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Uncivil communication and epistemic trustworthiness concerns in public online discussions in response to scientists during the Covid-19 pandemic

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Abstract

The Covid-19 pandemic illustrated important developments in science communication, with direct online interactions between scientists and the public. This study performs a content analysis of tweets (N = 6,000) directed at German virologists (N = 6) during the pandemic's first year. It identifies substantial levels of incivility and trustworthiness concerns, which often co-occurred. These findings enhance our understanding of online communication dynamics in crises by showing how incivility and trustworthiness concerns are not only prevalent but also evolve in response to specific events and phases. This analysis provides insight into the complexities of public sentiment toward scientists during the pandemic.

Keywords

Public engagement with science and technology

Received: 15th February 2024
Accepted: 25th August 2024
Published: 23rd September 2024

1 ▪ Introduction

The Covid-19 pandemic, while being a matter of significant societal concern, also exemplifies what is known as a 'socio-scientific issue' [Sadler, Barab & Scott, 2007]. Such issues are characterized by their complex interplay between scientific knowledge and societal values. Socio-scientific issues cannot be resolved by scientific practices alone; they require solutions that integrate moral, political, social, economic, and ethical considerations [Sadler et al., 2007]. Throughout the pandemic, social media platforms such as Twitter/X[1] served as public arenas where practical solutions and epistemic knowledge were negotiated. This dynamic process was particularly pronounced due to the continuous influx of newly published scientific evidence, occurring almost daily. Discussions around the pandemic were not only pursued by the general public but also by scientists. In Germany, some scientists used Twitter/X to disseminate findings and to address politics by making political calls for action or evaluating measures [Biermann, Peters & Taddicken, 2023]. In particular, some virologists gained popularity that was also reflected in their number of Twitter/X followers [Utz, Gaiser & Wolfers, 2022]. However, increased visibility led to scientists facing harassment and attacks on their credibility [Nogrady, 2021]. This underscores the relevance of researching direct science communication in online environments.

The possibilities of direct online communication from scientists to the public and vice versa create a dynamic interplay with potential advantages and inherent challenges. This study addresses two key challenges: the trust relationship between science and the public and deliberative challenges arising from incivility. Scientific information is usually complex and intrinsically uncertain [Popper, 2003]. Due to a limited comprehension of scientific information by non-scientists, reliance on and trust in science is vital, especially within global challenges and crises such as the pandemic where adherence to protection measures depends on trust in science [Dohle, Wingen & Schreiber, 2020; Wintterlin et al., 2022]. Furthermore, deliberative challenges are brought to the forefront. During the pandemic, responses to scientists' tweets sometimes veered into uncivil communication, with scientists even reporting threats after communicating on social media [Nogrady, 2021]. For a public negotiation of issue solutions, uncivil communication can have negative consequences as it impedes the democratic goal of deliberation [Anderson, Brossard, Scheufele, Xenos & Ladwig, 2013; Papacharissi, 2004]. Uncivil communication comprises derogatory forms of communication that violate social discourse norms or democratic principles. By conducting manual content analysis, we examine the prevalence of uncivil communication and concerns about epistemic trustworthiness directed at scientists on Twitter/X. Through this investigation, the aim is to gain a more detailed understanding of the dynamics of uncivil communication in the context of online science communication, particularly around socio-scientific issues. It is unclear whether such uncivil communication also impacts the trustworthiness of participating actors. Thus, a potential relationship between the co-occurrence of incivility and trustworthiness concerns is investigated. Therefore, this study provides insights into the dynamics of online discussions around a socio-scientific issue by investigating the interdependence of two challenges scientists face when communicating on social media: uncivil communication and trustworthiness concerns.

1. As of July 24th, 2023, Elon Musk, owner of Twitter Inc. (now X Corp.), renamed the platform to "X." Thus, in this paper, the platform will be referred to as Twitter/X. Along with the ownership change came changes to the functionalities of the platform. This is to be considered when drawing implications from the results of this study.

2 ▪ Background

2.1 ▪ *Science communication on social media during the Covid-19 pandemic*

The public relied on various information and evidence types to cope with the pandemic [Lu, Chu & Ma, 2021]. While social media provides direct access to unlimited content, research indicates that inaccurate information and fake news are disseminated more easily than factual information [Cinelli et al., 2020; Vosoughi, Roy & Aral, 2018]. Moreover, social media can foster inaccurate science communication and amplify science-skeptical views [Anderson & Huntington, 2017]. However, social media was a popular online source for pandemic-related information [Wissenschaft im Dialog, 2023]. New visible scientists emerged during the pandemic, communicating directly to the public. The term "visible scientist" originally referred to prominent scientists in mass media who brought issues to the media agenda [Goodell, 1977]. Today, there are various possibilities for scientists to acquire visibility, inter alia, through social media [Biermann et al., 2023; Olesk, 2021]. This direct online communication of scientists toward the public has the potential to educate the public and correct misinformation by writing comments and actively engaging in public discourse [Taddicken & Krämer, 2021]. In Germany, several scientists made use of these potentials and directly communicated toward a broader public or toward politicians on social media, such as Twitter/X [Drescher et al., 2021].

