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Predictors and outcomes of individual knowledge on early-stage pandemic: Social media, information credibility, public opinion, and behaviour in a large-scale global study

Yash Chawla [a,*], Agnieszka Radziwon [b,c], Laurent Scaringella [d,e], Ewa Lazarczyk Carlson [f,g], Marco Greco [h], Paulo Duarte Silveira [i,j], Eduardo Pestana de Aguiar [k], QingYang Shen [l], Markus Will [m], Anna Kowalska-Pyzalska [a]

[a] Department of Operations Research and Business Intelligence, Wroclaw University of Science and Technology, Poland
[b] Haas School of Business, University of California Berkeley, USA
[c] Department of Business Development and Technology, Aarhus University, Denmark
[d] Rennes School of Business, France
[e] Kozminski University, Poland
[f] Department of Business Administration, Reykjavik University, Iceland
[g] Research Institute of Industrial Economics, IFN, Sweden
[h] Department of Civil and Mechanical Engineering, University of Cassino and Southern Lazio, Italy
[i] Polytechnic Institute of Setubal, Portugal
[j] CEFAGE-UE, Evora University, Portugal
[k] Department of Industrial and Mechanical Engineering, Federal University of Juiz de Fora, Brazil
[l] Chengdu University of Information Technology, China
[m] Zittau/Görlitz University of Applied Sciences, Germany

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ABSTRACT

This study explores how individuals obtain knowledge, perceive information sources, behave, and form opinions while facing a pandemic at an early stage. We develop a conceptual model linking the predictors of individuals' knowledge with people's behavior and opinions. The model is empirically tested through a large-scale global survey of 15,552 respondents from 126 nationalities. Our results indicate that relying on one source of information does not lead to favourable behavior towards curbing the pandemic. Furthermore, we need to educate people and control misinformation spread on policy and social network platforms to curb emergencies collectively.

1. Introduction

During a natural catastrophe or a pandemic, precise crisis information is crucial (Liu & Palen, 2007; Reuter, Kaufhold, Schmid, Spielhofer & Hahne, 2019). Under such circumstances, social media can serve as an information dissemination tool and influence both

* Corresponding author.
E-mail addresses: yash.chawla@pwr.edu.pl (Y. Chawla), agra@btech.au.dk (A. Radziwon), laurent.scaringella@rennes-sb.com (L. Scaringella), ewalazarczyk@ru.is (E.L. Carlson), m.greco@unicas.it (M. Greco), paulo.silveira@esce.ips.pt (P.D. Silveira), eduardo.aguiar@engenharia.ufjf.br (E.P. de Aguiar), m.will@hszg.de (M. Will), anna.kowalska-pyzalska@pwr.edu.pl (A. Kowalska-Pyzalska).

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public opinion on health-related issues (Kareklas, Muehling & Weber, 2015) as well as individual behavior (Chew & Eysenbach, 2010; Choi, Yoo, Noh & Park, 2017; Fox, 2011, 2014). Taking the example of the Zika virus, an increase in the social media coverage had a significant impact on how people perceived risk, which in turn influenced their behavior (Chan et al., 2018). In another context, during the H1N1 flu crisis in Taiwan, legacy media were proven to shape the information which subsequently influenced people's adoption of specific behaviors (Chang, 2012; Dudo, Dahlstrom & Brossard, 2007). The COVID-19 pandemic allows us to study how people obtain accurate and reliable knowledge once a crisis emerges (Vosoughi, Roy & Aral, 2018). As misinformation may have a detrimental effect on attitudes and behaviors, policymakers, social network platform owners and large organizations – such as the World Health Organization (WHO) – need to prevent the spread of misinformation, while increasing the reliability of shared knowledge among individuals (Chew & Eysenbach, 2010; Choi et al., 2017; Fox, 2014). Emergency and crisis communication focuses on both raising public awareness of emerging risks and preventing public reactions from escalating (Panagiotopoulos, Barnett, Bigdeli & Sams, 2016). Even though misinformation can spread fast and receive extensive coverage during economic crises (Rapoza, 2017), natural disasters (Gupta, Lamba, Kumaraguru & Joshi, 2013; Mendoza, Poblete & Castillo, 2010) or terrorist attacks (Starbird, Maddock, Orand, Achterman & Mason, 2014), the mechanisms to ensure that individuals can access appropriate knowledge from reliable information sources require further studies in the specific case of a sanitary crisis. During the past year, several articles studied fake news in countries such as Nigeria (Apuke & Omar, 2021a, 2021b), Bangladesh (Najmul Islam, Laato, Talukder & Sutinen, 2020; Samuli Laato, Islam, Nazrul Islam & Whelan, 2020), and the United States (Pennycook, McPhetres, Zhang, Lu & Rand, 2020). Studies on how individuals obtain knowledge, perceive information sources, behave, and form opinions while facing a pandemic are essential to better understanding and collectively curbing the emergencies.

Based on the available literature, this study intends to understand how individuals obtain knowledge about the early stage of a pandemic, using the case of COVID-19. Moreover, it also shows the effect of individuals' knowledge on their behavior and opinions towards emergencies.

Consequently, this study investigates the following two research questions:

- RQ1: *How is the access to specific information sources, their perceived credibility and people's stance on information associated with individuals' knowledge?*
- RQ2: *How is individuals' knowledge associated with their behavior and opinions?*

To operationalize the accuracy of individuals' knowledge embedded on COVID-19 pandemic, we built the "individual knowledge on COVID-19″ (IKC) index as a score based on the correctness of the responses in the three following categories:

1 General knowledge about COVID-19
2 Knowledge regarding myths and facts about COVID-19
3 Knowledge regarding the prevention of COVID-19 infection spread

Each of these three categories consists of items directly referring to public information shared by the WHO.[1]

The structure of the article is as follows. After giving a brief introduction to the study in Section 1, the detailed findings from literature and the theoretical background have been discussed in Section 2. This is followed by the elaboration of the methodology of the study, in Section 3, that discusses the development of the survey, variables used, the obtained sample, and methods used to analyze the collected data. After that, the results and discussions based on previous literature are detailed, in Sections 4 and 5, respectively. Finally, in Section 6, the conclusions elaborate on the main findings, the limitations and further research scope based on this study.

2. Theoretical background

In this section, we first present the most recent studies on fake news about COVID-19 (Section 2.1). We then describe three key predictors of IKC: (1) social media multitasking and misinformation (Section 2.2), (2) the perceived credibility and use of various sources of information (Section 2.3) and (3) the number of global and national COVID-19 cases (Section 2.4). Subsequently, in Section 2.5, we describe the outcomes of IKC.

