



# Should I trust or should I go? How people perceive and assess the quality of science communication to avoid fake news

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## Abstract

This paper investigates how citizens of five European countries (Italy, Poland, Portugal, Slovakia, and Spain) enquire about scientific issues, how they rate scientific information on climate change and vaccines in terms of quantity and quality, and their strategies for overcoming perceived defects. We conducted a public consultation involving almost 500 citizens and addressed controversial science-related topics. Discussions were qualitatively content analyzed. The public consultations revealed the prevalence of traditional media as a source of scientific information, and the results presented a general perception of inadequate, imprecise, and insufficient scientific communication. Finally, we show how traditional media are still the most frequently used channels and that personal criteria prevail in the evaluation of the reliability of information sources.

**Keywords** Misinformation · Fake news · Science communication · Public consultation · Vaccine · Climate change

## 1 Introduction

### 1.1 Quality and reliability of science communication in the post-truth era

During the COVID-19 pandemic a dramatic increase was noted with regard to the public importance of the quality and reliability of science communication. According to the dominant narrative circulating in the media we have been recently witnessing an uncontrolled spread of so-called ‘fake news’, with repercussions on the political, economic and social scene that would mark the entry into the era of post-truth (Oxford Dictionary 2016). Fakeness affects both social information and science, which have become highly interactive globally, and trust in science and also the capacity of individuals and society to make evidence-informed choices are becoming increasingly undermined. Scientific knowledge is not immune from the dissemination of false news, however, according to some authoritative

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observers, it would moreover appear to be at the centre of an information storm. The disseminators of anti-vaccination propaganda, climate change deniers, subjects who promote medicines that are not based on scientific evidence and many others are evidently launching an attack on science (Achenbach 2015; Vernon 2017; Crease 2019). The latter would also represent real threats to the health of millions of people and the protection of the environment (Douglas and Sutton 2015). Even before the official announcement of the COVID-19 pandemic on 11 March 2020 conspiracy theories (Mahl et al. 2022; Bessi et al. 2015) and misinformation about the origin, extent, prevention, treatment, and other aspects of this disease began to spread on the Internet. The World Health Organisation has declared that an ‘infodemic’ has arisen, whereby incorrect information concerning the virus will pose risks to global health.

The credibility and reliability of information are always central to science communication and the public understanding of scientific matters. In the age of the infodemic, as noted by Bucchi and Trench (2014, p 10), “the contemporary overload of information requires that the user is more competent and requires new definitions of quality.” In this paper, on the one hand, we offer definitions of ‘quality’ and ‘reliability’, bearing in mind a debate widely present in studies on the Public Communication of Science and Technology (PCST) (Šuljok and Brajdić Vuković, 2013; Bucchi 2019; Olesk et al. 2021). On the other hand, we assume a grounded theory approach to define the ‘quality of information’ and the ‘reliability of information’ on the basis of the opinions and comments of European citizens who were consulted during our research activity, proposing various definitions of ‘quality’ and ‘reliability’. By means of an inductive analysis the ‘citizen consultation’ allowed us to understand what European citizens consider to be ‘quality information’ and ‘reliable information’. As a result of this analysis it was possible to identify four main dimensions which the citizens identified as emblematic of ‘quality’ and ‘reliability’: accessibility, validation, understanding, and engagement.

Exposure to information about science and technology in the media is an indicator often used to comprehend the relationships that exist between science and society. Studies on the PCST can play an essential role in defining the relationships between citizens, scientists and institutions, especially considering a trend whereby citizens are now increasingly aware and demanding with respect to posing questions and requesting spaces where they may listen to presentations and discussions on issues relating to science and technology which may have a strong public impact.

Weingart and Guenther (2016) show that science communication depends on trust in both the source and the communication mediums. However, some scholars have associated the emergence of pseudoscientific news with the spread of traditional media, such as television (Schiele 2020).

Fake news currently abounds and scholars, news media and the public are devoting a lot of attention to this issue. However, disinformation strategies are not a new phenomenon (Lazer et al. 2018). Disinformation has existed throughout history (Uberti 2016), and has more nuances than might appear.

For a long time, misinformation was considered an anomalous phenomenon of journalism (Gorbach 2018) or an individual bias. However, in recent years, fake news has penetrated mainstream discourse and media coverage, has permeated political debates (Ali and Zain-ul-abdin 2021; Grinberg et al. 2019) and has become the focus of a stereotypical view of social media (Bridgman et al. 2020).

However, the dominant discourse—often conveyed precisely through the mainstream media—tends to associate the new forms of disintermediated participation online with the proliferation of fake news and the affirmation of a post-factual condition.

This trend is one of the factors which are stimulating among researchers a growing interest in how fake news is mediated and communicated (Baptista and Gradim 2020). Unsurprisingly, the role of new information and communication technologies lies at the centre of this emerging research field and an intention to explore how social media interacts with the flow of disinformation (Porshnev and Miltsov 2020; Conti et al. 2017; Tangherlini et al. 2020).

In the so-called post-truth era, many scholars and commentators have stressed the role of the Internet and digital tools for scientific communication, primarily through social media (e.g., Facebook, Twitter, Instagram), and their impact on scientific communication and public trust in science and scientists.

While the so-called infodemic may be considered a normal process of forming opinions in the current infosphere (Florida 2014), the role of the quality and reliability of the information becomes subject to particular attention. According to a recent study, the COVID-19 pandemic produced both false and reliable messages, with the former category representing 5% of the total (Cinelli et al. 2020). Moreover, although public opinion has become polarized on some controversial aspects of science, at the worldwide level citizens identify scientists and research organisations (e.g., universities, academic bodies) as actors deserving of a strong reputation and trust (Funk and Rainie 2015; Lobera and Torres 2015; Wellcome Trust 2021).