While scientific evidence on the transmission of the virus was scarce at the beginning of the pandemic, new evidence appeared almost daily and was often communicated publicly at an early stage. This led to a public negotiation of epistemic knowledge on social media. It sometimes preceded the scholarly discourse or happened concurrently, providing the broader public with opportunities to raise trustworthiness concerns while observing scientific disagreement [Broer & Hasebrink, 2022]. Therefore, the pandemic may represent the transformation of the knowledge system where roles, phases, contexts, and hierarchies become flexible due to a change in values, digitalization processes, and conflicting knowledge claims [Neuberger et al., 2023]. A strict differentiation between scholarly discourse, mass-media communication, and dialogue-oriented discourse becomes increasingly challenging as diverse actors negotiate epistemic knowledge [Broer & Hasebrink, 2022]. Thus, the intended recipient or audience of public social media communication may not always be definite and deviate from the imagined audience of the communicator, promoting the risk of context collapse, such as the flattening of multiple audiences into one [Marwick & boyd, 2010]. When communicating online, scientists need to be aware of the context in which they are communicating [Martini, Battisti, Bina & Consolandi, 2022].

2.2 ▪ *Uncivil communication in online discussions*

A free and respectful exchange of ideas is considered a democratic goal. This approach to democracy lies behind the concept of deliberation and aims to identify solutions by exchanging arguments publicly and involving citizens in the discussions [Habermas, 1985]. However, while public discourse has always been partly uncivil, in online environments, uncivil communication is able to spread faster and wider than before [Coe, Kenski & Rains, 2014]. Moreover, due to mainly text-based communication, the absence of face-to-face communication in an online context can foster more heated discussions [Papacharissi, 2004] and communication is often more informal and personalized [Ward & McLoughlin,

2020]. Moreover, emotional, heated discussions sometimes take an uncivil route [Anderson et al., 2013].

Incivility as a conceptual framework to investigate debate is rooted in political science and political communication research, but it is not only suitable for political debate. Besides, there is a difference of opinion over what incivility and uncivil communication comprise. Papacharissi [2004] defines incivility as "disrespect for the collective traditions of democracy" [p. 267], whereas others see it as explicit attacks that insult another person's character and that detract from healthy debate [Anderson & Huntington, 2017; Brooks & Geer, 2007]. Also, while some conceptual definitions differentiate between incivility and impoliteness — with impoliteness comprising lighter forms such as vulgarity, sarcasm, or the usage of all-caps to imply shouting — others consider incivility as a subcategory of impoliteness, which also refers to moral issues or democracy [Papacharissi, 2004; Theocharis, Barberá, Fazekas, Popa & Parnet, 2016]. The contestation around incivility's understanding also lies in subjectivity. What one person considers uncivil might be appropriate and civil for another. Incivility may thus be best described as a continuum [Sydnor, 2017]. However, there is a concurring understanding that incivility is a violation of norms, but there is not yet an understanding as to which norm violations are considered uncivil [Bormann, Tranow, Vowe & Ziegele, 2021]. Thus, some studies include public perceptions of norm violations and sanction worthiness to classify violations as uncivil [e.g., Bormann et al., 2021; Muddiman, 2017].

Even though incivility may not be a clear term and its presence cannot be reliably compared, the effects of uncivil communication on engagement behavior, opinion formation, and issue perceptions [e.g., Anderson et al., 2013; Borah, 2012; Chinn & Hart, 2021] show the necessity to further explore this phenomenon, and to sharpen the conceptualization, especially around an issue with high societal relevance and many controversies such as the Covid-19 pandemic. Researchers have discovered that exposure to incivility can polarize risk perception on a scientific issue [Anderson et al., 2013]. Incivility can also increase aggressiveness [Gervais, 2015; Rösner, Winter & Krämer, 2016] or lead people to retaliate [Masullo Chen & Lu, 2017; Masullo Chen, Muddiman, Wilner, Pariser & Stroud, 2019]. Therefore, aggressive language can affect the trustworthiness the person using it, negatively impact the credibility of the information, and may lead to the impression that less was learned [König & Jucks, 2019]. Moreover, being exposed to uncivil communication can also increase the use of incivility by the recipient and increase intentions to participate politically [Masullo Chen et al., 2019]. Within science communication, (uncivil) disagreement amongst scientists also has negative effects. Civil and uncivil disagreement online between scientists can lead to lower acceptance of the scientific issue, as well as lower trust in science, scientific methods and less attention towards the issue at hand [Chinn & Hart, 2021]. Besides the effects of uncivil debate on recipients, uncivil disagreement can also affect the target or the initial communicator — in this case, the scientist. Personal attacks may decrease scientists' willingness to attend future media interviews [Nogrady, 2021]. However, it may also be outweighed by a motivation to provide expertise to the public discourse, especially in a crisis such as the Covid-19 pandemic [Nölleke, Leonhardt & Hanusch, 2023].

