In science we trust: The effects of information sources on COVID-19 risk perceptions

Marta Entradas

Department of Psychological and Behavioural Science, London School of Economics, London, United Kingdom

Department of Sociology, ISCTE-Lisbon University Institute, Lisbon, Portugal

The goal of this study was to investigate the effects of sources of information on COVID-19 risk perceptions. Using data from a representative sample of the Portuguese population (N=1,411) collected early in the pandemic, we find that while media sources were more frequently used, scientific sources played a more important role on perceived personal and societal-level risks; higher trust in scientific sources associated with increased risk perceptions (i.e. amplified perceived risk), trust in social media associated with dismissing personal threat (i.e. attenuated perceived risk). These findings suggest that people's relations with science were determinant factors in risk perceptions, and dimensions that measure these deserve further investigation.

Keywords: Risk perceptions, information sources, COVID-19, trust in science, attitudes to COVID-19.

Introduction

On 19 March 2020, the Portuguese Government announced a state of emergency, in the face of the COVID-19 pandemic and global public health threat. A full lockdown was imposed, schools, restaurants and other businesses were closed, and citizens movements were restricted to help combat the spread of the novel coronavirus. The state of emergency lasted for forty-five days (from March 22 to May 2), shifting to mitigation from the 3rd of May, when the country entered a re-opening phase in steps. This study was conducted during this transition period. On May 1st, Portugal had registered a total

of 24.980 cases and 1000 deaths from COVID-19, and was seeing around 200 new cases and 20 deaths per day.

In a public health emergency such as COVID-19, a global event with direct impact on every sector and individual daily actions and behaviours (e.g. using masks in public spaces or social distancing), and also one in which the fragilities of science have been brought 'live' to the public sphere (e.g. uncertainty and disagreement among experts), public health communication assumes perhaps its most important and challenging role. It is likely that this communication impacts the perceptions that people hold about the disease (Kasperson et al., 1988; Ramírez et al., 2013) – importantly, whether they consider it a serious threat or dismiss it. One critical question that thus emerges is how information sources shaped people's risk perceptions about COVID-19.

The investigation of communication sources as risk articulators has received considerable attention in media and risk communication studies, with research specifically covering health threats including previous epidemics (e.g. H1N1, Ebola, and Zika). The bulk of this research has focused on coverage by legacy media (e.g. (Ophir, 2018; Rossmann et al., 2018) and more recently by social media channels (e.g. (Oh et al., 2020). Few studies have covered the breadth of sources of information people rely on during public health threats such as scientific sources (Piltch-Loeb et al., 2018), with recent research looking at the importance of instructional science-based messages about epidemics to non-scientific publics (e.g. Sellnow-Richmond et al., 2018). In the case of COVID-19, many actors other than the media became involved in informing the public about the risks of COVID-19 and providing measures to help contain the spread of the virus. Among the most visible were scientific sources including scientists, medical doctors and other health professionals (medical professionals hereafter), national and international health organisations including the WHO - and even

politicians. Despite no data being yet available on the content of this communication, generally speaking, the focus was largely on risks, dangers of the virus, and needed action to contain the spread, in a homogeneous 'alarming' tone across the main actors, as our own survey shows (e.g. 80% considered the information from journalists alarming and from scientists (60%), 'confusing and contradictory' (52% agreeing), while also generating preoccupation with the virus (77% agreeing).

We add to previous research by investigating a broader spectrum of communication sources. We were particularly interested in the distinction between media sources (traditional and new media) and scientific sources (experts such as scientists and researchers, and health professionals), and how they compare as determinants of public risk perceptions. This analysis furthers our understanding about the impact that providers of information about a public health event have on perceived threat, and may provide clues to actors in public health communication as to how to better communicate uncertainty and the limitations of science. No less important, this study provides a general sense of public opinion about science and trust in scientific sources among the Portuguese in the context of the COVID-19 pandemic, in a time when the risk event was particularly salient.

COVID-19 and public (health) communication

It makes sense to expect the public's construction of the COVID-19 risk event to be sensitive to the information that is communicated, and that this communication has consequences for people's risk perceptions and behaviours. Information about hazards is communicated through various means, which is then received, processed, and judged by people. Kasperson and colleagues (1988) have described this phenomenon within the social amplification of risk framework, in which a physical event is portrayed by

sources (transmission) and obtained by groups (reception) in ways that can attenuate, maintain, or intensify risk perception. This reception interacts with psychological and cognitive factors, values and attitudes, political and social concerns to form what a person perceives as a threat (Renn et al., 1992; Sjöberg, 2000a).

