the pandemic is arguably difficult to control by authorities. Since a pandemic can only be effectively handled and controlled when a majority of citizens accept a basic set of accurate information, perceived spread of misinformation can be theorized to increase worries about COVID-19. This leads to our first hypothesis:

H1: Perceived prevalence of misinformation fuels people's worries about the pandemic.

Misinformation prevalence and case-Fatality ratios as country differences

One could argue that the relationship described in H1 depends on the actual amount of misinformation that respondents were exposed to. More specifically, the share of misinformation in the media varies considerably between countries. Therefore, in one country, individuals may have the perception that misinformation is heavily present, while in other countries, people could have the feeling that misinformation is not actually prevalent, which could also be rooted in the real prevalence of misinformation. The relationship between perceived prevalence of misinformation and COVID-19 worries might be hence contingent on the actual amount of misinformation. We therefore need to look at the extent to which news consumers in different countries are exposed to higher or lower doses of misinformation. In a recent study, Gallotti et al. (2020) developed a COVID-19 Infodemic Risk Index (which we use as a proxy for misinformation prevalence in the media) by categorizing Twitter posts as misinformation based on external ratings by fact checking agencies worldwide. They found substantial variations in misinformation across countries. Likewise, analyzing web searches for misinformation content, a study by Nsoesie et al. (2020) suggests that the spread of misinformation depends on country contexts. They found that those searches varied in their start and peak times. Using survey data from 40 countries, Singh et al. (2022) found that the belief in misinformation varied from 6% to 37% of individuals depending on country, with poorer regions being more susceptible to believing COVID-19 misinformation. Also, Madraki et al. (2021), looking at the spread of COVID-19 misinformation on social media in multiple

countries and on multiple platforms, showed that COVID-19 misinformation varied substantially across countries.

Such objective counts of misinformation may also affect the perceptions of how prevalent misinformation is and, by doing so, influence worries about the pandemic. It may be speculated that the relationship between perceived prevalence of misinformation and people's worries is higher in countries with high as opposed to low levels of actual misinformation. The reason may be that the spread of misinformation may be out of control, people may perceive that, so worries are reinforced. However, given the apparent lack of any prior research and these conflicting considerations, we formulate the following specific research question:

> RQ1: Is the relationship described in hypothesis 1 lower or higher with rising levels of actual misinformation in a country?

Besides the actual amount of misinformation, the death toll due to COVID-19 may also play a role at the country level. In a ten-country comparative study, Dryhurst et al. (2020) suggest a huge variability across cultures in terms of perceptions of risk associated with COVID-19. Also, there were significant variations in the number of deaths at the beginning of the pandemic. But again, comparative research on COVID-19 is scarce, and there is not enough substance to formulate any hypothesis. In this study, we focus on the case-fatality ratio, that is, the number of deaths per infected people. The case-fatality ratio is the key epidemiological parameter for the seriousness of a infectious disease (e.g., Ghani et al., 2005; Luo et al., 2021). One could speculate that misinformation would lead to more worries for higher as compared to lower case-fatality ratios in a country. The reason could be that high case-fatality ratios may give additional weight to the misinformation. That is, the belief in misinformation by others may be perceived as more dangerous and more consequential. Independent of the theoretical mechanisms, the case-fatality ratio is an important country level factor that arguably needs to be explored. However, since there is no theoretical or empirical prior work, we ask in another specific research question:

> RQ2: Is the relationship described in hypothesis 1 weaker or stronger with higher levels of the COVID-19 case-fatality ratio at the country level?

Trust as a Driver and Facilitator of Worries about COVID-19

In times of crisis, people rely heavily on information coming from the media, to get a basic orientation and to stay informed about the situation. News consumption spiked at the beginning of the pandemic (Kantar, 2020), across all age groups. In times of social disruption, 'there is an unusually high need for information and sense-making by individuals' (Lowery, 2004, p. 339). The need for orientation (NFO), that is people's tendency to seek information about an issue in the news media, is particularly strong when an issue is highly relevant for an individual and contextual uncertainty is high (Matthes, 2006). Additionally, based on media system dependency theory (Ball-Rokeach & DeFleur, 1976), in times of crisis people rely on the media to offer timely and 'expert' information (Lowery, 2004, p. 339), and actively engage in news seeking to get updates of the unfolding situation (Lachlan et al., 2009).