In summary, throughout this paper, the terms "incivility" and "uncivil communication" synonymously refer to forms of communication that violate social discourse norms and/or democratic principles. This includes language that implies shouting, using vulgarity or sarcasm, name-calling, threats, silencing, and sexist or stereotypical remarks. Therefore, this

uncivil communication may have destructive consequences when negotiating socio-scientific issues.

2.3 ▪ *Raising epistemic trustworthiness concerns online*

During crises such as the Covid-19 pandemic, reliance on and trust in scientific knowledge is vital as protection measures also depend on trust in science [Wintterlin et al., 2022]. Public trust generally refers to the complex concept defined as a mechanism for reducing complexity and coping with uncertainties involving the object and subject of trust, i.e., the recipient and the giver of trust [Reif & Guenther, 2021; Luhmann, 2014; Giddens, 2007]. Direct communication by scientists offers the public the chance to develop opinions regarding the trustworthiness of scientists [Wintterlin et al., 2022]. In general, the potential for direct online participation in science can strengthen the trust relationship between science and the public [Reif, 2021]. In Germany, trust in science initially experienced a substantial increase at the onset of the pandemic and subsequently maintained a high level. This high level of trust has slightly decreased as the pandemic has progressed maintaining a high level [Bromme, Mede, Thomm, Kremer & Ziegler, 2022]. However, concerning the issue of Covid-19, some polarization existed in terms of skeptical beliefs about the evidence related to Covid-19 [Bromme et al., 2022]. In direct exchanges with scientists, decreasing trust and growing polarizing attitudes in terms of science rejection might have become visible, and discussants might question the epistemic trustworthiness of scientists. Epistemic trustworthiness describes experts' characteristics that determine whether individuals will rely on or acknowledge them regarding scientific information because of laypeople's limited knowledge in this field [Hendriks, Kienhues & Bromme, 2015]. Epistemic trustworthiness is a multidimensional concept, with crucial factors considered as expertise, integrity, and benevolence [Hendriks et al., 2015; Mayer, Davis & Schoorman, 1995].

Examining publicly expressed concerns about the trustworthiness of scientists is relevant insofar as it may have further effects. It may influence how recipients assess the credibility of the claim, or how they estimate the trustworthiness of the source, i.e., the scientist [Gierth & Bromme, 2019]. In controversial science debates, trust in science is often the main focus [Laslo & Baram-Tsabari, 2019]. So far, questioning or doubting epistemic trustworthiness has been investigated as, inter alia, science-critical user comments [Gierth & Bromme, 2019], as ad hominem attacks [Barnes, Johnston, MacKenzie, Tobin & Taglang, 2018], or as ethical concerns toward science [Laslo & Baram-Tsabari, 2019]. While these are different phenomena, attitudes toward science and scientists may be affected. However, what has to be considered is that concerns referring to scientists' expertise, integrity, or benevolence can also be very constructive as critique is a usual and necessary dimension of democracy [Egelhofer, 2023]. Moreover, within scholarly discourse, claims are often scientifically criticized, which is part of the scholarly discourse and ensures the quality of research. Scientists' disagreement can be considered a normal process to identify knowledge gaps [Dieckmann et al., 2015]. When scientific disagreements are discussed publicly online, they can have negative consequences as these might disrupt the picture of science as a provider of reliable evidence to decide on political measures [Broer & Hasebrink, 2022]. Scientific disagreement may also influence the public's ascription of competence toward scientists [Dieckmann et al., 2015].

2.4 ▪ *Examining uncivil communication and trustworthiness concerns in socio-scientific debates*

Within uncertain socio-scientific issues, debates can become controversial and heated due to their high societal relevance and urgency. Identifying solutions for such challenges requires a trusting relationship between science and society. Additionally, deliberate and civil engagement from actors across various fields is vital, as solutions to socio-scientific issues cannot rely solely on scientific practices but must also consider moral and ethical aspects [Sadler et al., 2007].

This study examines incivility and trustworthiness concerns as distinct concepts. Trustworthiness concerns can be expressed civilly, and raising justified concerns about the trustworthiness of scientists can be constructive. Conversely, unfounded trustworthiness concerns can undermine deliberation [e.g. Gierth & Bromme, 2019] and thus may be perceived as a form of uncivil communication within socio-scientific debate. Despite this, the study does not classify unfounded trustworthiness concerns as a form of incivility, as incivility as a concept is rooted within the context of political debate. Epistemic trustworthiness concerns, on the other hand, specifically pertain to scientific actors. Furthermore, whether these concerns are justified or not is often subjective and not easily assessable from an external perspective. Therefore, this study investigates incivility and epistemic trustworthiness concerns as distinct constructs while not differentiating between unfounded and justified trustworthiness concerns. The co-occurrences of incivility and trustworthiness concerns are examined to provide insights into how these two forms of disruptions exist within the negotiation of a socio-scientific issue, the Covid-19 pandemic, thus shedding light on their dynamics.