The question of the credibility and quality of information available on the web and in social media has generated numerous projects, initiatives, and training courses with a view to contrasting fake news. Fact-checking websites in which international experts present their observations, conferences, and the foundation of relative associations are increasingly widespread sources of support. According to a report, which since 2015 has been published annually by the Duke Reporter's Lab, there are currently 290 information verification projects active around the world, most of which are based in Europe. Moreover, social media platforms, such as Facebook and YouTube, have announced actions to limit the spread of false content. In conditions of uncertainty, such as that which recently occurred with the onset of the COVID-19 pandemic, trust in the quality of scientific information appears to be strategic and fundamental for the purpose of effectively counteracting risks and emergencies. However, social media are not the principal source of information for European citizens.

## 1.2 Usage and credibility of scientific information sources

A Eurobarometer (EB) survey conducted in 2020 has revealed that most Europeans still acquire their information on science and technology from television (63%). Around three in ten respondents (29%) use online social networks and blogs as primary sources of information, and around a quarter (24%) use online or printed newspapers. Only 14% of citizens use the radio, including podcasts, online encyclopedias (13%) and online or printed scientific journals (10%). Using online social networks and blogs is the second or third most widely mentioned source of information in almost all EU Member States except Finland (EC 2021). Moreover, the EB survey has illustrated that age strongly influences the sources of information people use, and especially those offered by the Internet through online social networks and blogs.

However, international data collected during the recent COVID-19 pandemic have shown that a minority of citizens collect information through social media (V & A, 2020; Observa 2020). This issue leads to a need to determine whether the credibility of

scientific information related to science and technology varies depending on the source of communication. Regarding climate change, Sanz-Menedez and Cruz-Castro (2019) have concluded that the general public may be willing to trust scientific institutions more than any other actor when scientific issues—even of a controversial nature—are reported. Boothby and colleagues (2021) have compared the credibility of scientific information presented on Twitter with the degree of credibility of the same information provided through other media, and the results have revealed that information concerning issues of a scientific nature is perceived as less credible when it is presented on Twitter compared to other platforms.

The proliferation of online sources of scientific information suggests that the information system presents an abundance of voices. Recent research has examined many of these different sources of science communication, including science journalists (Hayden and Hayden 2018), public relations professionals (Autzen 2014) and scientists themselves (Liang et al. 2014). A brief review suggests that the sources receiving less attention are politicians, while the more credible sources are scientists and researchers. On the other hand, Tong and colleagues (2019) have found that different sources directly influence the audience opinion relating to scientific research. Also in this case, scientists—as sources—contribute to forming a better attitude towards science. With regard to information on nature-related topics a recent study has confirmed the trust in science: the most trusted sources are science organisations, universities, and friends/family (Wilkins et al. 2018). Several studies on science communication reliability have shown that the demographic characteristics of audiences influence the judgement regarding channels and sources.

Regardless of the types of sources used by citizens to obtain information, recent data from Europe show that a significant proportion of citizens think that the overall influence of science and technology is positive (86%). Trust in science and technology has been consistently high during the past few years (e.g., Portugal (99%), Poland (91%), Spain (90%), Slovakia (83%) and Italy (82%)). It is therefore necessary to consider the criteria adopted to evaluate information: how do citizens assess information? How do they identify reliable sources? Few studies on the public communication of science have investigated the strategies adopted by citizens to orient themselves in this complex media ecosystem.

This paper examines how citizens from five European countries (i.e., Italy, Poland, Portugal, Slovakia, and Spain) evaluate the scientific information about two relevant topics (i.e., climate change and vaccines) in terms of quantity and quality and their strategies to overcome perceived flaws. Studies on credibility and trust in sources have shown that the source's reputation is an essential credibility heuristic (Metzger et al. 2010) and that, above all, credibility lies in the trustworthiness and expertise of the source itself (Tseng and Fogg 1999). Users tend to transfer the reputation of the sources (companies and news organisations) to the content itself (Metzger et al. 2010).

## 2 Method

The study is part of the H2020 program from the European Commission [Grant Agreement N. 824537], coordinated by the University of Valencia. CONCISE, involving partners from five European countries (Italy, Poland, Portugal, Slovakia, and Spain), aims to understand the role of science communication with respect to the beliefs, opinions and perceptions of laypeople concerning controversial science-related issues. To achieve this purpose, CONCISE carried out a public consultation in each consortium country on four topics, which

are both environment-related, i.e., climate change, genetically modified organisms (GMOs) and health-related, i.e., vaccines, complementary and alternative medicines (CAMs).

The countries involved present differing democratic traditions and forms of public involvement in techno-scientific issues. In particular, the differences between public communication systems in the three Southern European countries (Italy, Spain, and Portugal) and the two Eastern European countries (Poland and Slovakia) are evident with regard to the use of traditional and new media. There are consolidated media infrastructures in the former countries, and these are usually 'television-centred'. In the Eastern European countries there are developing communication infrastructures, and the second information channel is the Internet, which has been considered the primary source of information relating to national political issues since late 2015 (European Commission 2021).

These differences affect the accessibility of scientific information, and many correspondents do indeed report on increasing opportunities for the public to gain access to information about science and technology. However, there is also an increased awareness that this accessibility does not necessarily foster knowledge or interest (Mejlgaard et al. 2012).

This study focused on climate change and vaccines for several reasons. The issues of climate change and vaccines have a lot in common: their salience in the media, skepticism/opposition on the part of some social groups, a strong international dimension, their presence in the recent public agenda following the COVID-19 pandemic, and the ascent of the Friday for Future movement. These subjects were thus immediately found to be the most sensitive matters for citizens involved in research activities as, potentially, they might elicit the most diverse and participatory discussions.

## 2.1 Participants

Various channels were employed to recruit participants. The organisers published information about the public consultation on their institutional websites and social media, using newsletters to publicise the event since May 2019. The involvement activity attracted the interest of 2000 people, and expressions of interest were collected through web platforms. During July and August 2019, the organisers contacted all available subjects via e-mail and by telephone. The recruitment phase was completed about one week before the public consultation occurred.