We argue that, at the beginning of the pandemic, characterized by unusual levels of uncertainty and therefore by very high levels of need for orientation, people turned to the media particularly to stay informed with recent developments, and therefore, their NFO increased substantially. Though turning to media for information should arguably decrease the level of uncertainty about an issue, we believe that the COVID-19 crisis and the multiple lockdowns in various countries around the world as well as the monopolization of the public space with COVID-19 related information, and the constant reporting about the number of cases and deaths, may have made people even more concerned (Bareket-Bojmel et al., 2020). In fact, other research about times of crisis indicates that news media may accelerate fears and worries, rather than reducing it (e.g., Thompson et al., 2019). More germane to the purposes of the present study, Garfin et al. (2020) reviewed the available literature and concluded that media exposure, in times of crisis, will accelerate, rather than reduce fears.

To our knowledge, the role of media trust in reducing fears is however understudied. Brashers et al. (2000) suggest that information seeking could either reduce uncertainty by helping people 'better discriminate between or among alternatives' or increase uncertainty by 'increasing the number of alternatives, or by blurring the distinction between or among alternatives' (p. 63). Given the huge amounts of negative and potentially distressing information provided by the media during the early months of the pandemic, such as death counts and number of infections, we assume that trust in the news media fuelled feelings of concern during the pandemic. In fact, a recent study suggests that 91% of COVID-19 stories by U.S. major media outlets are negative in tone, and more interestingly, that such media negativity is not attenuated by positive developments regarding the pandemic (Sacerdote et al., 2020). Moreover, there is some evidence that the media use language inducing 'scaremongering', rather than language promoting self-efficacy (Ogbodo et al., 2020, p. 265). Therefore, we hypothesize:

> H2. The more people trust news about COVID-19, the more concerned they are about the pandemic.

While trust in news media may increase people's worries, other factors may work in the opposite direction. It can for example be assumed that trust in political actors such as the national government and parliament as well as trust in medical actors might help individuals cope with the situation, leading to less worries. In times of crisis, trust in political national institutions often increases, and such 'rally-around-the-flag' effects (Mueller, 1970) have been observed in many countries and contexts. In fact, studies suggest that there was an increase in political trust at the beginning of the pandemic, at which the majority of governments around the world reacted with strict lockdowns and measures (Bol et al., 2021). In most countries, people regarded the strict measures as necessary and tended to support those who enforced them (Bol et al., 2021). Against this background, we theorize that trust in national political institutions is associated with reduced levels of worries about the pandemic.

A similar argument can be made for medical actors. Medical experts, doctors, and nurses are perceived as *the* experts during medical emergency crises. Researchers have documented the key role of medical experts or health agencies in influencing people's willingness to comply with recommended behaviours during previous pandemics (Siegrist & Zingg, 2014). Though medical actors could also serve as a source of alarmism, we

would expect that trust in medical actors will provide individuals with the impression that the crisis can be handled and overcome. Obviously, medical expertise marks the way out of the pandemic. Also, in most countries, medical experts have urged the public to take the threat of COVID-19 seriously (World Health Organization, 2020), and argued in causal language about how the pandemic can be kept under control. We therefore theorize that trust in medical experts will reduce people's levels of concern about the pandemic. Our final hypotheses thus are:

H3. The more people trust political actors, the less concerned they are about the pandemic

H4. The more people trust medical actors, the less concerned they are about the pandemic

Study 1

Method and measures

We use a two-wave panel survey fielded in 17 European countries (Austria, Belgium, Denmark, France, Germany, Greece, Hungary, Israel, Italy, the Netherlands, Norway, Poland, Romania, Spain, Sweden, Switzerland, and the UK) between December 2019 (wave 1, i.e., before COVID-19) and May and June 2020 (wave 2, i.e., after the outbreak), conducted by Dynata. Dynata recruits and verifies the identity of their panel members and then draw samples from their panels. In our sample, we used quotas for age, gender, and metropolitan region. The samples are not representative, as they are no random samples, but they are in line with the distribution of age, gender, and metropolitan region in a respective country. According to Aaron et al. (2022), Dynata has a higher selection sampling quality as compared to MTurk samples.

In wave 1, a total of $N = 28{,}317$ respondents completed the survey. The average age was 42 and 55.4% of the sample were female. At wave 2, $N = 14{,}218$ respondents completed the survey with a sample size per country ranging from $n = 641$ to $n = 1{,}002$ cases, depending on country size. The retention rate ranged from 39.9-60.6% (for more information, see Authors, 2020). Since COVID-19 came up after the first panel wave, we primarily use the second panel wave data for our key independent and dependent variables.