3 ▪ Research questions

In order to gain insights into the dynamics of uncivil communication and concerns about the epistemic trustworthiness, this study investigates the prevalence of incivility forms and trustworthiness concerns within Twitter/X replies towards visible German virologists. Against the background of previous research, which has shown that uncivil communication is a common feature of online discussions, studies have also concluded that uncivil comments account for a minority of overall comments. Research investigating incivility in various online communication contexts suggests that most tweets do not contain uncivil communication [e.g., Anderson & Huntington, 2017; Coe et al., 2014; Collins & Nerlich, 2014; Papacharissi, 2004]. Exact shares of incivility vary, which might be explained through different measurements but is also rooted in the topic of discussion and the platform on which the discussion takes place [e.g., Coe et al., 2014; Su et al., 2018; Theocharis, Barberá, Fazekas & Popa, 2020]. As definitions and operationalizations of incivility are contested, this study investigates individual forms of uncivil communication separately. Thus, it is easier to compare results with other conceptualizations and operationalizations. Content analyses that investigate individual forms of uncivil communication are scarce, and they are rarely conducted in the context of science communication or science-related content. Consequently, this study aims to answer the following research question:

> RQ_1: To what extent are replies toward visible German virologists' tweets uncivil, and what forms of incivility are predominantly used?

Within its first year, the Covid-19 pandemic overshadowed almost every other issue on the political and news agenda [Rauchfleisch, Siegen & Vogler, 2021]. During this time, there was conflicting and uncertain information regarding the virus's spread, vaccination progress and safety, and the necessity of lockdown or containment measures. Over time, certain subjects, particularly those revolving around political responses to the pandemic, became increasingly polarized, as evidenced in debates on topics such as mask-wearing [Lang, Erickson & Jing-Schmidt, 2021; Pascual-Ferrá, Alperstein, Barnett & Rimal, 2021] and vaccination [Jiang et al., 2021]. Previous research has found that discussion associated with polarized issues, tend to be uncivil [Anderson et al., 2013]. As the aim of this study is to ascertain the dynamics of incivility by relating the occurrences of incivility to the co-occurrences of incivility and concerns raised about epistemic trustworthiness concerns, the development of tweets over time containing these concerns is also investigated.

> RQ_2: How do forms of incivility in replies toward visible German virologists' tweets and concerns about epistemic trustworthiness develop over the course of the pandemic?

A previous study by Anderson and Huntington [2017] shows that uncivil communication often co-occurs with climate-skeptical perspectives within discussions around extreme weather events. Social media might also fuel science-skeptical perspectives toward science, which has already become apparent for issues such as vaccines [Kata, 2012] and climate change [Anderson & Huntington, 2017]. Direct interactions between scientists and the public on Twitter/X offer the potential for users to communicate trust attitudes toward scientists directly. Uncivil communication and science-skeptical attitudes can negatively affect recipients' attitudes toward communicators of the debates and the debated issues [Anderson et al., 2013; Chinn & Hart, 2021]. It can be assumed that the co-occurrence of incivility and concerns about trustworthiness can exacerbate negative effects. Moreover, exposure to uncivil communication may motivate users to raise trustworthiness concerns about the initial communicator. Also, in a controversial debate, raised trustworthiness concerns can foster more uncivil communication and further polarize the discussion. Thus, the interplay of these two phenomena is investigated.

> RQ_3: Does the occurrence of uncivil communication relate to the occurrence of concerns about the epistemic trustworthiness of scientists?

4 ▪ Methods

To answer the research questions, a manual content analysis of Twitter/X replies (N = 6,000) directed toward six visible German virologists was conducted by two coders. This study focuses on the replies toward scientists in the field of virology, as they were the experts in the field that gained the most attention, in particular during the beginning of the pandemic. The selected scientists are all professors of virology and are actively engaged in research. At the time of data collection, they had over 10,000 followers on Twitter/X. The selected sample consisted of three male and three female virologists, thus minimizing potential gender effects.