The participants were informed of the objectives of the project and of the importance of contributing towards a better understanding of the communication processes of science and technology. The invitation letters sent to the participants highlighted the importance of active participation and the fundamental role of citizens in processes of involvement with respect to the issues of scientific communication.

In order to facilitate participation in the consultations the travel and accommodation expenses incurred by the participants were paid for.

It should be noted that the public consultation procedure is not a survey and thus a statistically representative sample was not required. Our aim was to construct a sample that would ensure the heterogeneity of the participants. To construct the sample the organisers consequently initially created a theoretical sample of 150 cases per country based on the official statistics of the relative population (stratified by gender, age, area of residence and level of education). Subjects whose characteristics adhered most closely to the established criteria were then invited to participate. Compared to the theoretical sample, the resulting sample of individuals involved was representative, considering age and residence data.

**Table 1** Public consultation layout of participants by gender, age, education, and residence (n: 497, %)

	Italy (93)	Poland (100)	Portugal (102)	Slovakia (99)	Spain (103)	Mean	DS
Male	53.70	37.00	37.00	42.40	43.00	42.62	6.82
Female	46.30	63.00	63.00	57.60	57.00	57.38	6.82
Age 16–34	32.26	30.00	26.80	49.00	28.00	33.21	9.07
Age 35–54	42.01	34.00	30.40	32.00	34.00	34.48	4.47
Age > 55	24.73	36.00	32.70	19.00	38.00	30.09	8.00
Primary + lower education	16.13	8.00	5.00	3.00	12.00	8.83	5.31
Upper secondary education	38.71	44.00	26.00	40.50	32.00	36.24	7.20
University degree	45.16	48.00	70.00	56.50	58.00	55.53	9.76
Urban area	75.80	80.00	77.00	81.70	72.00	77.30	3.78
Rural area	24.20	20.00	23.00	18.30	28.00	22.70	3.78

The public consultation involved 497 citizens (Table 1).

## 2.2 Procedures and data collection

The public consultation procedure was based on the World Wide Views consultation approach (Blue and Medlock 2014; Riedy and Herriman 2011).

The consortium organised public consultations in the respective countries, adopting a standard format involving one hundred volunteer citizens per country. The subjects involved participated in debates in small groups (each of which comprised 7–10 people), with the help of a moderator and an observer, at a single-day event. All of the public consultations took place between September (Italy and Poland), October (Spain) and November 2019 (Slovakia and Portugal).

The underlying rationale of the choice to engage in a public consultation as the preferred method of data collection was determined by the intention to (1) hold multiple group discussions simultaneously; (2) create a participatory experience for the attendees and empower them by creating an opportunity to contribute to science development; (3) generate among the citizens the feeling of being a part of a large national event and the international community. No other method would satisfy these needs; a public consultation was thus deemed to be the most suitable method. Group discussions were held in order to acquire the citizens' opinions, beliefs and perceptions and to benefit from group dynamics and interaction which helped to reveal the reasons underlying the participants' attitudes towards a particular topic which may not have been identified if survey techniques were applied.

The possibility to involve males and females of various ages, origins, and educational levels led to an exchange of views within a favourable context and the participants were able to freely express their views. In this way, a participatory context was created in which it was possible to listen to the participants' observations and note their orientations, this being a situation that would not usually occur. Unlike other types of consultation, oriented to the development of decisions (Fernandez-Jesus et al. 2019; Rowe and Frewer 2005), the public consultation had as its central focus the collection of suggestions, criticism, and opinions.

At the beginning of each consultation, the objectives and tasks were illustrated during the working sessions. Within each group of participants, appropriately trained facilitators explained the objectives of the meetings, the methods that would be adopted and the contribution required from the participants.

The consultations were devised and arranged, and a shared protocol was adopted focusing on organisational aspects and the manner in which the discussions should be conducted. All details concerning the relative events, such as selected venues, equipment and accommodation, were agreed upon in advance, following specific standards established for the realisation of the project. Elements concerning the management of the groups, data collection and the definition of results were established following a specific protocol. In particular, group discussions followed a specific script (see Online Annex. 1). The study of the results and all information collected was implemented following the procedures indicated in the section concerning data analysis.

The general organisation of the public consultations followed a detailed protocol and corresponded to that of all the national working groups described in the publication which illustrates the entire initiative (Moreno Castro et al. 2020). An effective implementation of consultations was possible as they were organised six months in advance during discussions which focused on contextual elements within the working group. This procedure allowed for a homogeneous implementation of the consultations, with minimal variations which may have been caused by the renunciation of subjects invited to participate in the events or minor changes in the timing of the sessions.

Each discussion addressed a) the sources and channels used to acquire scientific information, b) the question of their reliability, and c) proposals regarding the improvement of scientific communication. The role of the facilitators was to ensure that the participants discussed all points, avoiding any 'off-topics', to encourage the contribution of all participants and to control and cope with the lengthy and loquacious intervention of some individuals and a tendency to remain silent on the part of others.

To obtain answers to the questions referred to above we adopted the public consultation methodology, which is specifically designed to investigate the ideas, values, beliefs and feelings of citizens regarding science-related topics. Moreover, this procedure is particularly useful in an attempt to learn about sources referred to and the decision-making process adopted by citizens with respect to specific items (Lezaun and Soneryd 2007).

The discussions held at each table were audio and video-recorded, transcribed verbatim and anonymized to guarantee the privacy of the participants.