2.1. Recent studies on Covid 19 fake news

During the pandemic of COVID-19, media did not only contribute to information transparency (Abramson et al., 1990; Tewksbury, 2003), but the social media (unintentionally) transferred fake news (Lazer et al., 2018; Allcott & Gentzkow, 2017). The latter have been discussed from political and social aspects (Lazer et al., 2018; Kavanagh & Rich, 2018). Interestingly, among the social media fake news predictors one can find not only self-promotion or the urge for instant news sharing, but also socialization and even altruism as the strongest predictor (Apuke & Omar, 2021a, 2021b). In line with (Apuke & Omar, 2021a, 2021b) the study of Najmul Islam et al. (2020) pointed out to self-promotion, which played an important role in the decision process of sharing unverified information but

[1] We consider WHO information as the reference point for the correctness of the responses to the survey. As some of the WHO positions did not always reach a scientific consensus (for instance regarding the origin of the virus), the survey reflects the state of the pandemic knowledge as of March 2020.

extended it by including entertainment as additional factor. The unverified aspect of information sharing is particularly important in the context of social media, because the difficulty in assessing the information accuracy (Pennycook et al., 2020), trust in online information (Samuli Laato et al., 2020) and (perceived) information overload (Bermes, 2021) are strong predictors of unverified information sharing (Samuli Laato et al., 2020). Last, but not least, even trusted sources, clearly having good intentions and unquestioned 'authenticity' may fail us. One of the examples is the re-tweet of Olivier Veran, French minister of health about treatment people can take in case of contamination (Orso, Federici, Copetti, Vetrugno & Tiziana, 2020). Given the progress of science at that time, the reliability of the recommendation was questioned. The presence of discordant warning was making the distinction between false and true even more challenging. In such instance, it is not possible to talk about fake news as the intent was not to be misleading.

2.2. Social media multitasking and misinformation safeguarding mechanisms

The latest developments in media technologies allow people to use any type of social media content whenever and wherever they want (Duff, Yoon, Wang & Anghelcev, 2014). A social media user may refer to multiple sources of information (Batra & Keller, 2016). This new behavior is known as "media multitasking" (Garaus, Wagner & Bäck, 2017), defined as the simultaneous exposure to two or more types of media content. Past studies have shown that media multitasking decreases the persuasiveness of the messages as well as message memory, comprehension, recall and recognition (Jeong & Hwang, 2012; Srivastava, 2013; Van Cauwenberge, Schaap & Van Roy, 2014). Media multitasking increases the likelihood that a person would be exposed to misinformation. The presence of misinformation on social media is another major issue that needs to be addressed. One of the potential interventions would be to empower individuals to take appropriate action to verify the source of information or question the credibility of the source before considering certain information as a fact (Lazer et al., 2018).

2.3. Perceived credibility and use of the various information sources

The information sources people use will influence their IKC. We distinguish between traditional media such as TV, radio, newspapers (Rice, Gustafson & Hoffman, 2018), social media such as Facebook, LinkedIn, Twitter, WhatsApp, YouTube, Instagram (Kim & Dennis, 2019; Panagiotopoulos et al., 2016; Vosoughi et al., 2018) and information gathered through personal relations. These information sources contribute to the individual's body of knowledge and might be perceived as credible or non-credible (Morris, Choi & Ju, 2016; Yang, 2012). Among the existing social media, the dominant ones such as Facebook and Twitter have been studied frequently in literature (Kim & Dennis, 2019; Lerman, Yan & Wu, 2016; Marwick & Boyd, 2013; Panagiotopoulos et al., 2016). In the past, Facebook has been under significant pressure to eliminate misinformation (Wingfield, Isaac & Benner, 2016). There is mixed evidence on the reliability of information offered by Twitter. On the one hand, Panagiotopoulos et al. (2016) found that Twitter offered high-quality emergency information, whereas, on the other hand, Vosoughi et al. (2018) revealed that false information is retweeted more frequently than accurate information. In this view, the trustworthiness of social media as sources of information is likely to influence the individual's critical judgment about the shared messages. Since studies comparing information reliability across various social media platforms are limited, we intend to fill this gap by studying all dominant social networking platforms. In a state-oriented risk culture, people trust the government information and give less credit to social media, which are perceived as less credible sources, in the case of an emergency (Reuter et al., 2019).

2.4. The number of global and national cases of COVID-19

The national context of the respondents is significantly associated with the amount and type of information they receive. Hence, countries that have been strongly affected by the pandemic in its early stage may be more accurately informed about COVID-19. The country-specific context (Hofstede, 2001, 2017) is likely to impact the level of the individual's uncertainty avoidance (De Meulenaer, De Pelsmacker & Dens, 2015), trust in the authorities (Douglas & Widavsky, 1983; Reuter et al., 2019) and reaction to fear. That is why health organizations have to adapt their messages and their communication strategies to each specific type of community (Chan et al., 2018).

2.5. Outcomes of IKC

In the context of a pandemic, and especially its early stages, it is crucial to understand not only how people's knowledge is shaped, but also how their behavior is influenced (i.e., limit socially harmful behavior and encourage publicly responsible conduct). Message efficacy is the most important factor in dealing with communication in the healthcare sector when it comes to positively affecting people's behavior (De Meulenaer et al., 2015). On the one hand, the higher the perceived efficacy of a message is, the more likely people are to comply with the recommendation and vice versa (De Meulenaer et al., 2015; Ruiter, Abraham & Kok, 2001). On the other hand, there is a negative relationship between perceived threat and message acceptance for certain groups (De Meulenaer et al., 2015). People characterized by low uncertainty avoidance, low anxiety, and low and high chance beliefs, who perceive a threat as more likely, are less prone to adopt the recommendations. The same could not be concluded for people with high uncertainty avoidance and high anxiety, as the results were not significant (De Meulenaer et al., 2015).

There is a link between the effectiveness of health messages coming from public service announcements (PSA) and electronic word-of-mouth and the perceived credibility of these messages. For instance, people's behavior towards vaccination is more influenced by online comments than PSA, even if the perceived credibility of a PSA is high (Kareklas et al., 2015). Additionally, organizations commonly use fear appeals in their health-related campaigns to influence people's behavior and actions. The concept of fear appeals

has been defined by Witte (1992) as "persuasive messages designed to scare people by describing the terrible things that will happen to them if they do not do what the message recommends" (p. 329). Even though the topic of fear appeals has been extensively studied, its working process is still unclear (Morales, Wu & Fitzsimons, 2012; Peters, Ruiter & Kok, 2013).

Against the backdrop of the early-stage pandemic, we study individuals' behavior, willingness, and opinions regarding various socially responsible actions. Based on different levels of knowledge about COVID-19, people are forging their own opinions about the likelihood of getting reinfected, travelling, hoarding groceries, the satisfaction with government actions, the impact of COVID-19 and willingness to volunteer to help others.

Consequently, we developed a conceptual model (Fig. 1), which identifies the predictors explaining how people acquire information and the outcomes explaining how individuals' knowledge is reflected in their behavior. We operationalized our model to test it empirically in the context of the COVID-19 pandemic.