This study's sample encompasses reply tweets from four distinct periods within the German pandemic context: the onset of the first lockdown (16.03.2020–28.03.2020), the onset of the second lockdown (28.10.2020–10.11.2020), the middle phase of the second lockdown (16.12.2020–03.01.2021), which encompassed the Christmas holidays and the beginning of the vaccine rollout, and lastly, the concluding phase of the second lockdown (03.03.2021–16.03.2021). Data for the identified scientists and time periods were tracked by a crawler that made use of Twitter's open-source library. The crawler was based on the social media analytics framework [Stieglitz, Mirbabaie, Ross & Neuberger, 2018]. A stratified sampling approach was employed to select the reply tweets. To ensure proportional representation from each time period, the data was divided into strata based on the time periods. Subsequently, 6,000 reply tweets were sampled from each stratum proportionately to the subsample size, thus accounting for temporal variations (t_1: n = 299; t_2: n = 2017; t_3: n = 2995; t_4: n = 689). The number of reply tweets during these time frames varies quite strongly. The possible reasons for this may include the number of original tweets by scientists, specific (political) events (e.g., changes in lockdown measures), or certain statements or actions by scientists or politicians that garnered significant attention and encouraged dialogue. A proportionately weighted sample achieves a more accurate representation of the dynamics in each time period. Changes in attitudes toward science over time might become visible, in particular during ongoing lockdown measures, possibly in combination with strong socializing restrictions over Christmas and New Year celebrations, the increasing controversialities and polarization on political measures, and the beginning of the first vaccine rollout.

The codebook (see supplementary material) that formed the basis for this analysis included formal categories such as the time period, gender of the virologist, and whether the tweet contained a personal address (e.g., "You are a…" or "You should make…") or not (e.g., "They should all…" or "He is…"). We analyzed whether the tweets contained any form of uncivil communication, regardless of who it was directed at. If they did contain uncivil communication, we further scrutinized the manifestations of incivility present, derived from former conceptualizations and operationalizations from the literature [e.g., Anderson & Huntington, 2017; Papacharissi, 2004; Southern & Harmer, 2019; Theocharis et al., 2016]. The forms of uncivil communication under investigation encompassed emotionalizing language (including the use of all-caps or overuse of punctuation that implied shouting, e.g., "You are SO RACIST!!!!!"), sarcasm/cynical language (e.g., "This hurts! Is she talking to fourth graders or adults?"), vulgarity (e.g., "Germany is testing shit and above all wrong!"), name-calling (e.g., "You are a liar and scaremonger"), violence and threats (e.g., "You are sussed, the clock is ticking"), sexist or stereotypical remarks (e.g., "Snooty, know-it-all elite societies don't have long lives"), and silencing (e.g., "anyone who […] is always wrong and still shoots his mouth off, simply has no right to do so anymore"). Sexist and stereotypical remarks were combined in one variable as sexist remarks often included gender stereotypes, and a distinction between these two variables was not always clear.

Subsequently, we examined whether the reply tweet raised trustworthiness concerns, focusing on epistemic trustworthiness dimensions expertise, integrity, and benevolence derived from the Muenster Epistemic Trustworthiness Inventory (METI) [Hendriks et al., 2015]. We examined whether users questioned, doubted, or denied the epistemic trustworthiness of the

scientists, i.e., their expertise (e.g., “For me, you are a conspiracy theorist with no in-depth knowledge”), integrity (e.g., “Stop the lies. Pull yourself together at last!”) or benevolence (e.g., “It is irresponsible how she constantly agitates against scientists who disagree with her.”).

To ensure the reliability of our coding, reply tweets were independently coded by two coders. Krippendorff’s alpha intercoder reliability was calculated using a random sample comprising 10% (n = 600) of the tweets, and the resulting values ranged between .70 and 1 (see supplementary material). Identifying forms of incivility, as well as trustworthiness concerns, within textual communication poses a significant challenge. Among these challenges, identifying sarcasm proves to be particularly difficult, especially within short forms of communication such as tweets with a limited character count. Nonetheless, a Krippendorff’s alpha coefficient of 0.70 for the sarcasm variable was considered acceptable.

5 ▪ Results

Overall, 6,000 reply tweets toward six German virologists were analyzed. Within this sample, 17.3% (n = 1039) of the replies contained at least one form of uncivil communication, while the other 82.7% of replies were considered civil as they did not contain a form of uncivil communication as per the provided definition of incivility (RQ_1). The majority of Twitter/X replies toward visible German virologists during the Covid-19 pandemic did not contain uncivil communication. This result aligns with previous research findings [e.g., Coe et al., 2014; Theocharis et al., 2020]. Roughly, in the same number of tweets (n = 1048), discussants raised trustworthiness concerns.

In order to acknowledge a continuum of incivility with milder and heavier forms, the occurrence of each incivility form individually was analyzed (see Table 2). Sarcastic or cynical language occurred by far most often (n = 416). Name-calling (n = 291) and emotionalized language (n = 165) were also identified often. Threats, silencing, sexism, or assigning stereotypes, as well as vulgarity, were less prevalent. Also, tweets that were considered uncivil, sometimes contained more than one form of incivility (M = 1.2, SD = 0.4). Thus, while the majority of tweets did not contain forms of incivility, a substantial number of tweets did contain one or more forms of uncivil communication (17.3%), with sarcasm being the most frequent and vulgarity the least frequent form identified within the 6,000 analyzed tweets.