## 2.3 Data analysis

The transcribed content of the discussions was analyzed on a qualitative basis with the support of the NVivo software. The 'conversational turn' was chosen as a unit of analysis. The total corpus comprised 21,050 conversational turns (10,510 relating to climate change and 10,540 regarding vaccines). A tree-structure coding scheme was developed and constantly shared and debated amongst the researchers involved in the analytical process. In its initial branches the tree contained some codes that were transversal to the topics and identified a priori. Then, each branch was populated by other topic-specific codes emerging from the data during the coding process. In particular, we proposed three main sets of dependent variables a priori, in a manner coherent with the objectives of the project. Drawing upon the scripts of the discussions, these variables comprised the questions of how citizens are informed, the reliability of sources and proposals relating to the improvement of science



**Table 2** Number of references (i.e., conversational turns) expressing a negative evaluation of science communication (quantity and quality) by topic and country

	Climate change		Vaccines		Total	
	Quantity	Quality	Quantity	Quality	Quantity	Quality
Italy	23	95	29	97	52	192
Poland	14	44	17	2	31	46
Portugal	76	78	40	35	116	113
Slovakia	13	11	36	41	49	52
Spain	15	56	23	46	38	102
Total	141	284	145	221	286	505

communication. More specifically, to achieve the principal objective of the study the following aspects and mutual relationships were examined:

- (1) Evaluation of science communication in terms of quantity and quality;
- (2) Channels and sources used to acquire scientific information;
- (3) Individual strategies implemented to overcome perceived flaws in science communication.

Each aspect was investigated as a whole and depended on the topic discussed.

### 3 Results

#### 3.1 Evaluation of science communication

The results provide many references to the manner in which the citizens involved in public consultations in the five European countries evaluate science communication (Table 2). It is worth noting that most of the statements have a negative connotation, stressing a perception of inadequate science communication, in terms of both quantity and quality. The participants appear to be more inclined to assume a critical rather than an appreciative view of science communication in their countries. With respect to quantity they refer to both a lack and an overabundance of information, depending on the specific nature of the topic and the relative cultural context. With regard to quality, they consensually share the perception of poor science communication, revealing minor topic-specific or country-specific differences, with a variety of nuances.

In quantitative terms, the participants perceive science communication as insufficient, rather than excessive, in all of the countries, except Poland. However, significant differences emerge according to the topic discussed.

Specifically, among the five countries referred to the citizens involved in the public consultations consensually indicate an overload of information concerning climate change. They acknowledge that climate change is a topical issue in public discourse, however, they stress the excessive pervasiveness of content relating to this issue.

“It is an important issue that has no solution; there is an overabundance of information everywhere” (Slovakia)

“Information is appearing everywhere at the moment” (Poland)



A paradox is generated, whereby this vast quantity of information does not reflect accurate knowledge of the current reality. Citizens seem to lose themselves in this variety of reported data, making it challenging to acquire relevant and reliable information.

“We have an increasing quantity of information, but we feel less and less informed, which is a paradox” (Portugal)

“There are thousands of reports out there and we have to filter through all of them” (Italy)

On the contrary, opinions on science communication relating to vaccines broadly vary, depending on the cultural context. Portuguese, Slovak, and Spanish participants lack information on this topic.

“There is no information about vaccines. Vaccines are mandatory. We do not know whether they are good or bad, or whether they are effective or not” (Portugal)

“The Government is not fulfilling its role in terms of communication ... and doctors do not provide any information on vaccinations” (Slovakia)

On the contrary, in Italy and Poland, people have the impression there is an overabundance of information.

“I agree, we are overloaded with far too much information” (Italy)

“I have the impression that this is the main subject of interest, and I am bombarded with information about vaccinations and vaccines ... everywhere, via the radio, television and the Internet. My perception is that this is a never-ending topic” (Poland)

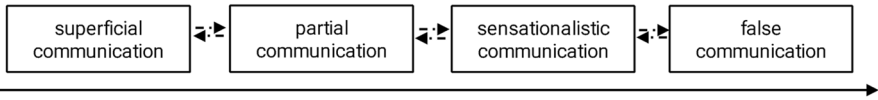
With respect to quality, the European citizens participating in the public consultations evaluated science communication as ‘poor’. Ample space was dedicated to indicating the reasons why, in their opinion, it is perceived as inadequate. The most frequently cited motives pertain to the perception of alarmist news stories, biased positions, ‘clickbait’ content or phony titles, the threats of conspiracy theories, denigrating content, the presence of fake news or hoaxes, fragmented or generic information, inconsistent news, polarized content and pseudoscientific positions.

We have divided these reasons into four different levels of misinformation, as follows.

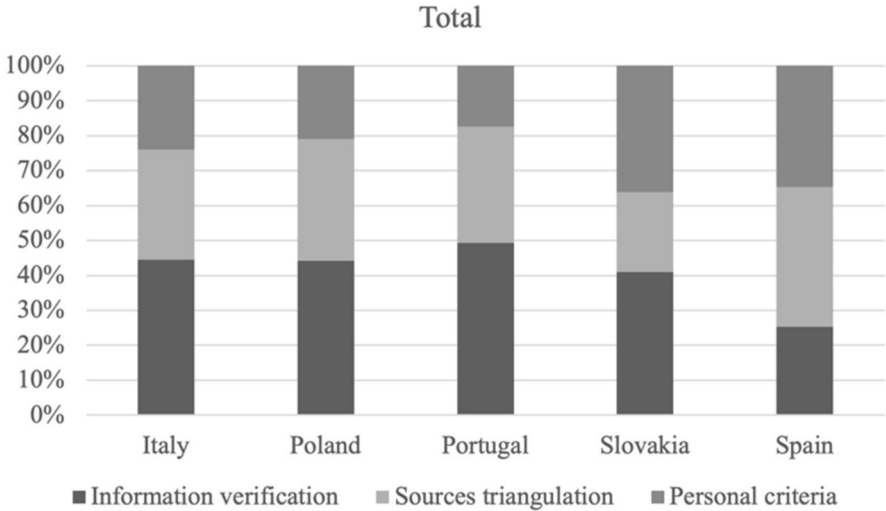
1. Superficial communication is the dissemination of imprecise, vague or inaccurate information and includes inconsistency, fragmentation, and generalisation;
2. Partial communication indicates the diffusion of incomplete, prejudiced and partisan positions and comprises bias, polarisation and denigration;
3. Sensationalistic communication transmits tawdry, exaggerated, and captivating news and covers alarmism, phony titles and clickbait content;
4. False communication refers to the circulation of deceitful, fabricated and untruthful contents and comprises fake news, conspiracy theory and pseudoscience.