3. Methodology

3.1. Survey development

To examine how individual knowledge on COVID-19 is related to a wide spectrum of behaviors and opinions, we conducted a global study employing a structured, self-administrated, online questionnaire consisting of several variables divided into four sections, including:

- *Attitudes and behaviors towards COVID-19*: general knowledge about the virus and the illness; prevention; opinions, myths, and facts; impacts, and future expectations regarding the effects of the pandemic.
- *Individual use of social media to gather information about COVID-19*: respondents' perceptions of credible and non-credible information channels, their actions to limit the exposure to false information about COVID-19, and the frequency of social media use during the pandemic.
- *Sociodemographic data*: gender, age, marital status, educational level, employment status, country of residence, nationality, size of the area of residence, and household size.
- *Individual propensity to retrieve further information on COVID-19 and to share their perspective on the topic:* respondents' willingness to search for more information regarding COVID-19, to share their advice with the Government, and to share their perspective regarding positive outcomes of the pandemic.

A pilot study was carried out to validate and improve the survey. The first version of the survey was in English and was pre-tested among 29 individuals through convenience sampling. Authors and colleagues sent the survey to between three and ten respondents from Poland, Portugal, Denmark, Iceland, Indonesia, Germany, China, Netherlands, Spain, and the USA. We adjusted the questionnaire and implemented minor modifications based on the responses and subsequent interviews with the pilot study participants. The responses from the pilot study were excluded from the final sample. The final version of the survey was translated into 27 languages and included 76 mandatory questions, 15 questions asked to the relevant respondents based on their answers to the mandatory questions (e.g., people who have children) and two optional open-ended questions.

3.2. Sample

The survey was distributed through a convenience sample that leveraged the personal and professional connections of 15 researchers living in 14 different countries. The channels used to disseminate the questionnaire were: emails to university mailing lists, personal messages, and social media (see Table 1 for more details). All potential respondents were asked to share the questionnaire among their contacts. This allowed reaching respondents outside the immediate social network of the researchers involved in the study, thus increasing the sample size and enhancing the external validity of the study (Baltar & Brunet, 2012).

The questionnaire was available online from 26 March until 20 April 2020; 15,552 responses (all valid) from 126 nationalities were collected. among them, 21 countries had more than 200 responses (Franke & Richey, 2010). Selection-bias cannot be excluded since people particularly uninterested in the COVID-19 pandemics – who are likely to be uninformed or even misinformed about it - may also have ignored the invitation to participate in the research. Google analytics data, for the webpage that hosted the survey, show that 67,511 unique respondents visited the survey landing page from various sources, out of whom 39.87% of the respondents (26,917) did not start the survey and dropped off from the landing page itself. Out of the remaining 40,594 respondents who started the survey, 15,552 valid responses were recorded. As answering all the questions was mandatory, and submission of incomplete responses was not possible, all recorded responses were valid. Incomplete responses were not recorded. The average response time of the questionnaire was 7 min and 29 s. IP addresses of the respondents were no tracked through Google Analytic, hence it was not possible for the authors to identify the source of individual responses. Thus, maintaining the respondents' anonymity.

According to the International Telecommunication Union (ITU) estimate, there are 4.1 billion global internet users, formed by 58.3% of the male population in the World and 48% of the female population in the World.[2] Thus, 47.79% of internet users are men

[2] https://www.itu.int/en/ITU-D/Statistics/Documents/facts/FactsFigures2019.pdf (Last accessed: 15 December 2020).

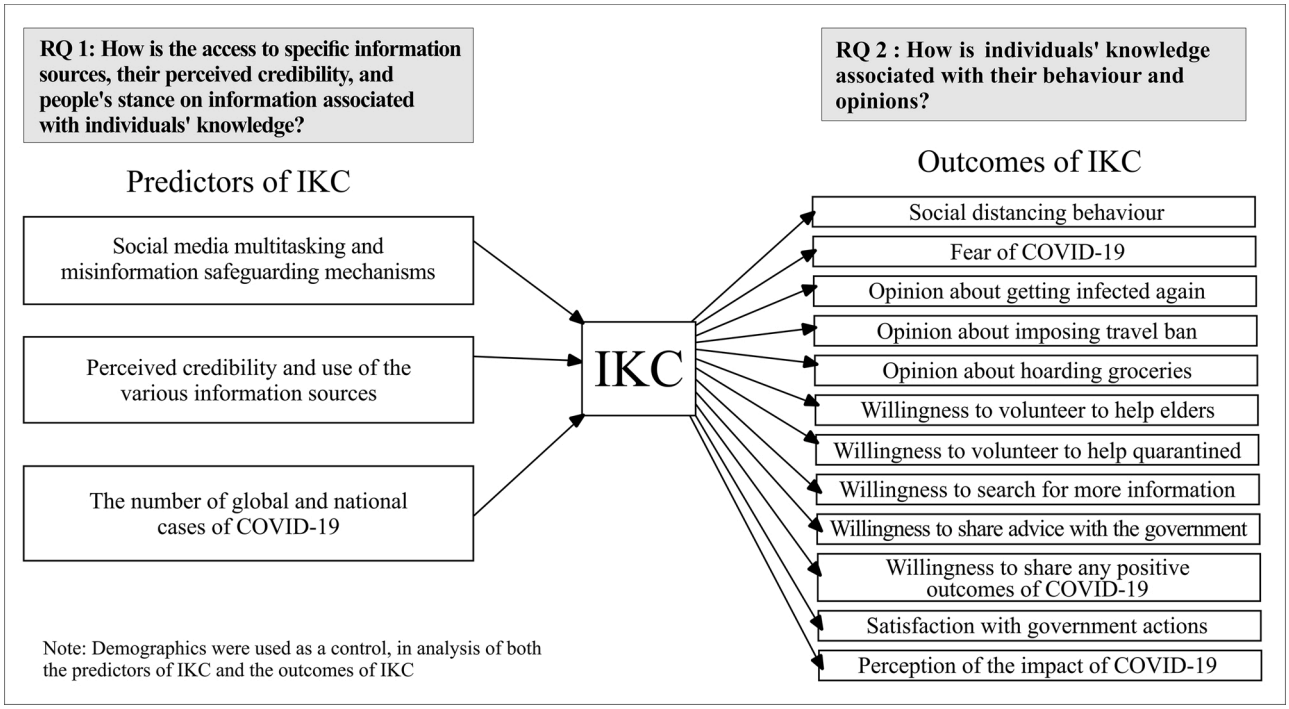

Fig. 1. Conceptual model.

Table 1
Dissemination actions.

Platform	Number of actions	Platform	Number of actions
Emails	16,881	LinkedIn group posts	104
Facebook post	31	WhatsApp personal messages	1278
Facebook Messenger messages	1019	WhatsApp group posts	108
Facebook group posts	65	Twitter tweets	31
LinkedIn posts	22	WeChat messages	5000
LinkedIn personal messages	7921	Other messages	50

and 52.21% are women, which is reflected in the gender distribution of the respondents in this study (41.6% men and 56.7% women). The comparison in Table 2 also confirms that the age distribution of the respondents in this study fairly reflects the age distribution of global internet users. Hence the sample can be considered as representative.