All measures, means as well as standard deviations are detailed in the online APPENDIX at OSF: https://osf.io/px986/?view_only = 142874fda3184ce0ab281f14bde89476. Prevalence of misinformation in one's media diet was measured with two items asking respondents how often they came across information that they suspect is false ($r_{SB} = .68$, $M = 2.45$, $SD = 1.12$, 5-point scale). As an alternative measure, we also used a single item specifically referring to prevalence of misinformation with respect to COVID-19.

Similar to related research (Barber & Kim, 2021; Coifman et al., 2021), worries regarding Covid-19 were tapped with three items asking about worries to get infected and economic consequences ($\alpha = .68$, $M = 4.95$, $SD = 1.28$, 7-point scale). Worries typically relate to different aspects (see Barber & Kim, 2021; Coifman et al., 2021; Taylor et al., 2020), and for COVID-19, worries center around two main dimensions: (a) Worries about the dangerousness of the virus for oneself and one's social relationships and (b) worries about socio-economic consequences. Trust was assessed by asking respondents about the extent to which they trusted political actors (two items, national parliament and national

government, $r_{SB} = .86$, $M = 4.06$, $SD = 1.59$), medical experts (two items, experts as well as doctors and nurses, $r_{SB} = .82$, $M = 5.27$, $SD = 1.27$), and the news media (single item) to deal with and responding to the coronavirus outbreak ($M = 3.71$, $SD = 1.49$). We also controlled for age, gender, left-right ideology, objective knowledge about the virus ($M = 4.36$, $SD = .82$), and exposure to news about the virus.

The present study also accounts for cross-country variation in misinformation news prevalence. We used the 'Infodemic Risk Index' by Gallotti et al. (2020) that categorized Twitter posts as misinformation based on external ratings by fact checking agencies worldwide. This project produces frequency estimates of misinformation per country on Twitter. The data are freely available on https://covid19obs.fbk.eu/#/api. The index assed all tweets posted about COVID-19 since 22 January 2020 using Filter API, For each country, we summarized the Tweets categorized as misinformation between January 1, 2020 and the starting date of the second panel wave per individual. The classification method is detailed in Gallotti et al. (2020). We argue that this variable is a good proxy for country differences in misinformation prevalence. Even if Twitter is more likely to be used in one country than in another, Twitter is an important platform where misinformation spreads. If there are high amounts of misinformation on Twitter in one country, it is highly likely that this country also ranks higher in misinformation prevalence on other platforms. We cross-checked the Twitter-based ranking with information from the Poynter database which collects misinformation found by fact checking agencies on various platforms across countries and found a very similar ranking of countries. As for COVID-19 case-fatality ratios, we relied on the 2019 Novel Coronavirus Visual Dashboard (see Dong et al., 2020). We extracted the number of deaths in a country due to COVID-19 divided by the number of infections, up to the day of the individual interview per respondent as an objective measure.[1]

Data analysis

We ran multilevel mixed effects regressions, which account for country random effects (see Grilli & Rampichini, 2015). We do this to explain differences in the dependent variable between the countries. To test the robustness of our findings and to control for potential selection biases, we performed propensity score matching. One of the shortcomings of observational data to study causal inferences is difficulties in attaining the covariate balance between treatment and control group. Unlike in controlled experiments where the treatment is randomly assigned, in observational data, treatment and control groups often have systematically different covariates. To get rid of these systematic covariance differences, matching the individuals in treatment and control groups who share same or similar covariates could be performed. However, exact matching is almost impossible with observational data. To overcome this, Rosenbaum and Rubin (1983) recommended the use of the propensity score. The propensity score is the probability of being assigned to the treatment (in our study, being exposed to misinformation) based on the individual's covariates. Though the propensity score has limitations as it is calculated post-treatment and only based on the observed covariates, it is regarded as a robustness check.

Table 1. Multilevel model predicting emotional concerns about COVID-19, Regression coefficients with Standard Errors in brackets (Study 1).