These levels should be construed as forming part of a continuum ranging from a milder form of misinformation, where no intention to deceive is present, to a more severe practice of misinformation, where a certain degree of deceit is detected (Fig. 1).

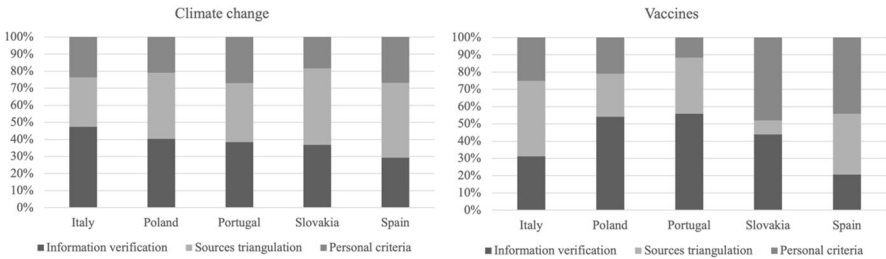
First of all it should be noted that the results show that superficial communication is transversal to the issues of climate change and vaccination. More specifically, the participants report occurrences of inconsistency or, to a lesser extent, generalisations in the information which they access (Figs. 2, 3).



**Fig. 1** A model of (science) misinformation as a continuum



**Fig. 2** Percentage of references (i.e., conversational turns) expressing the three different strategies implemented to assess and overcome perceived flaws in science communication



**Fig. 3** Percentage of references (i.e., conversational turns) expressing the three different strategies implemented to assess and overcome perceived flaws in communication about climate change (left side) and vaccines (right side)

“There are many inconsistent opinions or news items; you read about things one way, then you hear about them another way. Everyone is now contradicting everything ... it is a complex situation” (Italy)

“The same news is communicated in a variety of ways and may be attributed with varying levels of relevance. Worse still, even through the same communication medium, numerical data will be presented differently by various speakers” (Portugal)

“What’s all this about a campaign? Get vaccinated! And that’s it, period. It’s no longer a question of a backstage scenario. Have they explained the situation?” (Spain)

It is then also worth noting that false communication is widely present in information relating to these areas. The idea of a poor level of science communication emerged from the discussions; this was mainly due to the presence of untruthful content and especially fake news based on pseudoscientific positions.

“In social networks and on Facebook, which I use, sometimes a person will see something and then feel it is not credible or that it is fake information. If it is fake, sometimes you have to be careful and do some screening; in any case there will sometimes be news items that you do not want to believe, let’s say” (Portugal)

“One thing members of the No-Vax group are extremely good at, also compared to other various hoaxes, is using of a lot of pseudoscientific terms in the scariest way possible” (Italy)

“The whole anti-vaccination movement stems from the content of a scientific article, which was of course disproved, and the author had to apologise [...] This is no longer known, but the disinformation started to spread” (Slovakia)

However, some specific elements emerge with respect to the two topics referred to above. With regard to the dissemination of news concerning climate change the main flaw perceived appears to be a form of sensationalistic communication. The citizens involved in the public consultations highlight the diffuse presence of alarmistic news, which often accompanies clickbait content or phony titles.

“Information is often provided in this way; imposing headlines appear, having an impact that only generates anxiety and panic. It is not clear how we should proceed” (Italy)

“They talk about the effects and various consequences related to climate change, but there is an extreme exploitation of the negative [...]. There are technological solutions, but this is no longer appealing for mass communication; the solutions are not attractive, the good news is not attractive” (Portugal)

“So, these exaggerated observations are present of course on all channels, and you will find them on almost every site; there is a need for a slightly more scientific site that can be trusted” (Spain)

On the other hand, with regard to communication relating to vaccines, the main flaw perceived is partial communication. The participants highlight the circulation of biased or polarized information, whereby an evaluation of the quality of science communication is rendered inadequate.

“This issue also arises in social media because the vaccine deniers share a thousand articles, all of which present the same single study supporting the No-Vax stance. There are then fifty thousand articles that support the pro-vaccine rationale” (Italy)

“Returning to our main topic of adverse vaccination reactions, if the political option proposed is in line with the perception contrary to vaccination, they will not inform you, for example, of the number of vaccinations that have been administered or whether the relative percentages are higher or lower or the same. If the option presented is pro-vaccination, they will generally not refer to any undesirable reactions, which, again, is not a good way of proceeding. This is because it creates the impression that pro-vaccine people have something to hide” (Poland)

“We do not receive information from both parties, and that is the problem; we then have to bear the consequences.” (Spain)

**Table 3** Number of references (i.e., conversational turns) expressing a source or a channel of scientific information by country

	Italy	Poland	Portugal	Slovakia	Spain
Traditional media	285	126	325	163	160
Digital media	266	149	204	251	179
Interpersonal exchanges	284	22	43	262	92
Scientists	133	11	129	10	118
Communicators	132	22	69	337	35
Institutions	73	6	121	89	25
Organizations	50	24	90	72	63
Politicians	42	6	17	17	15

### 3.2 Channels and sources of information

Having described the perception of science communication, it becomes crucial to understand which sources or channels people use to acquire scientific information and which may be the primary vehicles of misinformation.

In brief, the results from the qualitative analysis of the public consultation indicate commonalities and differences among the five European countries (Table 3).

With regard to commonalities, the media (both traditional and digital) are the most important sources in all countries: traditional media are preferred in Italy and Portugal, and digital media are preferred in Poland, Slovakia, and Spain.