We use this framework as a basis for analysing the communication process of COVID-19 by focusing on the transfer of information by various sources (transmission), while also considering socio-demographic factors, interest in the pandemic, and attitudes towards science, which are likely to interfere with people's opinion formation (e.g. Sjöberg, 2000b), and become particularly relevant in scientific controversies (e.g. Sturgis & Allum, 2004). And, we distinguish between attention to, and trust in, sources of information, as both may be important and independent factors.

Attention to sources. The volume of coverage has been a key indicator of relationships between media communication and public opinion, with findings showing significant associations between higher exposure to mass media and increased perceptions of risks (Berry et al., 2007; Mazur, 1981; Wirz et al., 2020) – the coverage-attitude hypothesis (Mazur, 1981). The rationale is that the more a person is exposed to news about a risk event, the greater his or her sense of risk. Mazur's initial idea that higher quantity of print coverage of new technologies would lead to negative attitudes toward the technologies, has since been used by many, in studies that examine reported level of exposure to media coverage and risk perceptions. For example, Wirz et al. (2020) found that risk perceptions of Zika virus were higher in the United States at times of high reported attention to TV news, official websites and online media. These findings are not surprising given that media communication of epidemics is strongly driven by media values. Media tend to alter risk information before communicating it to the

public, often highlighting risks and negative consequences (Ophir, 2018) drama and emotion (Rossmann et al., 2018). In addition to traditional media, we have seen an increase in social media networks as a source that people turn to look for scientific news and health information (EC, 2013; NSF - National Science Foundation, 2018). But social media is also a powerful source of polluted information (Wardle & Derakhshan, 2017) including health misinformation (Kata, 2010), which spreads easily through these means and may interfere with people's risk perceptions (Lin, 2019; Oh et al., 2020). We build on this idea and test whether similar relationships are true for reported attention to the information sources investigated here – media and scientific sources.

We would expect, for COVID-19, too, greater attention to media sources – both traditional media and social media – to associate with increased perceptions about the risks of COVID-19, and similar relationships in regard to scientific sources – i.e. greater attention to information from medical professionals, scientists and researchers to associate with increased concern about COVID-19. Science experts are important actors in public communication of science and scientific controversies (e.g. Entradas et al., 2019), and in combating health misinformation (e.g. Vraga & Bode, 2018). Although we expect that media and scientific sources exert an important role in the public communication of the pandemic, it is difficult to predict how they compare to one another as determinants of perceived risk, i.e. which are better predictors. Media, is often the main source in public information about epidemics, yet scientific sources, had an unprecedent role in informing the public in the COVID-19 pandemic. We pose the following hypothesis and research question:

H1: *Attention to media and scientific sources will associate with high risk perceptions about COVID-19.*

RQ1: *How do attention to media and scientific sources compare as determinants of perceived risks of COVID-19?*

Trust in sources. In addition to attention, we examine trust in information sources. Previous research has shown that trust in scientific sources is an important element in the public's relationship with science during controversial events, and an important factor in perceptions of environmental risks (Malka et al., 2009; Milfont, 2012), risks of nanotechnologies (Priest et al., 2010) and genetically modified crops ((Petts et al., 2001). For example, Malka et al. (2009) found that people more trusting that scientists would provide reliable information about the environment also showed increased concern about global warming.

We know also that scientific sources such as medical professionals and scientists are often reported by the public as the most trusted sources to discuss science in the public sphere, while journalists and politicians are seen as less trustworthy (EC, 2013; NSF - National Science Foundation, 2018) and less credible sources (Chaiken & Maheswaran, 1994; Eastin, 2001). It would then make sense to expect higher trust in scientific sources to associate with increased risk perception of COVID-19, and that trust in scientific sources would also exert a stronger effect on perceived threat than media sources, or others. We hypothesize:

H2: *Trust in scientific sources will associate with high risk perceptions about COVID-19*

H3: *Trust in scientific sources is a better predictor of high risk perceptions than trust in media sources*

Risk perceptions

In this study, we distinguish between personal and societal risks. Use and trust in information sources could potentially relate to changes in perceptions of the new coronavirus pertaining 'to me' (personal risk) and 'to society' (societal risk) (Boholm, 1998; Dunwoody & Neuwirth, 1991; Lima et al., 2005; Tyler & Cook, 1984). That is, while some sources might be more likely to influence perceived risk to the individual, others might influence the perceived risk to society. Researchers have often found that mass media influence societal level judgments (but not personal), and interpersonal channels (family and friends, neighbours and experts) influence personal risk perception ((Mazur & Hall, 1990) (Tyler & Cook, 1984), and few studies pointed to interpersonal channels affecting also perceived societal risk (but not personal) (e.g. (Coleman, 1993). Yet, the literature on what types of channels are better predictors of risk perceptions, the media or interpersonal, has been mixed.