	Worries about COVID-19		
	(1)	(2)	(3)
Prevalence of Misinformation (PoM)	0.087***	0.087***	0.086***
	(0.010)	(0.010)	(0.010)
Age	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)
Gender (Male)	0.254***	0.254***	0.254***
	(0.020)	(0.020)	(0.020)
Education	−0.088***	−0.088***	−0.088***
	(0.017)	(0.017)	(0.017)
Political Interest	0.086***	0.086***	0.086***
	(0.007)	(0.007)	(0.007)
Left-right Ideology	0.015***	0.015***	0.015***
	(0.004)	(0.004)	(0.004)
Frequency of News about COVID-19	0.186***	0.186***	0.186***
	(0.008)	(0.008)	(0.008)
Objective Knowledge about COVID-19	−0.033	−0.033	−0.033
	(0.021)	(0.021)	(0.021)
Trust in News Media	0.058***	0.058***	0.058***
	(0.009)	(0.009)	(0.009)
Trust in Medical Actors	0.111***	0.111***	0.111***
	(0.010)	(0.010)	(0.010)
Trust in Political Actors	−0.078***	−0.078***	−0.078***
	(0.009)	(0.009)	(0.009)
COUNTRY LEVEL: Actual Misinformation Prevalence (AMP)	0.048	0.047	0.048
	(0.120)	(0.120)	(0.120)
COUNTRY LEVEL: Case-Fatality-Ratio (CFR)	0.028	0.028	0.028
	(0.022)	(0.022)	(0.022)
CROSS-LEVEL: PoM*AMP	−0.002	−0.009	
	(0.009)	(0.008)	
CROSS-LEVEL: PoM*CFR	−0.004*		−0.004**
	(0.002)		(0.002)
Constant	−0.189*	−0.188*	−0.188*
	(0.109)	(0.109)	(0.109)
Observations	12,791	12,791	12,791
Log Likelihood	−19,511.340	−19,507.550	−19,507.610
Akaike Inf. Crit.	39,058.670	39,049.090	39,049.210
Bayesian Inf. Crit.	39,192.890	39,175.850	39,175.970

Note: *$p < .05$, **$p < .01$***$p < 0.01$.

Results

Findings are depicted in Table 1. In line with H1, results of the multilevel model suggest that perceived prevalence of misinformation positively predict worries about COVID-19 ($b = .087$, $p < .001$). Also in line with our second hypothesis, there was a positive relationship of trust in the news media with worries about COVID-19 ($b = .058$, $p < .001$). Confirming H3, trust in political actors to deal with the Covid-19 crisis was negatively related to worries ($b = -.078$, $p < .001$). Yet against expectations, trust in medical actors did not reduce, but accelerated, worries ($b = .111$, $p < .001$). To test the robustness of the observed relationship between perceived prevalence of misinformation and worries, we used a single item specifically asking for perceived prevalence of misinformation with respect to COVID-19. Similar to the initial finding, we found that perceived prevalence of misinformation regarding COVID-19 positively predict worries about COVID-19 ($b = .038$, $p < .001$). The same was found when using this specific item for the propensity score matching analysis.

There may, however, be substantial differences between the countries. To investigate those, we turn to the country level variables. Here, we found no significant relationships between actual misinformation prevalence and worries ($b = .048$, $b = .69$). Also, there was no cross-level interaction between actual misinformation prevalence and perceived prevalence of misinformation when explaining worries about the pandemic ($b = -.002$, $b = .83$). In an additional analysis, we tested for a possible mediation: one could expect that actual misinformation prevalence drives perceived prevalence, which then in turn, fuels concerns. However, we found no evidence for a mediation. There is no significant relationship between actual misinformation prevalence and perceived prevalence, both for the index ($b = -.065$, $b = .42$) and for the single item specifically asking for perceived prevalence of misinformation with respect to COVID-19 ($b = -.078$, $b = .42$)

We found no relationship with the case-fatality ratio at the country level ($b = .028$, $b = .21$). However, there was a significant negative interaction ($b = -.004$, $p < .05$) between the case-fatality ratio and perceived prevalence of misinformation. The negative sign of this interaction as well as additional probing suggest that the effect of perceived misinformation on worries is reduced with rising levels of the case-fatality ratio per country. Finally, with respect to the control variables, there was a positive relationship with news exposure about Covid-19 ($b = .186$, $p < .001$), interest in politics ($b = .086$, $p < .001$), and left-right ideology ($b = .015$, $p < .001$), but no significant effect of objective Corona knowledge ($b = -.033$, $p = .11$).

Since these were cross-sectional relationships, we turned to propensity score matching. We calculated the propensity score within a caliper distance of .04. The caliper width was set to be .2 of the standard deviation of the propensity score, based on the suggestion by Austin (2011). In calculating the proper propensity score, choosing all covariates which could have affected the outcome (e.g., the potential confounders) is crucial. Hence, all the covariates used in the multilevel model were also included to calculate the propensity score, including the high-order interaction terms. The standardized mean differences between the covariates after matching were smaller than .25 and the variance ratios were between .5 and 2.0, and became closer to 1.0 after matching. We took 30% of our sample as a treatment group (which has prevalence of misinformation

at a level higher than 4.5) and assigned the rest of the respondents into the control group (which has prevalence of misinformation level lower than 4.5 or equal to 4.5). The matching was performed with replacement since the number of treatments was smaller than the number of controls. At last, 4,210 individuals were matched. Once matched, the sample showed that perceived prevalence of misinformation had positive and significant Average Treatment Effect (ATE) on perceiving COVID-19 related worries (ATE = .23, SE = .03, $p < .005$), which corresponds to our findings from the multilevel analysis. In other words, perceived prevalence of misinformation had positive and significant influence on worries related to the pandemic.[2]