3.3. Variables of the study

IKC is constructed through 25 items (K1-K25, shown in Supplementary Material, Table A1) directly referring to public information shared by the WHO and then disseminated by the authorities and media of each country. The rationale to select these items was: (i) they were the myths and facts WHO was hoarding to communicate globally through all of its internet dissemination channels; (ii) WHO's communication was treated as the basis for policy actions and for public communication by the majority of the governments around the World. All items included in IKC were ranked according to a five-point Likert scale, with the highest score being assigned when the respondent strongly agreed with the correct answer (direct scale). The resulting variable was then rescaled on a 0–100 scale with a 0.766 Cronbach's alpha that exceeds the 0.70 rule-of-thumb threshold (Nunnally, 1978).

In the first part of the study (for RQ1), we analyzed the relationship between IKC (dependent variable) and the predictors of individuals' knowledge about COVID-19, including:

i The use of social media channels (SO1-SO18, SO_Sum);
ii Respondents' confidence in their knowledge about COVID-19 (Con_Confidence);
iii Respondents' perception of various information sources' credibility regarding COVID-19 and the use of these sources by the respondent (SC1-SC17, SNC1-SNC17);
iv Whether the information was received directly from the Government on an individual level (P1);
v Acquaintance with anyone infected by COVID-19 (P2);

Table 2
Comparison of the age distribution of respondents and global internet users.

Age Group	Respondents (%)	Global Internet Users (%)[a]
18–25	32.6	18
26–35	29.3	32
36–45	19.8	19
46–55	11.3	14
56–65	5.6	10
66+	1.4	7

[a] https://www.statista.com/statistics/272365/age-distribution-of-internet-users-worldwide/ (Last accessed: 15 December 2020)

vi The frequency and trust in the received or seen messages/updates about COVID-19 (T1, TG1, TNC_Trust, TGNC_Trust);
vii The actions taken to safeguard oneself from fake news (A1-A5);
viii The type of people with whom respondents discussed COVID-19 (W1-W5) and other demographics as control variables.

In the second part of the study (for RQ2), IKC was used as an independent variable to analyze the outcomes of people's knowledge, along with demographics as controls in separate models where the dependent variables were:

i Social distancing behavior (Bh_SocialDistancing);
ii Fear of COVID-19 (Eom_FearofCOVID);
iii Opinion regarding getting reinfected, the Government imposing a travel ban, people hoarding groceries, willingness to volunteer (O1_InfectAgain, O2_TravelBan, O3_StockUpGroceries, O4_Volunteer_Elders, O5_Volunteer_Quarantined);
iv Willingness to search for more information, share advice with the Government, share positives that might emerge from COVID-19 (Q1_SearchMoreInfo, Q3_AdviseGovernment, Q4_AnyPositives);
v Perceived impact of COVID-19 ("Impact" constructed from IM1-IM4 and I1-I8).

3.4. Models

First, we used a multiple regression model explaining IKC with the use and perceived credibility of various sources, including social media (Facebook, LinkedIn, Twitter, WhatsApp, YouTube, Instagram), traditional media (national TV, TV news, radio, newspapers), and friends, relatives and colleagues. Additionally, we included a variable measuring media multitasking and two variables measuring the number of COVID-19 cases, one for the global number of cases and other for the number of cases in the country of residence. For each respondent, the number of cases on the day before the date of response was considered. For instance, if a respondent submitted the response on 31st March 2020, then the number of cases from 30th March 2020 was considered for that particular respondent. We evaluated the respondents' immigration status by comparing the country of nationality with the country of residence. To account for potential cultural differences across countries that could explain the level of IKC in the main regression, we included an array for country of nationality (D7) dummies. All results are reported with the use of heteroscedasticity robust standard errors. We omitted 11 countries to address multicollinearity issues (which made it 115/126 nationalities).[3]

Second, we developed nine multinomial logistic models, two logit models and one multiple regression model, where the dependent variable is registered on a three-point Likert scale: 1: disagree, 2: neutral, 3: agree. The main independent variable in these models is IKC. Additionally, we accounted for gender, education level, age, relationship status, employment, number of members in the household and type of residence area.

4. Results

We found that the distribution of IKC for most of the respondents is close to the median value (83), whereas the number of the respondents gradually and consistently decreases as IKC increases/decreases from the median value (see Fig. 2). The mean score of IKC for respondents from individual countries ranged from 62.86 to 97. Fig. 3 shows the distribution for mean score of IKC, for each of the 126 countries of nationality from where respondents participated in the study.

Our analysis is divided into two sections. First, we elaborate on the predictors of IKC, and second, we investigate the relationship between IKC and individual behaviors and opinions.

[3] List of countries that were excluded due to multicollinearity, with the number stating the number of nationals from that country: Turkmenistan 1; Yemen 37, Philippines 38, Finland 39, Greece 40, Belgium 41, Malaysia 42, Ukraine 43, Jordan 46, Ireland 49, Australia 56, Korea 61, Colombia 64.

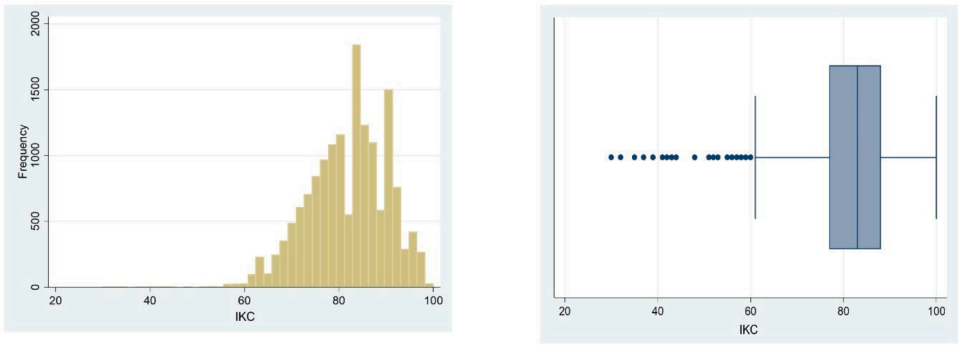

Fig. 2. Histogram and boxplot of IKC. Note: boxplot elements are defined as follows; centre line, median; box limits, upper and lower quartiles; whiskers, 1.5x interquartile range; points, outliers.