In the case of COVID-19, given its unique features and range of communication actors involved, as previously described, it is difficult to predict how information sources would influence different dimensions of risk, yet it is possible that the relationships are more complex that those previously found. It is not our aim to draw a parallel with those previous studies that have attempted to interpret how 'mass media' and 'interpersonal' sources affect risk perceptions, as this conceptualisation would be limiting to classify the breadth of sources examined here, and our main distinction (media versus scientific). We, nevertheless, will refer to scientific sources (experts) as a proxy indicator of interpersonal communication. We ask:

RQ2: *Will media and interpersonal sources affect personal and societal risk perceptions differently?*

In what follows we address these hypotheses and research questions. Our main thesis is that the level of attention to information sources and the trust people have in them relate to perceived risk, and that different sources influence risk perceptions differently – on the personal and societal dimensions. We present some descriptive statistics to examine the use and trust in sources, and risk perceptions among respondents. We then run a series of multivariate regression models to investigate the effect of sources on risk perceptions.

Methods

Data

Data. Telephone interviews were conducted between 29 April and 15 May 2020 with a representative sample of the Portuguese population (N=1,411). The sample consists of individuals aged 18 and over residing in mainland Portugal in homes with a fixed telephone, and is proportional to the Portuguese population. Respondents were selected using the quota method, based on a matrix that crossed the variables gender, age, education, and region. The margin of error is 1.6% for a 95% confidence interval.

Dependent variables

Risk perceptions. We conceptualise perceptions of risk on two distinct dimensions: personal level risk judgment and societal level risk judgement. Personal-level is the perception of the threat to the individual (risk to the person), and societal-level risk, is the perception of the threat to society (concern and worry that people feel about the risk event/disaster/disease, how serious people see it). We do not combine them because conceptually they measure different types of perceptions and explore different

constructs of people's opinion formation (e.g. Tyler & Cook, 1984).We used this distinction as conceptual frame of risk perceptions, and asked three questions to capture both dimensions: (i) "How do you evaluate the risk of becoming infected with the new coronavirus?", (ii) "How do you evaluate the risk of developing a serious illness if you become infected?", measured on a scale from (=1) low risk to (=4) high risk; and (iii) "To what extent do you agree/disagree (disagree=1, agree=5) with four items". Items were developed to reflect concepts of seriousness, dangers and fears of the new coronavirus (Table S1). We performed factor analysis using principal component analysis on all six variables to investigate whether these items would form a coherent factor or several dimensions for risk perception of COVID-19. The items loaded appropriately in two factors, confirming a two-dimension structure of the construct risk perception of COVID-19 (KMO=0.62, $p<.05$, 54% of variance explained); the loadings are shown in Table S2. We labelled Factor 1 'perceived personal risk ', referring to the perceived likelihood of COVID-19 'affecting me', reflecting a person's perceived risk of infection; and Factor 2 'perceived seriousness', referring to perceived dangers of the virus, fear, and magnitude of the threat; and indicates perceptions of societal risk. We used factor scores for perceived personal risk (Cronbach =.80) and perceived seriousness in our regression analyses (Cronbach=.60). A higher value represents higher risk perceptions, personal and societal (i.e. agreement that the novel coronavirus represents a threat 'to me' and to society).

Independent variables

Attention to sources. To measure attention to sources of information, we asked respondents how frequently they used six different sources in the past week to look for information about COVID-19. Exposure refers to the frequency of contact with (1)

television/radio, (2) newspapers, (3) websites of institutional health organisations (e.g. Directorate General of Health, WHO), (4) social media networks (including Facebook and Twitter), (5) family and friends, and (6) medical professionals, measured in a four-point response option from (=1) never to (=4) regularly.

Trust in sources. We measured trust in seven sources of information: (1) journalists, (2) medical professionals, (3) national health institutions (e.g. the Directorate General of Health and the Ministry of Health), (4) international health institutions (e.g. WHO), (5) politicians, (6) scientists and researchers, (7) social media. These were measured on a 4-point scale from no confidence (=1) to high confidence (=4). We do not combine sources because they did not show similar tendencies in the frequency of use, showing that people use them differently, and we investigate their effects separately, gauging their unique influence on risk perceptions.