“Considering the way I gather information, when I am interested in a particular subject I keep an eye on things. Above all, I look for information on RTP and Euronews. They are the sources I prefer.” (Portugal)

“I set up my page on Facebook. I follow things that interest me, such as Science in Poland (...) Facebook offers me links to some articles (...). It provides me with links to external websites, but this is my basic channel of information because I don’t watch television, listen to the radio or read newspapers.” (Poland)

More specifically, among the traditional media, television is the most frequently cited, with numerous references to newscasts and documentaries and specific television channels (also international) or programmes. This is followed by newspapers (mainly national, local or international), magazines and books (including school or university textbooks). Albeit occasionally referred to, scientific journals and the radio are less relevant. Among digital media, the internet (and specialised or generalist websites, forums, and, more generally, the Google search engine) is the primary channel. This is followed by social networks and, to a much lesser extent, blogs. Instant messaging applications and e-mails have less importance.

Politicians are the least essential sources in all countries. They receive little attention, and their observations are hardly considered with respect to information on scientific issues.

‘Direct’ sources (i.e., citizens and personal experiences) are significant in all countries, especially Italy and Slovakia. Alongside the media, interpersonal exchanges thus contribute to knowledge of science issues. Such exchanges are referred to in terms of personal experiences, at school/university or work, and ‘word-of-mouth’ sources. It represents a means of sharing points of view, opinions and advice on controversial topics, such as those under investigation. In addition to personal experiences, direct communication also

**Table 4** Number of references (i.e., conversational turns) expressing a source or a channel of information about climate change by country

	Italy	Poland	Portugal	Slovakia	Spain
Traditional media	198	58	208	87	98
Digital media	176	95	124	115	116
Interpersonal exchanges	129	10	30	134	27
Scientists	20	9	51	5	20
Communicators	84	14	66	154	32
Institutions	34	6	22	57	16
Organizations	25	18	48	20	16
Politicians	29	6	17	9	13

plays an important role: the participants in the public consultation often refer to friends and their family circles as principal sources of information, and references are also made to acquaintances, colleagues, teachers, fellow students and strangers.

“I have a little grandchild. They introduce the idea at school, in biology classes, and they discuss these matters. I am surprised how they react positively to this. At school they teach children how to separate different types of waste, inducing them to act more responsibly.” (Slovakia)

“I heard about this for the first time many years ago. I acquired direct knowledge about it from my trade-union colleagues. I was involved in trade-union activities, and therefore these subjects of discussion emerged as a result of our interest in various topics. From that time onwards, I tried to acquire further knowledge concerning the issue” (Italy)

On the contrary, while different approaches are noted among the countries considered, information is sought from communicators, institutions, and organisations to a moderate extent. Communicators (i.e., opinion leaders, experts,<sup>1</sup> or journalists) are frequently cited. On the other hand, institutional sources (e.g., the Ministry of Health and universities or research institutes) are less frequently indicated. Similarly, governmental or non-governmental organisations and companies are rarely used as a source of information, remaining relatively marginal points of reference in public consultations.

Finally, scientists are attributed with a varying degree of importance in the countries considered. They are deemed to be fairly important in Italy, Portugal, and Spain and as less essential sources of information in Poland and Slovakia. Nonetheless, scientists have a strong influence, especially concerning health (e.g., general practitioners, medical specialists, pediatricians, pharmacists).

Moving beyond this general framework, some differences emerge considering the topics discussed.

With regard to climate change (Table 4), the results from Italy and Spain present some commonalities: on the one hand, communicators (especially opinion leaders) appear to be specific sources of information for this topic, while on the other hand, scientists are

<sup>1</sup> ‘Experts’ differ from the ‘scientist’ category referred to below as they are individuals who present a strong vocation with respect to the dissemination and communication of science, e.g., scientists who run science blogs, or contribute to science columns in newspapers/magazines, or host TV shows dedicated to scientific matters.

**Table 5** Number of references (i.e., conversational turns) expressing a source or a channel of information about vaccines by country

	Italy	Poland	Portugal	Slovakia	Spain
Traditional media	87	68	117	76	62
Digital media	90	54	80	136	63
Interpersonal exchanges	155	12	17	128	65
Scientists	113	2	78	5	98
Communicators	48	8	3	183	3
Institutions	39	0	99	32	9
Organizations	25	6	42	52	47
Politicians	13	0	0	8	2

**Table 6** Number of references (i.e., conversational turns) expressing a strategy implemented to overcome flaws in science communication by topic and country

	Climate change	Vaccines	Total
Italy	76	16	92
Poland	62	24	86
Portugal	26	43	69
Slovakia	49	73	122
Spain	41	34	75
Total	254	190	444

mentioned much less frequently when the variable is compared to what has been observed in the total corpus of data. Italian results also highlight the prominent role of politicians (mainly at the international level) in the acquisition of news on climate change.

Moreover, the results obtained in Portugal and Slovakia also present similarities. It would appear that citizens are less frequently considered as sources of information with respect to this issue. On the contrary, Portuguese results highlight the position of scientists when information on climate change is sought. On the other hand, the Slovak results suggest the importance of personal experience as a source of information.

Regarding vaccines (Table 5), the results from Italy and Spain again reveal similarities. The most relevant result concerns the principal role of scientists (especially physicians) in providing information on such topics, which exceeds that of the media.

Moreover, on the one hand, the results from Portugal stress the importance of institutions (especially health centres and hospitals) as sources of information on vaccines; however, the results highlight the marginal role of direct communication with laypeople (i.e., citizens) as a means of acquiring news on this subject.

### 3.3 Individual assessment strategies

The participants in the public consultation sessions also illustrated the individual strategies adopted to assess and overcome perceived flaws in science communication (Table 6).

These strategies are articulated in three different forms of evaluation.