The second research question encompassed whether the relative frequency of tweets containing uncivil communication and trustworthiness concerns increased across four periods. Table 1 presents the distribution of tweets with uncivil communication and trustworthiness concerns. The data indicate a partial, albeit inconsistent, increase.

Table 1. Development of tweets containing incivility and trustworthiness concerns over time (N = 6,000).

Time period		t_1	t_2	t_3	t_4	Total
Tweets containing incivility	%	12.4	19.0	16.2	19.4	17.3
Tweets containing trustworthiness concerns	%	8.7	18.5	16.9	20.6	17.5

The descriptive statistics show that the relative frequency of uncivil tweets in t_1 (16.03.2020–28.03.2020) is less than that of uncivil tweets in t_4 (03.03.2021–16.03.2021). However, the frequency does not increase consistently due to fewer uncivil tweets in t_3

(16.12.2020–03.01.2021) than in t_2 (28.10.2020–10.11.2020). Possible explanations for the lower shares in t_3 will be addressed in the discussion section.

The same descriptive analysis was conducted for the relative frequencies of tweets that contained concerns about the epistemic trustworthiness of scientists. Overall, concerns about the trustworthiness of scientists were raised in 17.5% of tweets across the four time periods. The development of relative frequencies within the four time periods is similar to the occurrence of incivility (see Table 1). The shares were lowest in t_1 and highest in t_4, while the tweets questioning trustworthiness were higher in t_2 than in t_3. Looking at the four time periods within the pandemic's first year, it can be concluded that the occurrence of incivility and trustworthiness concerns increased over time, although not consistently.

Examining the individual forms of incivility over the four time periods individually, the inconsistent increase is also visible amongst most forms (Table 2). Sarcasm, name-calling and emotionalization are the three most frequent forms across all four time periods, with an exception in t_4 where silencing is occurring more often than emotionalization.

Moreover, this study investigated whether or not a relationship occurred between the prevalence of incivility and trustworthiness concerns within the replies toward German virologists during the pandemic (RQ_3). Table 3 shows the shares of incivility and trustworthiness concerns separately as well as together. The data show that 72.7% of tweets do not contain either incivility nor trustworthiness concerns. Solely incivility is prevalent in 9.8% of tweets, while solely trustworthiness concerns occur in 10.0% of the 6,000 tweets. In 7.5% of the tweets, incivility and trustworthiness concerns occur together.

A chi-square test of independence was performed to examine the relation between incivility and trustworthiness concerns. The relation between these variables was significant χ^2 (1, N = 6,000) = 577.888, $p < .001$. Thus, there is a relationship between the co-occurrence of incivility and trustworthiness concerns within the reply tweets. However, it is important to note that this data does not establish a causal relationship in any direction.

6 ▪ Discussion

This study aimed to provide insight into the prevalence of uncivil communication and communicated concerns about the epistemic trustworthiness of scientists on Twitter/X. We analyzed reply tweets (N = 6,000) toward six visible German virologists during four different time periods within the first year of the Covid-19 pandemic.

These findings indicate that — independently considered — uncivil communication, as well as concerns about the trustworthiness of scientists, occur in the studied sample in more than every sixth Twitter/X reply to virologists' tweets. The share of the occurrence of incivility is similar to what studies in news website comments have found [Coe et al., 2014] and similar to shares of incivility in tweets mentioning politicians [e.g., Theocharis et al., 2020]. This parallelism is noteworthy given the nature of the responsibilities for political decisions and the heightened legitimacy pressures that politicians contend with, in contrast to scientists. Nevertheless, the noteworthy similarity may be attributed to the perceived influence of scientists during the pandemic in shaping political decisions. Visible scientists frequently issued calls for political action [Biermann et al., 2023], and some were portrayed by the

Table 2. Total numbers and shares of forms of incivility over the four time periods in reply tweets (N = 6,000).

	Form of Incivility		Sarcastic language	Name-calling	Emotionalized language	Sexism/ stereotypes	Silencing	Threats	Vulgarity
Total	Frequencies of incivility forms	*n*	416	291	165	95	92	92	80
	% of overall tweets that contained … (N = 6,000)	%	6.9	4.9	2.8	1.6	1.5	1.5	1.3
	% of uncivil tweets that contained … (N = 1,039)	**%**	**40.0**	**28.0**	**15.9**	**9.1**	**8.9**	**8.9**	**7.7**
t_1	Frequencies of incivility forms	*n*	16	10	7	5	1	1	2
	% of overall tweets that contained … (N = 299)	%	5.4	3.3	2.3	1.7	0.3	0.3	0.7
	% of uncivil tweets that contained … (N = 37)	**%**	**43.2**	**27.0**	**18.9**	**13.5**	**2.7**	**2.7**	**5.4**
t_2	Frequencies of incivility forms	*n*	178	112	52	33	28	32	18
	% of overall tweets that contained … (N = 2017)	%	8.8	5.6	2.6	1.6	1.4	1.6	0.9
	% of uncivil tweets that contained … (N = 383)	**%**	**46.5**	**29.2**	**13.6**	**8.6**	**7.3**	**8.4**	**4.7**
t_3	Frequencies of incivility forms	*n*	167	137	83	49	38	56	54
	% of overall tweets that contained … (N = 2995)	%	5.6	4.6	2.8	1.6	1.3	1.9	1.8
	% of uncivil tweets that contained … (N = 485)	**%**	**34.4**	**28.2**	**17.1**	**10.1**	**7.8**	**11.5**	**11.1**
t_4	Frequencies of incivility forms	*n*	55	32	23	8	25	3	6
	% of overall tweets that contained … (N = 689)	%	8.0	4.6	3.3	1.2	3.6	0.4	0.9
	% of uncivil tweets that contained … (N = 134)	**%**	**41.0**	**23.9**	**17.2**	**6.0**	**18.7**	**2.2**	**4.5**