Perception of overall communication. We also measured perceived tone of communication in general and by scientists in particular. We asked respondents to agree or disagree on a 5-point scale (strongly disagree (=1), strongly agree (=5) with the statements 'The communication of COVID-19 has been confusing and contradictory' (M=3.3, SD=1.2), and 'Experts emphasised too much the negative consequences' (M=3.2, SD=1.4). This was included as a further indicator of people's relations with science.

Demographic variables. In addition, we measure and control for the potential effects of person-level variables in our multivariate regression models, which have been used in previous studies of risk perceptions; they are coded as shown in Table 1. These include demographic factors age, gender, and level of education, attitudes towards science role in the pandemic, and self-reported interest in the pandemic, known to relate to opinion

formation. Level of interest was measured from very interested (=3) to not interested at all (=1). Gender is a dichotomous variable coded male (=1) and female (=2) (54% of the sample is female); age is measured in years (M=51, SD=17); education is measured on a 3-point scale ranging from elementary school (=1) to graduate degree (=3) (M=1.6, SD=.8).

Attitudes. We asked about people's attitudes towards the role of science in the pandemic both as a cause of it and a response to it, as they might provide clues on how misconceptions of science relate to risk perceptions. For example, the belief in misinformation and distrust in the role of science may put individuals at greater risk. Four attitudinal items measured general views about the role of science in the pandemic in a 5-point scale from strongly disagree (=1) to strongly agree (=5) (Table S3). Factor analysis using principal component analysis shows two factors loading from these variables (KMO=.60, p<.0005, 71% of variance explained) (Table S4). Factor 1, which we called 'attitude cause' (science) refers to people's perceived origin of the virus and results from items "The new coronavirus resulted from laboratory experiences" and "science developments caused this pandemic" (Cronbach= .70). Factor 2 'attitude evaluation (poor)' refers to people's evaluation of the scientific response to the pandemic and results from the items "science has been slow finding a vaccine" and "scientists have given bad advice to politicians" (Cronbach=.60). In both cases, higher scores refer to agreement with the statement and represent a negative view of science (that science caused it, and science was inefficient).

Analysis

We used multivariate regression analyses to investigate the level of perceived risks about COVID-19, as a function of personal and communication-level factors.

Personal and societal risk perceptions – two dependent variables (perceived personal risk and perceived seriousness) were regressed on individual-related variables (Model 1), communication-related variables (Model 2) and on the two sets of variables (Model 3). Regressions were run separately to investigate the contributions of both sets of variables separately, and together. We report unstandardized Beta (B), and consider $p<.05$ for significance.

Results

Descriptive statistics

Table 1 shows descriptive statistics for independent variables. Tables 2 and 3 show regressions on perceived risk.

Attention and trust in sources of information. Overall, people reported TV as the most frequently used source of information about COVID-19 (M= 3.8, SD=0.4, 86% using it frequently), and also discussing COVID-19 with family and friends (M=3.2, SD=0.9, 48% reporting doing it frequently). Websites of health organisations (M=2.8, SD=1.3, 44% using it frequently) and social media networks (M=2.5, SD=1.3, 34% using it frequently) were moderately used; newspapers (M=2.2, SD= 1.2) and information from medical doctors (M=2.0, SD=0.9) received the least attention. Medical doctors were nevertheless the most trusted source of information among all sources (M=3.7, SD=0.5) followed by scientists and researchers (M=3.5, SD=0.6); trust in national and international health institutions (M=3.3, SD=0.5 and M=3.3, SD=0.7, respectively) and journalists (M=3.0, SD=0.7) was moderate, while trust in social media (M=2.0, SD=0.9) and politicians (M=2.6, SD=0.9) was low.

Perceived risks of COVID-19. We find a generalised believe that COVID-19 is serious and people are worried (95% said they were worried or very worried). The data show that both perceived personal and societal risk are high. Most consider this pandemic more dangerous than a seasonal flu (M=4.4, SD=0.8) and are concerned about it (M=4.4, SD=0.7), 74% thought the pandemic could get out of control (M=3.8, SD=0.9) and 86% thought that with precautions, spread can be avoided (M=4.1, SD=0.8). And they see personal risk: about 33% consider they are at high risk of getting infected (41% at a moderate risk, and 20% at low risk) (M=3.1, SD=0.8) and at a high risk of developing a serious illness (30%), 38% felt at moderate risk and 24% at low risk (M=3.9, SD=0.8).

[Table 1 near here]

Effects of sources on risk perceptions

The multiple regression models support our thesis that the factors tested influence perceived risks of COVID-19, and exert different effects in the different types of risk judgements, but also challenge some of our expectations.