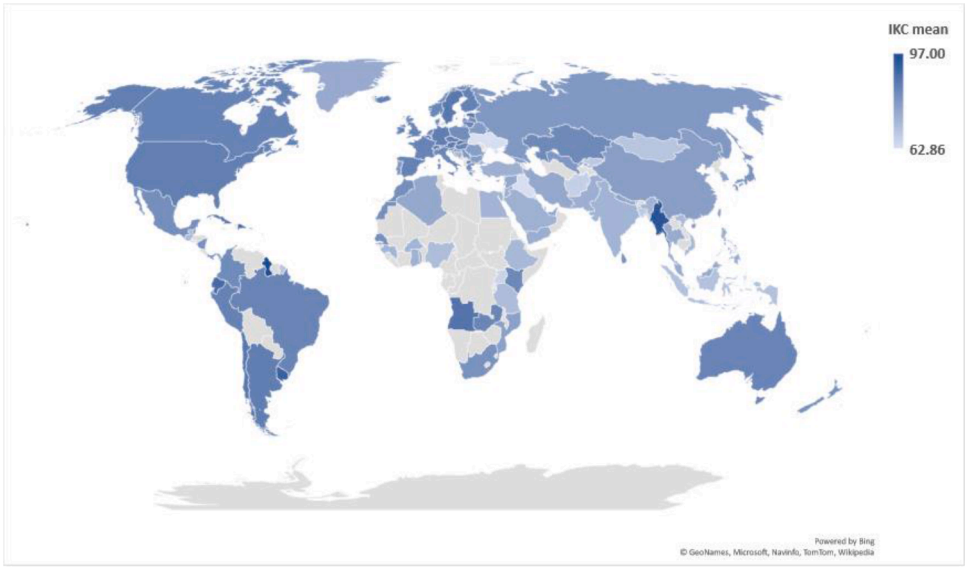

Fig. 3. Mean score of IKC in all countries of nationality of the participants in the study. Note: The grey areas on the map show that no participant had participated from that country.

4.1. Predictors of IKC

4.1.1. Social media multitasking, frequency of receiving information and actions taken to safeguard oneself from the effects of misinformation

Social media multitasking (Garaus et al., 2017) does not seem to have a significant effect on IKC. There is, however, an essential difference between passively receiving information and actively searching for and reviewing information. Respondents who actively searched for updates or posts on social media had a significantly higher IKC. Instead, there is no significant association between passively receiving messages regarding COVID-19 and IKC. Additionally, the more the respondents trusted those messages, the lower their IKC was.

Respondents who indicated taking some action for screening for misinformation had a higher IKC than those who did not take any of these actions. Such actions include adopting a suspicious/mistrustful attitude towards social media messages, avoiding reading social media messages at all, questioning the sender to know the original source of information, only considering official government sources and the WHO, and cross-referencing information with other information sources.

4.1.2. The use of various social media and traditional media as sources of information and their perceived credibility

The respondents who discussed COVID-19 with their parents, friends, family or colleagues had a significantly higher IKC, while those who resorted to social media contacts or WhatsApp had a significantly lower IKC. In general, traditional media were perceived as more reliable than social media. Our results (Table 3) show that people's use of various sources of information and the perception of their credibility are significantly associated with their IKC levels .

For each source of information, we structured an ordinal variable according to three perceived levels of credibility: credible (value

Table 3
Results related to RQ1.

Category	Information source	Credible (w.r.t. Non-credible)	Neutral (w.r.t. Non-credible)
Traditional media	National TV	−0.584***	−0.275
		(−2.719)	(−1.443)
		0.00655	0.149
	TV news	0.608***	0.879***
		(2.7)	(4.167)
		0.00694	3.11E-05
	Radio	−0.182	0.0495
		(−0.635)	(0.191)
		0.525	0.849
	Newspapers	1.592***	0.718***
		(6.36)	(3.1)
		2.07E-10	0.00194
Offline social network	Friends, family and colleagues	−0.825***	−0.563***
		(−3.629)	(−4.580)
		0.000286	4.69E-06
Social media	Facebook	−1.511***	−0.618***
		(−5.872)	(−4.3)
		0	0
	Google Hangouts	−1.643**	−0.432**
		(−2.378)	(−2.467)
		0.0174	0.0136
	Instagram	−0.609*	0.0324
		(−1.892)	(0.219)
		0.0585	0.827
	YouTube	−0.0587	−0.149
		(−0.252)	(−1.006)
		0.801	0.315
	LinkedIn	−0.522	0.383**
		(−1.457)	(2.081)
		0.145	0.0374
	Reddit	0.699	−0.955***
		(1.35)	(−5.531)
		0.177	0
	Twitter	0.644***	−0.0245
		(2.644)	(−0.163)
		0.00819	0.871
	WhatsApp	−2.027***	−0.832***
		(−5.783)	(−5.487)
		0	0
Official sources	Family doctors	0.640**	0.832***
		(2.271)	(3.189)
		0.0232	0.00143
	Government websites	0.365*	−0.176
		(1.693)	(−0.816)
		0.0904	0.415
	The WHO website	2.183***	1.430***
		(5.556)	(3.649)
		0	0.000264
Search engines	Search engines	0.117	0.181
		(0.607)	(1.18)
		0.544	0.238
Other explanatory variables			
Multitasking	0.0133	Personal messages from the Government	0.451***
	(0.327)		(3.949)
	0.744		0
Frequency of checking posts	0.228***	Trust	0.290***
	(4.677)		0.616)
	0		0.00891
Frequency of getting messages	−0.0195	TGNC trust	−0.229**
	(−0.534)		(−2.418)
	0.593		0.0156
Adopting suspicious behavior	1.286***	Do not read social media messages	−0.367*
	(10.93)		(−1.819)
	0		0.069
Questioning the sender	0.468***	Consider official government messages only	0.757***
	(3.575)		(6.414)
	0.000351		0

(*continued on next page*)

Table 3 (*continued*)

Category	Information source	Credible (w.r.t. Non-credible)	Neutral (w.r.t. Non-credible)
Cross-referencing with another source	1.794***	Discuss with parents	0.883***
	(14.35)		(3.98)
	0		6.96E-05
Discussing with friends and family	1.300***	Discuss with colleagues	0.377**
	(3.006)		(2.349)
	0.00265		0.0188
Discussing with social media contacts	−0.242*	Discuss with WhatsApp	−0.295**
	(−1.777)		(−2.16)
	0.0756		0.0311
Controls			
Male	0.433***	Doesn't want to disclose gender	−2.481***
	(3.592)		(−4.553)
	0.000329		0
Other gender	−1.448	Age 26 to 35	−0.333*
	(−1.455)		(−1.701)
	0.146		0.0889
Age 36 to 45	−0.618***	Age 46 to 55	−0.649**
	(−2.627)		(−2.362)
	0.00862		0.0182
Age 56 to 65	−1.395***	Age 66 and more	−2.028***
	(−4.015)		(−3.131)
	0		0.00175
Marital status: in relationship	0.548***	Marital status: married	0.439***
	(3.638)		(2.608)
	0.000275		0.00912
Marital status: separated, divorced	−0.644**	Marital status: widowed	−0.556
	(−1.966)		(−0.634)
	0.0494		0.526
Education level: high school	−0.940***	Education level: master's	1.141***
	(−6.002)		(7.659)
	0		0
Education level: no education	−2.951***	Education level: PhD	2.478***
	(−3.672)		(11.26)
	0.000242		0
Education level: primary school	−3.599***	Job in the public sector	−0.0894
	(−7.359)		(−0.557)
	0		0.578
Own business	−0.00605	Student	0.332*
	(−0.0246)		(1.714)
	0.98		0.0866
Unemployed	−0.349	Retired	−0.256
	(−1.400)		(−0.559)
	0.162		0.576
Members in the household	−0.273***	Residence area: town, 20,000 to 100,000	−0.0697
	(−4.583)		(−0.408)
	0		0.683
Residence area: town, 300,000 or more	0.923***	Residence area: town, less than 20,000	−0.251
	(6.003)		(−1.344)
	0		0.179
Immigrants	0.326*	Number of global COVID-19 cases (LN)	−0.828***
	(1.71)		(−4.449)
	0.0874		0
Number of COVID-19 cases in the country of residence (LN)	0.273***		
	(4.148)		
	0		
Constant	81.89***		
	(31.03)		
	0		
Information about the model			
Observations	15,550	R-squared	0.371