Discussion

The aim of Study 1 was to test the relationship between perceived prevalence of misinformation and worries about the pandemic. Using a multilevel regression model as well as propensity score matching as an additional validation, we found clear evidence that perceived prevalence of misinformation is positively related to COVID-19 related worries. We interpret this finding with the notion of perceived uncontrollability. That is, when people think that they see a lot of misinformation, they assume that misinformation is highly prevalent, that other people may be influenced by such prevalent misinformation, and thus they infer that COVID-19 is spinning out of control. This perception of uncontrollability is likely to increase worries about one's own and others' situation. Interestingly, the effect was independent from the actual prevalence of misinformation at the country level. However, the case-fatality ratio at the country level significantly moderated this relationship. Findings suggest that the relation between perceived prevalence of misinformation and worries becomes weaker with rising levels of case-fatality ratios at the country level. We will revisit this finding in our general discussion section.

Also, we found that trust in the news media was positively related to worries, probably due to the negative nature of most news reports at the time of the study (see Sacerdote et al., 2020). Also, trust in political actors was negatively associated with worries suggesting that the measures taken during the first wave of the pandemic up to the summer of 2020 were perceived as reasonable, justified, and effective. Finally, against expectations, trust in medical actors was found to be more likely to increase rather than decrease worries. A potential explanation may be that medical actors were frequently cited in the media referring to the threat associated with the pandemic, as for instance, related to deaths and serious health consequences.

There are some limitations. First, though we used panel data, our key relationships were tested cross-sectionally with wave 2 data only. Even though we employed propensity score matching, we therefore cannot draw firm causal conclusions, and we cannot rule out a systematic influence of panel attrition on the findings. The reason for only using second wave panel data is that the COVID-19 pandemic hit in the midst of data collection, so we could not include questions on COVID-19 in the first wave. As with other COVID-19 research, a study at the outbreak of a pandemic cannot regarded standard research for which established measures are available. This limitation notwithstanding, we offer unique cross-national data from the early stages of the pandemic hardly available in the field.

Second and related, we did not measure the notion of perceived uncontrollability. Third, the Infodemic Risk Index has limitations since there are huge differences across countries regarding the use of Twitter. Fourth, we tested the role of the actual amount of misinformation at the country level. However, individuals may differ in the contents to which they were exposed, particularly misinformation about COVID-19. Misinformation may concern different aspects, such as threat of COVID-19, vaccinations, or conspiracy theories. These were not measured. To address these shortcomings, we conducted an experiment.

Study 2

Findings of Study 1 suggest that perceived prevalence of misinformation increases worries related to COVID-19. Study 2 was designed to replicate these findings, shedding light on the underlying mechanism – the belief that widespread misinformation makes COVID-19 difficult to control. When citizens believe that misinformation prevails, they may also think that misinformation potentially guides the behaviours of others and that the virus may get out of hand. Study 2 tests this mediation logic. It is theorized that the perception of prevalent misinformation will increase the notion of uncontrollability. This notion of uncontrollability, then, will foster worries related to the pandemic. In addition, Study 2 also separates economic worries from personal worries about getting infected. Finally, study 2 controls for the actual content of misinformation that individuals believe is prevalent.

Method and measures

We employed a between-subject design manipulating prevalence of misinformation on COVID-19. The experiment was conducted as part of a larger survey conducted by the private survey company Dynata in October 2020. A representative quota-sampling procedure of the Austrian population was applied with respect to age, gender, and education. The IRB board of the University of Vienna] approved the study. Participants ($N = 224$) were asked to take part in an online experiment. They were randomly assigned to one of the two experimental conditions. We used a multiple message design with two brief news articles in each condition, presented in random order. In the *misinformation prevalence condition*, individuals read two news articles arguing that internet misinformation on Covid-19 is on the rise (i.e., 'Every third online news story on COVID-19 is false'). In the *misinformation low-prevalence condition*, it was argued that there is hardly any misinformation on COVID-19 in online news. Both versions were identical in length and content, except for the experimental manipulation of misinformation prevalence. It is important to note that the perceived content of prevalent false information that respondents may have had in mind was not manipulated and is thus randomly distributed across conditions. We only manipulated prevalence, but we statistically controlled for the perceived content of prevalent false information that respondents had in mind. Results are identical without this control. Participants were asked to read the news articles at their individual speed. All materials and items are listed in the online APPENDIX: https://osf.io/px986/?view_only = 142874fda3184ce0ab281f14bde89476.