The first strategy, the verification of information, is the primary form of evaluation in all countries except Spain, where it is the least frequently cited. It comprises methods such as focusing on and acquiring further details regarding the news and ‘debunking’. By order

of importance, the second strategy is the triangulation of sources (i.e., the ‘pluralism’ of sources and channels to acquire information), except in Slovakia, where it is least often adopted, and Spain, where it is the most frequently implemented action. Finally, the results highlight yet a different strategy, i.e., the adoption of personal assessment criteria. These include a wide range of strategies ranging from personal filters, critical thinking, common sense and personal experiences to instinct, good faith, and complete trust in everyone.

These strategies differ considerably among the topics placed under discussion.

Specifically, compared to the other issue it is worth noting that climate change is the topic most frequently referred to using these three different forms of evaluation (254 references out of 444). Regarding climate change, the results from Slovakia and Spain show that source triangulation is considered to be more important than the other forms of evaluation (i.e., information verification and personal assessment criteria). Moreover, with respect to the types of assessment the participants from the five countries adopt personal assessment criteria to a lesser extent.

“I acquire information from professional journals, newspapers and also from the Internet” (Slovakia)

“In particular [I make use of] social media and Instagram. And, yes, when I access websites, and read the news published on the Internet, also from the United Nations, and in newspapers and so on, I have no particular preference, but I check some of them.” (Spain)

Concerning vaccines, the results from Italy indicate that source triangulation is perceived as more relevant than information verification.

“Go to the doctor and seek advice and ask him to inform you about the situation. You can also read leaflets, check the websites and read books. I don’t know; I might speak to a doctor who I know is in favour of the vaccination scheme and then visit someone who I know is against it and I would look for information from different sources, as we said previously ...” (Italy)

The results from Slovakia and Spain moreover suggest that personal assessment criteria (especially personal experience and common sense) are considered more important than the other forms of evaluation.

“In my opinion, every rational person will agree with the vaccination process as it has been working for decades, so why should it be any different now?” (Slovakia)

## 4 Discussion

By means of public consultations, it was possible to allow the citizens to voice their opinion and also to determine which sources/channels EU citizens use to acquire scientific knowledge and how these influence their strategies for navigating their way through the morass of information.

On the other hand, for over a decade now the digitization of information and the growing diffusion of digital media (We Are Social—Hootsuite 2021) have prompted a broad debate on the role played by the circulation of incorrect, false, or incomplete content when appropriate decisions have to be made at the individual, political and social level. The digitization processes also pose challenges for science communication in the mainstream media (Riesch 2011).



Our results show that the impact of social media must be extensively reconsidered. Indeed, in a manner coherent with long-term trends, the public consultations indicated a prevalence of traditional media and digital media as primary sources of scientific information and a particularly cautious use of social media to obtain information on scientific topics.

An initial observation concerns the use of media: citizens show that the traditional media is preferred in the Southern Europe countries (Italy, Portugal, and Spain), while in the Eastern countries (Poland and Slovakia) there is by and large a greater use of digital media. Moreover, older citizens from all of the countries involved prefer conventional media, and younger citizens also prefer them.

According to the citizens' perception in the public consultation, climate change is the topic that is most widely covered and discussed in traditional and digital media. Citizens do not need to search for information; they are bombarded with it. The situation suggests that the complexity of the topic and broad consensus on the effects of global warming require ways of expanding and deepening public knowledge which the social media cannot offer.

The question regarding vaccines is a polarizing subject in some countries and generates a more consensual response in others. Trust is placed mainly in government agencies, family doctors, and healthcare institutions, whereas pharmaceutical companies and non-verified websites are mistrusted. Interpersonal relationships however represent essential sources of information and offer an opportunity to engage in discussion in the case of health issues. An individual's family and circles of friends allow for confrontation, with the possibility to exchange views and opinions, revealing our attitudes and critical vision of medicine and science.

The public–private dimension makes it possible to identify the role recognised by institutional and expert sources in scientific debates, but, at the same time, this dimension highlights the importance attributed to personal experience in incorporating knowledge into daily practices within the private sphere.

It should be considered that the dimensions analyzed cannot explain the levels of trust or distrust in different science communication channels and sources. In any case, it is possible to detect diverse orientations. The differences that emerged from the analysis reflect the distinct historical-political backgrounds of countries that once formed part of the ex-Soviet bloc and countries in the Western area; in particular, this condition is evident with regard to the issue of trust in institutions and the media.

Participants described social networks as instruments of communication where it is easier to find incorrect content and stated that they would examine their content with conscious distrust (Bucchi and Saracino 2020).

The second observation concerns strategies adopted to evaluate the reliability of information sources. Our results show that the recipients or consumers of information evidently activate diverse strategies (e.g., triangulation, fact-checking) to select contents on the web. In this way they prevent themselves from (unconsciously) becoming multipliers of false news. However, the more widespread strategy in all countries may be associated with 'personal criteria'. This choice does not stem from generalized skepticism concerning the media or a tendency to debunk available tools. Trust is mainly fuelled by interpersonal relationships within particular social circles, and may depend on one's age and level of education, especially with regard to health-related issues. The results suggest that European citizens are not passive victims of a pervasive infodemic, however they tend to implement different forms of information assessment.

Our observations urge us to critically reconsider the role of misinformation or exposure to what is referred to as 'fake news'. Overall, the results deriving from a qualitative content

analysis of the public consultations have allowed us to comprehend the manner in which individuals interact with the various information channels, which would appear to present a significantly higher level of awareness than is contemplated in the dominant debate. A reconsideration of the aforementioned conditions might principally involve a rethinking of 'science communication' as a social conversation on science (Bucchi and Trench 2021), overcoming the dominant view of science communication (Hilgartner 1990) that relegated the debate on the effectiveness of communication to the question of an adherence to the values of science on the part of citizens. In this direction, our results increase the range of viewpoints and actors involved in the conversation.