Notes: results are displayed as coefficient, (Student t-statistic), p value;.
*** $p < 0.01$,.
** $p < 0.05$,.
* $p < 0.1$.

Table 4
Summary of findings related to RQ2.

model	Dependent variable	Scale of the dependent variable	IKC coefficient on the dependent variable category (1)	IKC coefficient on the dependent variable category (2)	IKC coefficient on the dependent variable category (3)	Number of observations
Multinomial logit reference category 1	People should stock up on groceries as much as they can [O3_StockUpGroceris]	1: strongly disagree and disagree 2: neutral 3: strongly agree and agree		−0.0575*** (0.00267) 0 R^2 0.25	−0.0845*** (0.00356) 0 R^2 0.33	15,552
Multinomial logit reference category 1	I would be willing to volunteer to help older people [O4_Volunteer_Elders]	1: strongly disagree and disagree 2: neutral 3: strongly agree and agree		−0.0163*** (0.00363) 6.72e-06 R^2 0.17	0.00559* (0.00315) 0.076 R^2 0.19	15,552
Multinomial logit reference category 1	I would be willing to volunteer to help people in quarantine [O5_Volunteer_Quarantined]	1: strongly disagree and disagree 2: neutral 3: strongly agree and agree		−0.0166*** (0.00324) 3.23e-07 R^2 0.21	0.0140*** (0.00286) 0.000 R^2 0.23	15,552
Multinomial logit reference category 1	I am in favour of governments imposing travel bans [Travel ban]	1: str. disagree & disagree 2: neutral 3: str. agree & agree		0.00724 (0.00572) 0.206 R^2 0.05	0.0146*** (0.00479) 0.002 R^2 0.20	15,552
Multinomial logit reference category 1	I am practising social distancing [Social Distancing]	1: strongly disagree and disagree 2: neutral 3: strongly agree and agree		0.0403*** (0.0114) 0.0004 R^2 0.13	0.113*** (0.00970) 0.000 R^2 0.46	15,552
Multinomial logit reference category 3	I am going to search for more information about COVID-19 [Search for more info]	1: no 2: not sure 3: yes	0.0288*** (0.00245) 0 R^2 0.3066	0.00321 (0.00246) 0.193 R^2 0.0578		15,552
Multinomial logit reference category 1	If you recover from COVID-19, you will be immune to getting reinfected [Infect Again]	1: strongly disagree and disagree 2: neutral 3: strongly agree and agree		0.00806*** (0.00230) 0.000459 R^2 0.0087	0.00120 (0.00259) 0.644 R^2 0.1740	15,551
Multinomial logit reference category 1	I am satisfied with the Government's response to COVID-19 [Satisfaction with Government]	1: strongly disagree and disagree 2: neutral 3: strongly agree and agree		−0.0335*** (0.00299) 0 R^2 0.04	−0.0156*** (0.00230) 0 R^2 0.24	15,552
Multinomial logit reference category 1	I am scared of COVID-19 [Scared of COVID-19]	1: strongly disagree and disagree 2: neutral 3: strongly agree and agree		−0.0162*** (0.00316) 3.03e-07 R^2 0.22	−0.00762*** (0.00280) 0.00642 R^2 0.27	15,552
Logit	Are there any positive aspects coming from the pandemic? [Any Positives]	1: yes 0: no	0.00677*** (0.00215) 0.00164 0.0219			15,552
Logit	Willingness to give advice to the Government in the survey [Q3_AdviseGovernment]	1: yes 0: no	−0.00133 (0.00210) 0.525 0.0146			15,552
Multiple regression	Perception of COVID-19 expected impact – Aggregation of 12 items	[1 – 5] [(low impact) - (high impact)]	0.00260*** (0.000522) 6.54e-07 0.021			15,552

Notes: results are displayed as coefficient, (robust standard errors), p-value, R^2 (McKelvey Zavoina pseudo-R2 for multinomial models, Pseudo R2 for logit models; or R squared for multiple regression);.
*** $p < 0.01$; **$p < 0.05$,.
* $p < 0.1$.

2), neutral (value 1) and non-credible (value 0). We assigned the neutral level to a source that was either not used by the respondent to gather information on COVID-19 or used but not deemed either credible or non-credible. We assigned the credible (non-credible) level to a source used to gather information on COVID-19 and perceived as credible (non-credible). In the regressions, we used "non-credible" as the reference level.

The results show that IKC was significantly higher when traditional sources such as TV news, newspapers, family doctors, the Government and the WHO websites were used and considered as credible by the respondents. On the contrary, many social media platforms (including Facebook, Google Hangouts, Instagram and WhatsApp) were negatively associated with IKC when deemed as credible. Some of them (including Facebook, Google Hangouts, Reddit and WhatsApp), instead, were positively associated with IKC when deemed non-credible. Interestingly, the only social media to be positively associated with IKC when deemed as credible was Twitter.

The results indicate that individuals use various conventional and digital sources to gather information regarding a pandemic like COVID-19. Furthermore, the use of different conventional and digital information sources, and the perception of sources' credibility are significantly associated with individuals' perception and retention of information.

4.1.3. The number of global COVID-19 cases

The number of COVID-19 cases in the country of the respondents' residence was positively related to IKC. Surprisingly, the global number of cases negatively relates to IKC.

4.1.4. Key control variables

In terms of demographics, men had a significantly higher IKC as compared to women. Middle-aged respondents and seniors between the ages of 36 and above had a significantly lower IKC than respondents between 18 and 25 years. Compared to respondents with a bachelor's degree, those with higher qualification (a master's degree or a PhD) had a significantly higher IKC, and those with a lower degree (primary school, high school or no education) had a lower IKC.