We measured the dependent variable, worries about COVID-19, with the same three items as in Study 1, plus additional items to form two separate dimensions. In fact, Principal Component Analysis revealed two factors, *worries about getting infected* (three items, α = .89, $M = 4.82$, $SD = 1.64$) and *worries about economic consequences* for oneself, one's family, and the country (three items, α = .76, $M = 4.80$, $SD = 1.54$). The mediator, controllability, was measured with five items tapping the notion that due to misinformation, the virus cannot be controlled or that misinformation shapes the behaviours of individuals regarding COVID-19. The index was one-dimensional (α = .91, $M = 4.34$, $SD = 1.54$). As a control, we listed eight different areas of misinformation on COVID-19 and we asked participants how frequently they think these contents appear online. We controlled for age, gender, and education (see online APPENDIX).

As a manipulation check, we measured two items after stimulus exposure asking about the degree to which the articles state that the majority of news on COVID-19 is false (α = .85, $M = 4.00$, $SD = 1.91$). The experimental conditions showed a statistically significant difference between the conditions (prevalence condition: $M = 5.09$, $SD = 1.37$; low-prevalence condition: $M = 2.94$, $SD = 1.76$) in the expected direction ($t = -10.20$, $p < .001$). The two conditions did not significantly differ on all items tapping the perceived content of prevalent false information. Thus, we measured perceived prevalence, not the actual misinformation content or areas.

Results

We ran mediation analyses relying on a 95% bias-corrected bootstrap confidence interval (CI) based on 5,000 bootstrapped samples (see Table 2). Worries served as the dependent and misinformation prevalence as the independent variable, and perceived uncontrollability as the mediator. As for worries about getting infected, we found a significant effect of the misinformation prevalence condition (compared to the low-prevalence condition) on perceived uncontrollability ($b = .47$, SE = .88, $p < .001$). As indicated in Table 2, uncontrollability was also explained by three of different types of misinformation that respondents had in mind. Overall, 35% of the variance was explained. In the next step,

Table 2. Mediation analysis predicting Worries about COVID-19 (Study 2).

	Perceived Uncontrollability	Worries about Getting Infected	Worries about Economic Consequences
Misinformation Prevalence (Experimental Manipulation)	0.68 (0.17)***	−0.23 (0.21)	−.28 (0.21)
Perceived Uncontrollability		0.47 (0.07)***	0.32 (0.08)***
Age	0.00 (0.00)	0.01 (0.01)	0.00 (.01)
Gender	0.10 (0.17)	−0.03 (0.20)	0.14 (0.21)
Education	−0.17 (0.18)	−0.24 (0.19)	0.14 (0.20)
Misinformation Existence COVID-19	0.23 (0.08)**	0.17 (0.10)	−0.11 (0.09)
Misinformation Medical Treatment	0.12 (0.09)	0.14 (0.10)	0.04 (0.11)
Misinformation Origin of the Virus	0.13 (0.09)	0.20 (0.09)*	0.09 (0.09)
Misinformation Course of Disease	0.01 (0.09)	−0.27 (0.10)**	−0.03 (0.10)
Misinformation Spread of the Virus	0.19 (0.09)*	−.30 (0.10)**	−0.56 (0.11)
Misinformation by Medical Experts	−0.05 (0.07)	0.05 (0.10)	−0.58 (0.10)
Misinformation by Scientists	0.03 (0.09)	−0.47 (0.10)	0.02 (0.11)
Misinformation by Political Actors	−0.18 (0.076)	−0.46 (0.09)	0.25 (0.09)
R^2	0.35	0.28	0.15

Note: *$p < .05$, **$p < .01$***$p < 0.001$.

we looked at the effects on worries about getting infected. Here, we found that the notion of perceived uncontrollability significantly predicted worries ($b = .47$, SE = .08, $p < .001$). Furthermore, worries were predicted by three misinformation contents that respondents had in mind, explaining 28% of the variance overall. The indirect effect of misinformation prevalence on worries, mediated by uncontrollability, was significant ($b = .32$, LLCI = .15, ULCI = .59). There was however no direct effect of experimental condition on worries ($b = -.23$, SE = .20, $p = .25$). For worries about economic consequences, exactly the same pattern emerged. Experimental manipulation of misinformation prevalence positively predicted the notion of perceived uncontrollability ($b = .68$, SE = .17, $p < .001$) which, in turn, explained economic worries ($b = .32$, SE = .08, $p < .001$), while no direct effect of experimental condition on economic worries emerged ($b = -.28$, SE = .21, $p = .18$). The indirect effect was significant ($b = .22$, LLCI = .08, ULCI = .46).