Perceived personal risk (personal risk). Model 1 shows a positive statistically significant relationship with age, with older people more likely to see high risk (B=.02 p<.001). Attitude 'cause' (science caused it) (B=.07, p=.015) and attitude 'evaluation' (poor) (B=.06, p=.002) show positive significant relationships with the level of personal concern about the risks of COVID-19. That is, those holding more negative attitudes towards science were more likely to think they were at higher risk. The significance of these relationships is also observed in Model 3, showing independent contributions of

attitudes and age. Model 2 shows that attention to TV news (B=.16, p=.002) and to medical doctors (B=.14, p<.001) increases perceived personal risk; and trust in international organisations decreases it (B=-.15, p=.008); yet the effect of this variable is lost in Model 3. Model 3, our best explanatory model, shows that peoples' personal concerns about COVID-19 were increased by attention to information from medical doctors, and decreased among those trusting more social media. And, those agreeing that experts overemphasised negative scenarios, were also more likely to see themselves at lower risk (B=-.05, p=0.048).

Perceived seriousness (societal risk). Model 1 shows that perceived seriousness was higher among males (B=.16, p=.007) and those more interested in the pandemic (B=.47, p<.001). Also, those agreeing that science caused the pandemic showed increased concerns about the seriousness of COVID-19 (B=.12, p<.001), and those agreeing that the response of science has been inefficient were less concerned about COVID-19 being serious (B=-.17, p<.001) (Model 1, Table 2). These relationships are also significant in Model 3 pointing to independent contributions of attitudes towards science (Model 3, Table 2). Model 2 shows that attention to newspapers exerts a negative effect on perceived seriousness of COVID-19 (B=-.08, p=.002), trust in the message from scientists associates with higher concerns that the virus is serious (B=.21, p<0.001) and trust in politicians decreases this perception (B=-.13, p=.001). Model 3 shows that these relationships are kept significant when person-level variables are controlled, and, the effects of communication-level variables decrease slightly. These findings support partly H1 and H2 about the attention to media and scientific sources: higher attention to medical doctors and higher trust in scientists associated with high personal risk judgement, yet, attention to print media and social media decreased it.

The best fitting model in each case is Model 3, which included both communication-level variables (attention and trust), and personal-level variables (demographics, level of interest, and attitudes towards science). These results imply that scientific sources are more important predictors than media sources, when controlling for demographic, interest and attitudinal variables. These findings indicate that scientific and media attention indeed differed in its effects across dependent variables, and collectively the effects of scientific sources were stronger than the effects exerted by media sources, supporting H3 and addressing RQ4.

[Table 2 near here]

[Table 3 near here]

Discussion

This study aimed at understanding how information sources related to perceived risks of COVID-19. First and foremost, it is important to note the general high concern among respondents about both personal and societal risks of the new coronavirus. And also the high level of confidence in science to solve the problem, in the initial phase of the pandemic when this study was conducted. The generalised opinion about the dangers of COVID-19 was aligned with the communication regularly heard by the public from national health experts, and national health institutions. Despite the general opinion, some of the public did not acknowledge the seriousness of the threat. We make some observations about the factors that explain variation in the way people perceived the risk of COVID-19.

The first observation is that differences in perceived risks of COVID-19 are partly explained by attention and trust in information sources, and sources affect types of risk judgments differently. These findings corroborate previous ones, which have

found that individuals responded differently to information when thinking about risk to themselves or risk to others. Yet, our findings challenge previous ones in two ways, and our own expectations.

One expectation is that higher attention to media sources leads to higher risk perceptions. In this study, opposite relations were found for some channels. For example, increased attention to print and social media and to information from health organisations decreased perceived risk. Second, both scientific sources (interpersonal) and media sources influenced both dimensions of risk, personal and societal, pointing to more complex relationships that previous studies have noted, i.e. the influences on perceived risk came from various sources that do not simply converge according to the theoretical dimensions of risk judgments. These relationships are understandable and can be partly explained by the content of information and focus of messages by the main actors. For example, medical doctors tended to emphasise individual risks and the higher incidence of the disease in the older and risk groups, which may explain the effects of interpersonal channels on personal risk; scientists, have emphasised the dangers of the virus as a national and world health threat, which may justify people's increased societal concerns among those trusting more scientific sources. In turn, the negative effect of international health organisations on societal risk suggests distrust in the international voice, in particular in the WHO, perhaps suffering from a crisis of reputation affected by the contradictory messages during the initial phase of the pandemic (for instance, using masks went from being discouraged by the WHO and experts at the beginning of the pandemic, only later to be recommended as an important measure to control the spreading of the virus), or due to the loud public criticism, particularly Trump's invective against WHO.