Note: Incivility forms are sorted from most prevalent to least prevalent from left to right within the total sample.

Table 3. Shares of incivility and trustworthiness concerns in reply tweets (N = 6,000).

	Trustworthiness concerns	No trustworthiness concerns	Total
Incivility	7.5%	9.8%	17.3%
No incivility	10.0%	72.7%	82.7%
Total	17.5%	82.5%	100%

media as crisis managers [Jarren, 2020]. This may have amplified public's perception that they exert influence on political decisions.

The frequency of various uncivil communication forms exhibits significant variations, with sarcastic or cynical language being the most prevalent by a substantial margin. At the same time, vulgarity is the least frequently employed form of incivility. The reasons behind the prevalence of the different forms can only be made speculatively. In general, social media communication is often more informalized, and especially on Twitter/X, restrictions on tweet length have been in place for a long time. Therefore, communication may be shorter and punchier [Ward & McLoughlin, 2020], possibly explaining high shares of emotionalization and sarcasm. Sarcasm incorporates a subtle attack within the discourse and often consists of provocative remarks that use exaggerated language or irony [Anderson & Huntington, 2017]. Here, sarcasm is considered as one form of incivility. Some researchers also view sarcasm and incivility as distinct concepts because subtle sarcasm might provoke incivility rather than being one of its manifestations [e.g., Anderson & Huntington, 2017]. In this study, sarcasm is considered one form of uncivil communication as it also incorporates an attack on deliberate discourse due to its provocative and derogatory language, which hinders the civil exchange of arguments. However, the high prevalence of sarcasm identified in this analysis shows the necessity to look at this form of uncivil language and its effects in more depth. Specifically, in the context of science communication, research on the dynamics of sarcasm is still considered limited [Anderson & Huntington, 2017].

Name-calling was the second most prevalent form of uncivil communication within the investigated tweets and is a predominant form of incivility that has also been the result of other studies. In their research analyzing news website comment sections, Coe et al. [2014] found name-calling to occur in 14% of the comments. In the present study, the overall prevalence of name-calling is 4.9% and thus significantly less than what Coe et al. [2014] identified. The name-calling often occurred within the investigated Twitter/X replies and might be explained partly by the nature of the material. Compared to news website comments, these comments were direct replies to scientists who may have presented study results but who also might have expressed their personal opinions on certain political measures. With the growing personalization tendencies that social media platforms and mass media enhance [Ward & McLoughlin, 2020], personal insults might be provoked more often.

The development of occurrences of incivility and concerns about trustworthiness should also be discussed. This study explored whether the share of incivility and the share of concerns about trustworthiness increased consistently over the four time periods. This was derived from an increasing polarization about certain political measures and governmental responses, as well as a slight decrease of trust in science as the pandemic endured, which was after a strong increase of trust in science at the beginning of the pandemic [Bromme et al., 2022]. Moreover, perceived scientific controversies about, for example, vaccine safety

and prevention measures may have contributed to this. Surprisingly, the Twitter/X replies within the third time period contain less incivility and less trustworthiness concerns than in the second time period. The fourth time period again contains the highest share of incivility and trustworthiness concerns. Reasons for this might lie in the time frame of t_3 (16.12.2020–03.01.2021). An explanation that should be considered is that some polarizing debates paused or continued more civilized over the Christmas and New Year holidays. Moreover, during the holidays, the vaccine rollout started in Germany, which might have positively affected the sentiment of the discourse. That the same development can be found for incivility and trustworthiness concerns underscores this reasoning.

In addition, this study investigated a potential relationship between the occurrence of uncivil communication and concerns about epistemic trustworthiness. Results show a significant relationship between the occurrence of these two phenomena. This result partly underscores the findings of Anderson and Huntington [2017], who found that skeptical perspectives toward science tend to elicit a higher frequency of uncivil and sarcastic language. The results of this study also indicate that epistemic trustworthiness concerns are often communicated in an uncivil manner. Thus, integrating the occurrence of concerns about epistemic trustworthiness into investigations on incivility enhances the theoretical conceptualization by recognizing the varied manifestations of incivility. Therefore, future research should investigate this relationship within science communication on social media.