Discussion

Findings clearly demonstrated the individuals' belief that there is prevalent misinformation, independent from the actual content of misinformation, leads to the feeling that COVID-19 is difficult to control, which in turn, fuels worries. We extended Study 1 by distinguishing two dimensions of worries, i.e., worries of getting infected and worries about the economic situation. When only using the items employed in Study 1, the very same findings emerge. There was no direct effect of the experimental condition, although the manipulation was strong and significant. However, it needs to be noted that an experiment cannot serve as a direct and strict validation of survey data. In the survey data, the statistical power was rather strong, so a direct effect may be observable without the mediator. In the experiment, statistical power was much weaker, so no direct effect emerged. Conceptually, the mediation effect observed in Study 2 is in line with the theory.

Study 2 also has limitations. First, we used a forced exposure design with comparatively simple textual stimuli. We were only interested to manipulate the perceived prevalence of misinformation, and thus, the stimuli were designed to be high in internal validity. Future research should replicate the study with audiovisual material. We ran mediation models, for which the effect of the mediator on the outcome cannot be interpreted in causal terms. Future research should thus directly manipulate the notion of uncontrollability. Finally, we did not account for the amount of misinformation individuals may have received prior to the experiment. Given the randomization of respondents, the amount and content of misinformation should however be equally distributed across conditions. Furthermore, we asked respondents about what they believe are the most prevalent contents of misinformation and used these measures as controls. We can therefore confidently say that the effects we observed are due to the perceived prevalence of misinformation, not specific types of misinformation.

General discussion

The present research was designed to examine the relationship between the perceived prevalence of misinformation about COVID-19 and worries about the pandemic. We tested this relationship using a multi-country survey, applying multilevel models with

cross-level interactions as well as propensity score matching. We also validated the findings of the survey with an experimental study. Thereby, we extend research on misinformation and COVID-19 in several ways. First, we offer correlational and causal evidence that perceived prevalence of misinformation can increase worries about the pandemic, which may have potentially detrimental effects on other psychological and social outcomes. Second, we shed light on the underlying mechanism. In fact, we theorized and demonstrated, based on the Transactional Theory of Stress by Lazarus and Folkman (1984), that perceived prevalence of misinformation fuels the perception of uncontrollability, that is, the feeling that the virus may be hard to get under control. When misinformation is out there, governments and medical experts may struggle to implement effective measures. Thus, people may come to believe that misinformation represents a potential harm, delaying or impeding the fight against the pandemic.

Third, we add to the understanding of how misinformation affects individuals by turning attention to the perception logic. That is, we studied the effects of the perception that misinformation is prevalent rather than explaining the attitudinal effects of misinformation itself. That is, the mere talking or reporting about misinformation may lead to the impression of the public that misinformation is prevalent, and this alone can have significant consequences (Chang, 2021). To reiterate, whenever we ask respondents whether or not they have seen information that they believe is false, we move to the perceptual rather than the attitudinal dimension. That is, when respondents state the information is false, this response by definition implies that *they do not believe the actual misinformation*. Therefore, we show that the mere perception of prevalent misinformation can have significant effects, even though people do not believe in it.

Fourth, we looked at the role of macro-level variables such as the actual amount of misinformation prevalent as well as the case-fatality ratios in a country. In Study 1, the effect of perceived prevalence of misinformation on worries was mitigated with rising levels of case-fatality ratios. This finding suggests that, the deadlier the pandemic, the less misinformation will affect worries. This finding may appear counter-intuitive. However, case-fatality ratios refer to the share of people that die after being infected. This ratio is an objective and hard criterion about the pandemic. Most likely, lots of misinformation in early stages of the pandemic centered around questioning the harm and seriousness of COVID-19. With rising death tolls, such misinformation is simply less meaningful. Similarly, misinformation about fake cures and other medical myths may appear arbitrary and more obviously false when many people die after being infected. Surprisingly, the case-fatality ratio was also unrelated to worries, perhaps due to a ceiling effect. Needless to say, these conjectures cannot be proven with the present data, necessitating additional, particularly experimental research.