This argument is further supported by the effects of social media. For example, the negative association between trust in social media and perceived personal risk may point to consumption of information rejecting the seriousness of the threat, i.e., more 'negationist' opinions. There is growing evidence that social media served as a powerful means to amplify misinformation, rumours, and conspiracies that circulated widely early in the pandemic (Cinelli et al., 2020; Romer & Jamieson, 2020) and was significant in the increase of the online anti-vaccine movement (CCDH, 2020) and anti-masks groups (Bhasin et al., 2020). The Centre for Counting Digital hate (CCDH) points to an increase of social media accounts of anti-vaxxers by at least 7·8 million people since 2019, with a total of 31 million people follow antivaccine groups on Facebook alone (CCDH, 2020). Interactions with such contents and groups could lead to people judging COVID-19 less risky than it is (Kasperson et al., 1988). Yet, these effects may be specific of certain groups, and vary with individual characteristics, as we discuss further.

Overall, these findings suggest that the effects of information sources are varied and thus, insufficiently explained by the coverage hypothesis, substantiating other studies that have also questioned the validity this direct relationship (Petts et al., 2001) and that the simple attribution of societal risk to effects of media sources and personal risks of interpersonal channels does not represent the complex trajectories for intensification and attenuation of risk found here. In this research, media channels (print media and social media) served as attenuators of perceived risk, and scientific sources, as amplifiers; this is opposed to the often found amplifying role of media on perceived risk, and clearly shows a prominent role of the media in dismissing the threat of COVID-19. These relationships were possible to disentangle due to the broader spectrum of sources investigated. The current findings, then reflect a more detailed

picture of communication of a public health threat, where information is received from various sources, and how they compare, particularly media and scientific information, which have lacked attention in previous research.

Our second consideration, based on the comparison of the models, is that the effects of communication variables on perceived risk vary when we control for individual demographics, attitude and level of interest. This directs us to remark that sources of information relate to person-level factors and communication means are chosen by groups according to their characteristics. For example, TV and social media were significant predictors of personal risk and lost significance in Model 3, when all variables were considered. This may be an indication that certain sources are tendentially used by certain groups, more likely younger cohorts turning more frequently to social media while older people relied more on TV (e.g. 48% aged 18-34 accessed information regularly from social media versus 17% aged 65 and older). Such relationships are often found in general surveys of public attitudes to science (e.g. EC, 2013; NSF, 2018). This supports our argument that there are groups at higher risk of consuming misinformation from media channels, likely younger groups, less educated, and corroborate recent findings pointing to these groups being more accepting of claims of COVID-19 misinformation (Bhasin et al., 2020; Brennen et al., 2020).

We also found variation in perceived risks depending on gender, level of interest in the pandemic, and attitudes. Males, those more interested in the pandemic, more educated, and those holding more positive views about science showed higher concerns of the pandemic to society. Males are generally more informed about international matters, while also more supportive and knowledgeable about science compared to women. It may well be that more educated males attentive to science were also those

with broader views of the magnitude of the pandemic, and more sensitive to the seriousness of the virus.

Our third observation is that information sources were not a major player in risk assessment, explaining only a small amount of the variance. However, this is not a characteristic of our study, but a common finding among many – typically, the amount of variance explained by information sources is small (Coleman, 1993; Trumbo, 1996). To explain the low variation of sources, some researchers have argued that risks have been investigated outside a specific context (Coleman, 1993; Dunwoody and Neuwirth, 1991), others that there are other ways in which people interact with information (e.g. seeking or sharing) and interpret messages, which are not captured by the social risk amplification framework (e.g. Petts et al, 2001).

While this low variance might be due to the study design and/or low variability among media variables, which might have resulted in statistical underestimation of their importance, it could also suggest that exposure to information may indeed have a small role to play as determinant of risk perceptions, while also pointing to the importance of analysing other aspects of communication, including trust, and the scientific nature of information. As seen here, scientific sources exerted stronger effects on risk judgements than media communication (as seen by the betas values), and how people rated the trustworthiness of the different sources they relied on for information about COVID-19 were important determinants of perceived risk.