The requests and proposals that emerged during the public consultations indicate the need for a more effective rapprochement between the world of science and research and the various components of civil society. Science communication is not simply a question of receiving information. The differentiation of the various audiences requires a special endeavour to offer a selection of non-universal methods and tools in order to meet not only fundamental requirements but also to provide the most suitable methods for effective communication.

During the consultations it was evident that the promotion and development of a society that favours scientific and technological knowledge should be based not only on knowledge but also on skills. While scientists and communicators have to identify adequate ways of communicating, using appropriate linguistic styles and formats, public decision-makers must be capable of adopting forms of communication that will allow them to enhance scientific knowledge, also addressing the most controversial issues and emergencies in which science can offer useful elements of support.

The quality of science communication is determined and measured by the capacity to offer spaces for discussion and not only for the transmission of information. The quality itself is also recognized in a possibility offered to the various social components to interact and offer contributions determined by their specific characteristics.

## 5 Conclusion

For more than a decade the digitization of information has prompted a broad debate on the social role of misinformation. Furthermore, the so-called 'fake news' phenomenon poses challenges for science communication in the mainstream media.

Communication, cognitive, social, and computer scientists are engaged in efforts to study the multiple reasons for the viral diffusion of misinformation online and to propose relative solutions. Furthermore, many scholars have proposed solutions to contrast misinformation, which include 'debunking', recommender systems, fact-checking, awareness-raising, media literacy, and innovations in science communication and public engagement. However, the proposals made do not seem to grasp the complexity of the phenomenon (Schäfer 2011) and would appear to be devoid of a true awareness of the public's attitudes.

Understanding the relationship that exists between the perception of the quality of science information, communication channels, sources of information and users makes it possible to identify the targets which our efforts should focus on to achieve an adequate and appropriate level of communication of scientific knowledge. In other words, with this study we collected data directly from citizens in order to comprehend: (a) the type of channels and sources citizens use to acquire information; (b) trust in sources and news and their

credibility; and (c) the criteria adopted to evaluate information and the strategies used by citizens to overcome perceived flaws.

The citizens involved in public consultations shared their perceptions of trust and mistrust in scientific information and information channels in an innovative manner, thanks to the possibility to express their opinions and refer to strategies adopted to control the quality of scientific knowledge.

The results presented here help us to critically reconsider the role of misinformation or exposure to information identified as ‘fake news’. In particular, the results from the qualitative content analysis of the public consultations allowed us to understand the forms of interaction with the various information channels, which appears to present a significantly higher level of awareness than is contemplated in the prevalent debate. An analysis of the public consultation occurring in the five countries revealed strong similarities with respect to ideas regarding how to rate the reliability of channels and sources. The principal diversity revealed by the data analysis does not reflect different geographical and cultural backgrounds but contrasts in attitude between generations or between subjects who present a higher level of education and individuals with a lower scholastic attainment.

Although many studies have underlined the difficulty of citizens to discriminate between trustworthy and untrustworthy sources, mostly concerning techno-scientific issues (Ceron et al. 2014; Fernández-Luque and Bau 2015; Ferrara et al. 2016), the results outlined so far show that the citizens’ trust in sources such as the media is not a primary factor. It should be noted that, especially with regard to issues relating to health, trust is fuelled by interpersonal relationships and an attachment to certain social circles, one’s age and level of education.

We are of course aware of the limitations of our study. Above all, the CONCISE public consultations were conducted before the SARS-CoV-2 pandemic was declared by the World Health Organisation (WHO) on 11 March 2020. The importance of the quality, trustworthiness and credibility of science communication became evident during the pandemic. Developing and articulating these findings in terms of initiatives to ensure the quality of science communication and building mutually trustworthy relationships among institutions, experts and citizens will be essential. It will be necessary to promote comparative studies to evaluate the impact of the COVID-19 emergency on science communication and the citizens’ perception of the quality of science communication.

It should be considered that the dimensions analyzed cannot explain the levels of trust or mistrust in the diverse science communication channels and sources. In any case, it is possible to detect different orientations.

Moreover, it should be considered that misinformation is not the main challenge for science communication. The broader, central challenge is the quality of science communication and how it should be improved, rewarded and distinguished from low-quality, improvised science communication having unclear aims and presenting a limited level of investigation of the context in question. Further studies, such as that proposed by CONCISE, which focus on a public audience, will allow for the scaling back of a representation of the public as hostile, skeptical and ignorant, collectively characterised by individuals who support a paternalistic—and essentially authoritarian—view of science communication and science in society. As our results clearly show, such a representation primarily reflects unfounded prejudices. Moreover, and, again, as is revealed in the outcome of our study, a cross-sectional tendency to evaluate scientific information on the basis of ‘personal criteria’ has emerged. Future research in the field of the public communication of science should indeed seek to provide further information on our understanding of the formation, sedimentation and reproduction of these ‘criteria’.

With respect to scientists, the trust in researchers expressed by the participants underlines the relevance of their becoming increasingly adept in the public communication of their work and studies. The input of scientists was repeatedly requested during the public consultation. Scientists are asked to provide information that will allow various stakeholders to adequately manage the response to emergencies caused by climate change and, more recently, by the pandemic. Scientists should therefore augment public awareness of technological challenges and the scientific understanding of the social and political aspects of social issues relevant to science (Fischhoff and Scheufele 2013, 2014).

In conclusion, the results emerging from the empirical research within the CONCISE provide valuable indications for our understanding of the relationship that exists between scientific information, the media and citizens. Our study may help to highlight the relevance of an inclusive approach and collaboration between scientists, communicators and audiences in order to include the views of the public in the decision-making process relating to techno-scientific issues of social relevance. This manner of proceeding would allow for the development of concrete proposals to create an action plan that considers recommendations promoted by citizens during public consultations, both at the national and European levels. Therefore, starting from these considerations, it will be possible to propose and prepare new adequate tools for a future assessment and monitoring of the effectiveness of public communication of science.

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