4.2. Outcomes of IKC

In the second part of the analysis, we focused on associating IKC with behaviors and opinions. Through various regression models with control of demographics, the results (reported in Table 4) showed statistically significant relationships between IKC and most dependent variables. We analyzed three types of dependent ordinal variables: 1 if the respondent strongly disagreed or disagreed with a statement, 2 if the respondent opted for the neutral answer and 3 if the respondent agreed or strongly agreed with a statement. In some other variables, the same logic was applied to track favourable positions as opposed to less favourable positions. The relationship between IKC and ordinal variables was studied through multinomial logit models. Two dependent variables were binary (yes/no), so we used logit models to analyze them. Finally, the variable *impact* was estimated as the aggregation of eight items on a five-point Likert scale and analyzed through a linear regression model.

The following significant and positive relations were found: The higher the IKC, the higher are the chances of practising social distancing and being less scared of COVID-19 in general. With a higher IKC, the acceptance of travel bans increases, and the tendency to hoard groceries decreases. People with higher IKC are more willing to volunteer to help the elderly and people who are quarantined. Also, a higher IKC leads to a lower level of satisfaction with the Government's decisions in the respondents' country of residence.

A higher IKC is also associated with a decreased intention to look for more information regarding COVID-19, less willingness to offer advice to the Government and an increase in the belief that people cured of COVID-19 can relapse or get reinfected.

Moreover, a higher IKC leads to a more positive outlook on the impacts of COVID-19 in terms of public health, economy, development of drugs, knowledge about new diseases, increased resources for the hospitals in the future, impact on the environment, collaborative innovation, the way people work and interact with each other, a more responsible society, and also the number of people in danger of losing their jobs due to lockdown measures.

5. Discussion

5.1. Predictors of IKC

Following the notion of "veracity of news" (Vosoughi et al., 2018), we observed that – during the pandemic – scientific knowledge could rapidly evolve. Untrue information could become true the following day, and vice versa. This extends our past understanding of binary classification between "true" and "false" news by proving the importance of thinking about the veracity of news as a continuum. This highlights the difficulty of managing information, even by a reliable source. Moreover, it calls for the development of new knowledge sharing mechanisms that would allow policymakers to keep people well-informed about the most recent developments in the event of an unforeseen crisis. These findings contribute to the investigation of the social origins of knowledge diffusion, which helps to understand how to reduce misinformation (Scheufele & Krause, 2019; Vosoughi et al., 2018).

In line with Gottfried and Shearer (2016), we noted that traditional media are still highly relevant in broadcasting verified information to increase the understanding of risks and precautions for handling an emerging crisis. Considering that the participants were global internet users, emphasises the results even more. Indeed, the use of traditional media such as TV news and newspapers, when considered as reliable sources of information, is associated with higher IKC.

In addition, we found that media multitasking (Garaus et al., 2017) does not play an important role in explaining the IKC. While past investigations have demonstrated that the simultaneous use of two types of media decreases the persuasiveness of messages, their retention, comprehension and recognition, our results reveal a different picture, as our findings indicate that IKC does not have a significant association with social media multitasking.

The global number of COVID-19 cases was associated with lower IKC, whereas the cases in the country of residence lead to higher knowledge. We propose two explanations for this phenomenon. First, when the survey was conducted, in the initial stage of COVID-19

pandemic, people were more impacted by the number of cases that directly affected them, while the impact of the number of global cases, which was dominated by a few hotspots such as China, Italy and the US, was negligible. Hence, self-interest and immediate concern about one's health most likely triggered the willingness to gather reliable information about COVID-19. Second, the first lockdown in March – April 2020 might not have been viewed by people as a major societal challenge, but rather as a temporary break from their regular lives. Such a large-scale impact of a viral disease and shift towards a "new normal" was unfathomable, as it was only a century ago that such an occurrence had last taken place. Moreover, more deadly viruses had emerged since then, but their effect was confined to a small region. Hence, the effort to know more about the pandemic took a back seat. It was only at a later point when the lockdown was either extended or started to impact other parts of the individual's life that people started to make a greater effort to learn more about the pandemic.

In line with Briggs and Baker (2012) and Correa, Hinsley and De Zuniga (2010) arguing that the manner and extent of the use of social media platforms are influenced by age, our results indicate that people between the ages of 36 and higher have a lower IKC as compared with younger individuals (18–35). This is particularly relevant, since in many countries young people tended to act more carelessly than the older generation, possibly assuming that mortality rates were much lower for them, and this may have favoured the spread of the virus. Interestingly, later studies, e.g., by Parida, Mostaghel and Oghazi (2016), showed increasing use of social media such as Facebook, Wikipedia, Twitter and YouTube among the elderly. However, these also indicated the importance of obtaining truthful health-related information (e.g., about the treatment of diseases). Our results indicate that these particular social media platforms often need to be approached with caution, assuming that they may not convey truthful information, to avoid assimilating unreliable knowledge.

Gender does not only play an important role in the processing and understanding of messages, as suggested by Meyers-Levy and Sternthal (1991) but affects the use of social media, as pointed out by Reuter et al. (2019). In our study, women consistently reported higher social media use levels than men (McAndrew & Jeong, 2012; Thompson & Lougheed, 2012), while our results indicate that their IKC is significantly lower than men.

5.2. Outcomes of IKC

Health-related studies show that better tailored and adapted communication are more likely to achieve the expected results (Hastall & Knobloch-Westerwick, 2013). As social media are a way to spread information and create communities that can prompt people to adopt a specific behavior (Chew & Eysenbach, 2010; Choi et al., 2017; Fox, 2014), we argue that their level of IKC significantly influences people's behavior. For instance, possessing reliable knowledge about a pandemic may imply some changes in social distancing behavior, the fear of people getting reinfected, the fear of not travelling, etc. Also, IKC enables people to be more critical towards the decisions made by governments and other policymakers. Moving towards a new normal has and will put much stress on people. Even in such times, we argue, IKC would positively and significantly influence a positive outlook on the future and impact of COVID-19.

6. Conclusion

Challenged by global misinformation and under-information about 'scientifically proven facts' and anecdotal evidence (Scheufele & Krause, 2019), governments and organizations such as the WHO need to act quickly and efficiently and inform a wider audience about emerging health risks. Thus, our study identified predictors and outcomes of individuals' knowledge for an early-stage pandemic, using the case of COVID-19. While these important aspects have been under-researched in the past, we claim that understanding how accurate information can be brought to people during early stages of a crises might help policymakers and governments select and manage the most appropriate communication channels and disseminate the 'true facts' to inform and protect the citizens. Our results show that governments should equip people to assess the received messages critically; in that respect, education is probably the best and most important tool in the long run. Moreover, identifying predictors of reliable knowledge might also help societies at a micro-level by understanding how individuals can protect themselves from unverified information, misinformation or subjective ideas and opinions. In combination with IKC outcomes, our study provides policymakers with a view of the consequences outlined by a range of behaviors triggered by the spread of information from both reliable and non-reliable sources.