The examination of people's opinions during this real, live risk event – as opposed to most risk research that has investigated hypothetical risks – revealed the importance of investigating other attributes - other than media interactions, while supporting arguments on the limitations of the social amplification risk framework. Hypothetical risks might be conceptualised based on attributes that may not necessarily

be the same as those that people rely to make judgments about a real risk (e.g. Wood et al., 2018). In other words, the dimensions of information investigated, might not fit under the conditions of 'live' risks as well as they fit under the condition of 'hypothetical' risks. For example, previous studies on epidemics have often been conducted with Western samples (often American samples), in contexts and countries where these events have had very low incidence (for example, the 2016-17 Zika outbreak only had a few cases in America contrasting with the millions of cases and hundreds of thousands of deaths from COVID-19 in the country). It seems therefore not surprising to observe a prominent role of attention to media channels on perceived 'distant' risks. However, in events closer to people, the data suggests that attention to media sources become less significant when compared to interpersonal sources (scientists and medical professionals here). Importantly, the data suggest that in a health risk situation where personal and societal risk is eminent and with potential effects on the lives of every citizen throughout society, the existing relations people have with science, being them attitudes or trust, become more important drivers of risk judgments, albeit amid scientific uncertainty.

Consequently, the risk perceptions that we identified are not simply the result of the variables examined. There are certainly many other variables that might be likely to influence risk perceptions. More recent research has pointed to the importance of psychological differences (e.g. anxiety and depression, desire for control, or experience in hazards (Barnett & Breakwell, 2001; Myers et al., 1997); our own research points to the importance of individual relations with science, in particular the dimension of trust. These, and other attributes, would deserve attention in future research aimed at understanding more fully the causes of risk perceptions of COVID-19.

The relationship between information sources and risk perceptions is likely to have implications for risk communication and adoption of recommended measures. While it is not our aim here to evaluate whether increased risk perception is a good or a bad thing, or what would be the adequate 'level of perceived risk' of COVID-19, we can assume that (increased) acknowledgment of the seriousness of the virus to the individual and society is a desirable effect, as it would be more likely to lead to action and behaviour. Thus, information from scientific sources, as seen here, might be more likely lead to the desirable effect on perceived risk and potential behaviour in response to it. Similarly, a disbelief in the voice of scientific and governmental messengers might make people resistant to advice on recommended measures to contain spread such as taking a vaccine (low perceived response efficiency) (Cauberghe et al., 2009). Yet, high perceptions of risk above reasonable levels can be counterproductive as people may sense that there is not much they can do to prevent the spread of the virus (low perceived self-efficacy). Health communicators and other actors involved in public communication of COVID-19, may want to use the voice of science in their communications (and communicate uncertainly) to achieve broader public action, particularly those that are most distrusted such as health institutions, media and politicians. Yet,

Conclusion

The results give considerable support to the complex relationships that are likely to occur when a person is faced with a real threat such as COVID-19. They highlight the importance of people's relations with science for risk judgements, such as attention and trust in scientific sources likely to impact both personal and societal risk perceptions. It also emphasises the crucial challenge in risk research to identify dimensions that clearly

explain variation in risk perceptions between people, as well as how these relationships occur to amplify or attenuate perceived risks.

Finally, this research maps public opinion during the initial phase of the pandemic and may serve as baseline study for future longitudinal comparison, for a better understanding of the role of sources in the perceived risk of COVID-19 throughout a risk event.

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Table 1. Descriptive statistics for independent variables

Variables	**N**	**%**	**Mean**	**SD**
Gender	**1411**	**100**		
Male	656	47		
Female	755	54		
Age (years)	**1411**	**100**	**51**	**17**
Highest level of education completed				
Basic	851	60		
Secondary	297	21		
Graduate	263	19		
Total	**1411**	**100**	**1.58**	**0.8**
Level of interest in the pandemic				
Poor	26	2		
Moderate	370	26		
High	1013	72		
Total	**1409**	**100**	**2.7**	**0.6**
Attitude 'cause' (science caused it)	**1411**	**100**	**3.0**	**1.0**
Attitude 'evaluation' (science inefficient)	**1411**	**100**	**2.4**	**0.9**
Attention to information sources		***% frequently***		
Television	1411	86	3.8	0.6
Print media	1408	24	2.2	1.2
Websites from official institutions	1398	45	2.8	1.3
Social Media	1388	34	2.5	1.3
Friends and family	1411	48	3.2	0.9
Medical doctors	1411	18	2.0	1.2
Trust in information sources		***% high trust***		
Journalists	1404	18	3.0	0.7
Medical doctors	1402	71	3.7	0.5
National health institutions	1399	45	3.3	0.7
International health institutions	1368	41	3.3	0.7
Politicians	1395	13	2.6	0.9
Scientists and researchers	1379	59	3.5	0.6
Social media	1179	3	2.1	0.9

Table 2. Perceived personal risk. Higher values in the dependent variable represent higher perceived personal risk (agreement that the novel coronavirus can affect me) (N=1,079). Reference categories are in brackets.