A few limitations must also be considered when drawing implications from this study. For this study, specific sampling requirements led to analyzing Twitter/X replies directed at just six selected scientists. The scientists needed to be full professors of virology and active researchers with a university affiliation as well as having over 10,000 followers. The number of followers was important to ensure these individuals communicated to a broader public instead of only within the scientific community. In addition, only reply tweets were analyzed; the contents of the original tweets were not considered. However, the preceding communication of the virologists may have influenced the replies as it may have fostered more emotional reactions depending on the statement type or language used. It also has to be acknowledged that the comments are not representative of recipients of the original tweets. It is however, important to investigate the prevalence of uncivil communication within tweets due to the effects that observing incivility can have. Moreover, the high epistemic uncertainty during the pandemic makes it almost impossible to assess the nature of the trustworthiness concern as new evidence questions the validity of earlier evidence or drawn implications that appeared on a regular basis. Thus, some trustworthiness concerns may have been justified or correct and may have also promoted the overall trust in science to enhance “informed trust” — also described as critical trust [Bromme, 2022].

7 ▪ Conclusion and outlook

This study highlights the importance of analyses concerning the responses toward scientists’ social media communication due to the potential of directly interacting with the public online which is accompanied by challenges and disruptions. This is especially true around a socio-scientific issue like the Covid-19 pandemic, which sparked controversial and polarized debates on topics such as mask-wearing and mandatory vaccination. By analyzing 6,000 reply tweets toward scientists from different time periods within the pandemic’s first year, this study provides insights into the dynamics and manifestations of online incivility in the

context of science communication. As more than every sixth tweet contained uncivil language (17.3%), and more than every sixth tweet contained epistemic trustworthiness concerns (17.5%), this investigation shows high relevance. This study also provides insights into the frequencies of the different forms of uncivil communication, which is a valuable contribution as conceptualizations and operationalizations of incivility are divergent. Studies, investigating the effects of uncivil communication should test forms of incivility individually, as it is expected that effects and consequences for deliberation vary for different forms of incivility. This study shows that not only do the occurrence of forms of incivility differ strongly, but it is also visible that the occurrence inconsistently increases over the pandemic time period, which indicates growing controversiality in online debates around the pandemic on Twitter/X. In addition, a key finding is that epistemic trustworthiness concerns are intertwined with incivility, indicating that trustworthiness concerns are often communicated in an uncivil manner. These results enhance our understanding of the dynamics of online incivility during the pandemic insofar as incivility possibly has been affected by specific events (e.g., Christmas) or phases (e.g., increasing polarization). Moreover, as the development of occurrences of incivility and trustworthiness concerns resemble one another and co-occurrences exist, this study provides a first step into a nuanced understanding of how public sentiments toward visible scientists evolve during a global crisis.

Future research should investigate the effects of trustworthiness concerns that are communicated uncivilly and the differentiation when trustworthiness concerns are communicated civilly and when incivility occurs without addressing epistemic trustworthiness. Both phenomena may reinforce each other; however, the data do not allow us to make statements about whether uncivil comments affect trust attitudes or vice versa. Neither, we can make assumptions about whether scientists' disagreements or statement types influenced the reply tweets. Former studies have shown that civil and uncivil disagreements amongst scientists can affect trust in science and scientific methods [Chinn & Hart, 2021]. Moreover, as the conceptualization of incivility is contested, in particular outside a purely political context, studies investigating this concept in more depth are needed. Therefore, content analyses and experimental studies should deal transparently with the underlying forms of their conceptualization of incivility and investigate potential differences of effects within the umbrella concept of incivility. Finally, research should further explore how both uncivil communication and raised trustworthiness concerns directed at scientists affect communication behavior, the overall motivation of scientists to engage publicly, and how scientists deal with these disruptions and challenges. This paper has offered a foundation for further research by providing evidence of the occurrences and manifestations of uncivil communication in the context of negotiating socio-scientific issues.

Acknowledgments

This research is part of the project "Science communication during pandemics: The role of public engagement in social media discussions", funded by Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) - 458609429. Grant applicants are Monika Taddicken, Nicole Krämer and Stefan Stieglitz. I would like to thank Maximilian-Joseph Dichtl for his assistance with data coding as well as my colleagues and my supervisor Monika Taddicken at the Institute for Communication Science for their valuable feedback. I also appreciate the constructive comments from the anonymous reviewers.

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How to cite

Peters, N. (2024). 'Uncivil communication and epistemic trustworthiness concerns in public online discussions in response to scientists during the Covid-19 pandemic'. *JCOM* 23(06), A03. https://doi.org/10.22323/2.23060203.

Supplementary material

Available at https://doi.org/10.22323/2.23060203
Codebook for the content analysis.

ISSN 1824-2049. Published by SISSA Medialab. jcom.sissa.it