Fifth and finally, the multi-level analysis demonstrated that perceived prevalence of misinformation fuelled worries independent from the actual amount of misinformation in a country. Also, the actual levels of misinformation in a country, as measured by the Infodemic Risk Index (Gallotti et al., 2020) was unrelated to worries about COVID-19. Related to that, surprisingly, the objective amount of misinformation did not predict the perceived amount of misinformation. These findings suggests that perceptions can, as in the present case, matter a lot even for countries for which the actual amount of misinformation was low. Perceptions of misinformation, may not be accurate and may depend on the media diet of each individual.

But what is the substantive significance of these findings? In both studies, the relation between perceived prevalence of misinformation on the dependent variables was moderately strong. Also, the general pattern was visible in both studies, across several countries, using different methodologies. We therefore tentatively conclude that the perceived prevalence of misinformation – although Study 1 suggests that perceived prevalence is unrelated to actual prevalence – has important consequences for people's worries. Although worries are an important cognitive activity potentially driving behaviours (Coifman et al., 2021), our findings do not allow conclusions about concrete emotions or more arousing affective states.

Limitations and future research

A few further caveats should be mentioned. First, study one was conducted in May/June 2020, shortly after the outbreak of COVID-19 in Europe (March), while study 2 was conducted in October 2020. Thus, the contexts of both studies differed. However, in Study 2, we only manipulated prevalence of misinformation, without mentioning any contents or areas of misinformation. The experimental logic of Study 2 should therefore be independent of time and context. Second, this research was limited to European countries. Third, since we only assessed worries as cognitive outcomes, future research should specifically measure concrete emotions such as fear (see Coifman et al., 2021). And finally, though we believe it is a major contribution of this research to shed light on the perception logic, the interplay of perceptions about and beliefs in misinformation deserves more attention.

These limitations notwithstanding, our findings hold considerable implications. Besides the general detrimental effects of misinformation related to public health (Southwell et al., 2019), worries about COVID-19 can have important psychological and behavioural consequences, some of them with negative, some of them with positive consequences. On the one hand, worries may be dysfunctional, leading to negative psychological states, such as depressive tendencies or psychotic disorders (see Fitzpatrick et al., 2020). On the other hand, worries about COVID-19 could have functional outcomes, such as protective behaviours such as social distancing.

This research could be extended to other outcomes such as psychological well-being or distress. Also, it appears worthwhile to study the effects of misinformation perceptions on actual behaviour during the pandemic, especially with respect to vaccinations. Future research should also explore the roles of other macro-variables such as cultural dimensions or perhaps even differences in the healthcare system. Finally, the relationship between trust in the news media, political experts as well as medical experts deserves more attention, especially across countries.

Conclusion

Perceptions of prevalent misinformation do matter. In the case of COVID-19, they lead to the impression that the pandemic is difficult to control which, in turn, increases worries among the public. Our findings suggest that perceived misinformation can have significant psychological effects even though audience members reject the information as being false. In a global pandemic with extensive death rate up to this date,

misinformation is indeed worrying, not only for citizens, but also politicians, medical experts, and journalists.

Notes

1. As an alternative measure, we also used the number of deaths divided by the country population at the time of the interview. We found no interaction between perceived misinformation prevalence and number of deaths divided by the country population (b = -0.048, p = .181). Thus, the interaction only holds for case-fatality ratio, which is one of the most important epidemiological parameters (Luo et al., 2021).
2. In an additional analysis, we ran a model also controlling for the attitudinal logic, that is actual belief in misinformation (i.e., conspiracy misinformation such as "The coronavirus is a bioweapon that has been deliberately created by China to harm people"). We did this to check whether the effects of perceptions remain robust. In fact, none of the findings change. We can thus say that the relationship between perceived prevalence of misinformation and worries cannot be explained by the actual belief in misinformation.

Disclosure statement

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

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This project was financially supported by the Network of European Political Communication Scholars (NEPOCS). Data collection in Denmark was supported by the University of Southern Denmark. The collection of data in Hungary and Poland was supported by the Economic and Social Research Council [ES/S01019X/1]. The collection of the data in France was supported by an Audencia Foundation grant. In Romania, the Interdisciplinary PhD school of SNSPA supported the data collection. The collection of data in Sweden was supported by the research project 'Knowledge resistance: causes, consequences, cures', funded by Riksbankens Jubileumsfond. Yannis Theocharis would like to acknowledge the support of the ZeMKI Lenkungskreis at the University of Bremen, which generously contributed to funding this research.

Data availability

https://osf.io/px986/?view_only = 142874fda3184ce0ab281f14bde89476.

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