	Model 1			**Model 2**			**Model 3**		
	B	SE B	*β*	B	SE B	*β*	B	SE B	*β*
Gender (female)	0.02	0.06	0.01				0.02	0.06	0.01
Age	0.02	0.00	0.27***				0.02	0.00	0.25***
Level of education (high)	0.03	0.04	0.03				-0.01	0.04	-0.01
Level of interest (high)	-0.01	0.06	-0.01				0.00	0.06	0.00
Attitude 'cause' (agree)	0.07	0.03	0.07**				0.08	0.03	0.08**
Attitude 'evaluation) (agree)	0.07	0.03	0.07**				0.06	0.03	0.06*
Attention to sources									
Television				0.16	0.05	0.10***	0.06	0.05	0.03
Print media				0.00	0.02	0.00	0.02	0.02	0.02
Websites of health organsiations				-0.01	0.03	-0.01	0.04	0.03	0.04
Social media				-0.01	0.03	-0.01	0.03	0.03	0.04
Friends and family				0.01	0.03	0.01	-0.01	0.03	-0.01
Medical doctors				0.14	0.03	0.16***	0.12	0.03	0.14***
Trust in sources									
Journalists				0.01	0.05	0.01	0.02	0.05	0.01
Medical doctors				-0.11	0.07	-0.06	-0.07	0.07	-0.04
National health institutions				-0.03	0.06	-0.02	-0.06	0.06	-0.04
International health institutions				-0.15	0.06	-0.11**	-0.08	0.06	-0.06
Politicians				0.02	0.04	0.02	0.04	0.04	0.04
Scientists and researchers				-0.06	0.06	-0.03	-0.05	0.06	-0.03
Social media				-0.05	0.04	-0.04	-0.11	0.04	-0.09**
Experts controversy (agree)				-0.05	0.03	-0.06*	-0.07	0.03	-0.08**
Comms contradictory (agree)				0.03	0.03	0.03	0.02	0.03	0.03
(Constant)		-0.76	0.21		0.38	0.34		-0.3	0.4
R^2		0.10			0.07			0.15	
F for change in R^2		16.154***			5.149***			4.122***	

*** <0.001; **<0.01; *<0.05

Table 3. Perceived 'seriousness'. Higher values in the dependent variable represent higher perceived seriousness of the pandemic (agreement that the pandemic COVID-19 represents a threat to society) (N=1,079). Reference categories are in brackets.

	Model 1			**Model 2**			**Model 3**		
	B	SE B	*β*	B	SE B	*β*	B	SE B	*β*
Gender (female)	0.155**	0.06	0.08				0.15	0.06	0.07**
Age	0.00	0.00	-0.03				0.00	0.00	0.00
Level of education (high)	0.07	0.04	0.05				0.09	0.04	0.07**
Level of interest (high)	0.47	0.06	0.24***				0.44	0.06	0.22***
Perception 'cause' (agree)	0.12	0.03	0.13***				0.11	0.03	0.11***
Perception 'response' (agree)	-0.17	0.03	-0.17***				-0.15	0.03	-0.15***
Attention to sources									
Television				0.09	0.05	0.05	0.01	0.05	0.01
Print media				-0.08	0.03	-0.10**	-0.08	0.02	-0.104***
Websites of health organsiations				0.01	0.03	0.01	-0.01	0.03	-0.01
Social media				0.05	0.03	0.06	0.02	0.03	0.03
Friends and family				-0.03	0.03	-0.03	-0.02	0.03	-0.02
Medical doctors				-0.03	0.03	-0.04	-0.01	0.03	-0.02
Trust in sources									
Journalists				0.08	0.05	0.05	0.09	0.05	0.06
Medical doctors				0.17	0.07	0.082*	0.09	0.07	0.05
National health institutions				-0.04	0.06	-0.03	-0.05	0.06	-0.03
International health institutions				0.05	0.06	0.04	0.06	0.06	0.04
Politicians				-0.13	0.04	-0.12**	-0.11	0.04	-0.1***
Scientists and researchers				0.21	0.06	0.12***	0.13	0.06	0.08*
Social media				-0.01	0.04	-0.01	0.00	0.04	0.00
Experts controversy (agree)				-0.05	0.03	-0.06	-0.02	0.03	-0.02
Comms contradictory (agree)				0.03	0.03	0.03	0.04	0.03	0.04
(Constant)		-1.55	0.21		-1.40	0.35		-2.22	0.37
R^2		0.12			0.07			0.16	
F for change in R^2		21.005***			4.906***			2.796***	

*** <0.001; **<0.01; *<0.05

Data availability statement

Data is available from the corresponding author upon request.