Our study demonstrated that a critical factor when assessing the value of information in the early stages of a pandemic is the personal perception of its source credibility. To reach this conclusion, we used a large-scale global survey collected during the early stages of the COVID-19 pandemic. In particular, we analyzed a number of a wide range of possible information sources that can be used to seek knowledge on an early-stage pandemic. Given that social media feeds are tailored to every individual (based on their network connection as well as the types and topics of content they interact with), resorting to different social media platforms exposes an individual to broader aspects of proper knowledge. Nevertheless, a critical approach towards the credibility of many social media and of information provided by friends, family and colleagues is positively associated with reliable knowledge about the pandemic. Furthermore, a trustful approach towards traditional media and official sources is also associated with more reliable knowledge about the pandemic, in its early stages.

Respondents who discussed pandemic with their inner social circle (parents, friends, family and colleagues) have a significantly higher individual knowledge than those discussing pandemic on social media. This finding has two implications. First, open discussion in the social media community – even about sensible topics during a crisis – is more likely to spread flawed opinions than facts, while offline discussions can be more constructive. Second, if people are not actively involved in a discussion on social media during the crisis but rather use them as a source of information, then content from experts and specific organizations (like the WHO) can reach a larger audience. Receiving a personal message from the Government also has a significantly positive association with individual knowledge of its recipients.

The global number of cases is associated with lower individual knowledge. However, the cases in the country of residence are

associated with higher individual knowledge. This underlines that people who felt that the pandemic hit closer to home were more inclined to collect further knowledge about it. Moreover, being an immigrant in a country was positively associated with the respondent's knowledge, possibly because immigrants often use information sources from both the country of residence and the country of origin.

As for the outcomes of individuals' knowledge, the results indicate that higher knowledge level is linked to how people act positively towards stopping the spread of the pandemic and containing it. People with higher individual knowledge tend to not panic or get scared of the situation and have lower satisfaction with government actions which indicates that they feel the governments could have taken better steps towards prevention and communication. Ironically, people with lower individual knowledge about the pandemic are more likely to offer advice to the Government.

Our sample size also offers a greater degree of generalization of the findings, in comparison to three- and four-digit sample size of other COVID studies on a similar topic (Apuke & Omar, 2021a, b; Najmul Islam et al., 2020; Pennycook et al., 2020). In particular, our study investigated a larger number of social media. Consequently, it complements the existing study which was restricted to Facebook and WhatsApp by Apuke and Omar (2021a).

The motivation of people to share information was important, as of altruism Apuke and Omar (2021a; 2021b), self-promotion (Najmul Islam et al., 2020) and entertainment (Najmul Islam et al., 2020) did not explain people's knowledge sharing motives. Similarly, while Bermes (2021) contributes to better understand the behavioral responses of consumers confronted to fake news about COVID-19, hour study offers new insights into the impact of people's knowledge on their behavior. Our study contributes to gender specificities (Samuli Laato et al., 2020) and is in line with the argument made by Pennycook et al. (2020) that true and false information are hardly identified. Moreover, our study shows that the term "fake news" should be used with caution on COVID-related topics, since in most cases information about COVID-19 were not meant to be misleading (Orso et al., 2020).

6.1. Limitations

Despite the large sample size, which reduced the sampling error and enhanced the representativeness of the study, the main limitation of this study lies in the use of a non-probabilistic sampling method and in the analysis of a cross-sectional sample, which prevented us from drawing causal relationships. Our study is based on the responses provided by the people, whereas we could not actually track their behavior (e.g., use of face masks and other precautions). Future research could overcome this limitation by matching responses with behavior, for instance by observing the behavior of people in a controlled environment. This would raise several methodological challenges, including the possible change of behavior of a person who agreed to be observed, or the ethical implications of observing people without informing them.

6.2. Paths for further studies

Grinberg, Joseph, Friedland, Swire-Thompson and Lazer (2019) suggested developing closer partnerships between social media platforms and fact-checking websites to reinforce misinformation control. To prevent misinformation impacting individuals, Lazer et al. (2018) discuss an intervention based on empowering individuals by fact-checking, either through specialized websites or credible news media. Swire, Ecker and Lewandowsky (2017) confirm that individuals will be more likely to accept familiar information as true. However, Lazer et al. (2018) present several limitations to nuance fact-checking effectiveness, which might be counterproductive under certain circumstances since people tend to remember the information rather than the context in which they encountered it. There is also an ambiguous role of claim repetition in fact-checking (Ecker, Hogan & Lewandowsky, 2017). Hence, we recommend further research on fact-checking news related to COVID-19 and health-related issues in general, potentially orchestrated by the WHO, and on the impact of fact-checking on knowledge.

Further research into the usage of bots in the context of health issues also seems to be of importance. Social bots are automated accounts impersonating humans that can increase the spread of fake news (Lazer et al., 2018). Estimations indicate the presence of around 60 million bots on Facebook (Senate Judiciary Committee, 2017). It has also been shown that between 9% and 15% of the accounts on Twitter are active bot accounts (Varol, Ferrara, Davis, Menczer & Flammini, 2017). These issues have been studied in politics (Ferrara, 2017; Lazer et al., 2018; Weedon, Nuland & Stamos, 2017), but much less in the context of empirical studies in the times of a global pandemic.

Finally, replication studies, either conducted in a particular country or across countries, focusing on other individuals' perceived knowledge in crises would allow for further testing of our empirical model and strengthen the reported results. It would also be interesting to study the collaboration and knowledge flows, not only on an individual but also at the organizational level while including the government interventions to curb the pandemic.

Code availability statement

The ".Do" file, with the code used for analysis of data in the STATA software, has been provided as a supplementary attachment.

Author contribution

Y.C. initiated and managed the study. A.R. was instrumental in adding key members to the consortium. Y.C. and A.K.P designed the initial survey. Y.C., A.K.P, A.R., E.A., M.W., E.L.C., P.D.S. reviewed the survey design and conducted the pilot test. All authors contributed to defining the aims and direction of this particular article, led by L.S. and M.G. and supported by Y.C., A.R.., E.L.C., and A.

R.. Y.C. setup the questionnaires in different languages, managed the data collection, sorted, cleaned and coded the data for analysis. Q.Y.S. supported in managing the online questionnaire platform. All authors disseminated the questionnaire to collect the data, supported in finalizing the coding of the data set. Q.Y.S. collected the country wise and date wise COVID-19 infection data and link it to the collected data. L.S. led the literature review and theoretical background along with A.R.. M.G. and E.L.C led the data analysis and were supported by Y.C. and A.K.P. All authors wrote a part of the manuscript, with L.S. making key contribution to the structure of the article. Preparing the methodology annex was led by M.G. with contributions from E.L.C. and Y.C.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ipm.2021.102720.

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