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Risk perceptions of COVID-19 around the world

Sarah Dryhurst[a]*, Claudia R. Schneider[a,b]*, John Kerr[a,b], Alexandra L. J. Freeman[a], Gabriel Recchia[a], Anne Marthe van der Bles[a,b,c], David Spiegelhalter[a] and Sander van der Linden[a,b]

[a]Winton Centre for Risk and Evidence Communication, University of Cambridge, Cambridge, UK; [b]Department of Psychology, University of Cambridge, Cambridge, UK; [c]Department of Psychology, University of Groningen, Groningen, Netherlands

ABSTRACT

The World Health Organization has declared the rapid spread of COVID-19 around the world a global public health emergency. It is well-known that the spread of the disease is influenced by people's willingness to adopt preventative public health behaviors, which are often associated with public risk perception. In this study, we present the first assessment of public risk perception of COVID-19 around the world using national samples (total $N = 6{,}991$) in ten countries across Europe, America, and Asia. We find that although levels of concern are relatively high, they are highest in the UK compared to all other sampled countries. Pooled across countries, personal experience with the virus, individualistic and prosocial values, hearing about the virus from friends and family, trust in government, science, and medical professionals, personal knowledge of government strategy, and personal and collective efficacy were all significant predictors of risk perception. Although there was substantial variability across cultures, individualistic worldviews, personal experience, prosocial values, and social amplification through friends and family in particular were found to be significant determinants in more than half of the countries examined. Risk perception correlated significantly with reported adoption of preventative health behaviors in all ten countries. Implications for effective risk communication are discussed.

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COVID-19; risk perception; coronavirus; risk communication

Introduction

> "We're deeply concerned both by the alarming levels of spread and severity, and by the alarming levels of inaction." We have rung the alarm bell loud and clear. – Tedros Adhanom Ghebreyesus, Director-General, World Health Organization (Ghebreyesus 2020).

The new coronavirus (SARS-CoV-2) is a highly infectious disease that caused an epidemic of acute respiratory syndrome (COVID-19). Between January and April 2020, the epidemic turned into a global pandemic from its centre of origin in Wuhan, China to now having reached most

CONTACT Sander van der Linden sander.vanderlinden@psychol.cam.ac.uk Department of Psychology, University of Cambridge, Cambridge CB2 3EB, UK.
*Claudia Schneider and Sarah Dryhurst contributed equally to the paper and share first authorship.

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countries around the world. As of April 14th, 2020, over 126,000 people have died from COVID-19 globally. Men are at higher risk of dying than women (Caramelo, Ferreira, and Oliveios 2020; Jin et al. 2020) and there are signs that in some countries, ethnic minorities may also be at higher risk (Garg, Kim, and Whitaker 2020; Rimmer, 2020). On January 30th, 2020, the World Health Organization declared the outbreak a "public health emergency of international concern". In this paper, we ask two critical questions; a) how concerned are people around the world? and b) what psychological factors determine their level of concern?

As the number of deaths from the disease rises around the world, it is becoming increasingly important to understand public risk perception (Van Bavel et al. 2020). Current governmental responses range from social distancing and hygiene advice (e.g. Sweden) to complete lockdowns of the general population (e.g. Italy). These measures aim to prevent national health services from becoming overwhelmed by a sudden onslaught of cases. Yet, we know from past pandemics that the success of policies to slow down the rapid transmission of a highly infectious disease rely, in part, on the public having accurate perceptions of personal and societal risk factors. In fact, collectively, people's behavior can fundamentally influence and alter the spread of a pandemic (Epstein et al. 2008; Funk et al. 2009; Reluga 2010; Van Bavel et al. 2020). Threat appraisal and risk perception are core features of protection-motivation theory (Floyd, Prentice-Dunn, and Rogers 2000; Rogers 1975) and as such, are known to be important determinants of the public's willingness to cooperate and adopt health-protective behaviors during pandemics, including frequent hand washing, physical distancing, avoiding public places, and wearing face masks (Bish and Michie 2010; Leppin and Aro 2009; Poletti, Ajelli, and Merler 2011; Rubin et al. 2009; Rudisill 2013; van der Weerd et al. 2011). In other words, accurate public risk perceptions are critical to effectively managing public health risks.

Yet, although official health organizations have now established the pandemic to be an objective threat to public health, ringing the alarm bell "loud and clear", as Slovic (1992) once stated, "risk does not exist independent of our minds and culture" (p. 690). Indeed, a large body of research over the last decades has shown that risk perception is a subjective psychological construct that is influenced by cognitive, emotional, social, cultural, and individual variation both between individuals and between different countries (Douglas and Wildavsky 1983; Loewenstein et al. 2001; Leiserowitz 2006; Joffe 2003; Kasperson et al. 1988; Sjöberg 2002; Wildavsky and Dake 1990; Slovic 2010; Slovic, Fischhoff, and Lichtenstein 1982; van der Linden 2015, 2017; Wåhlberg 2001).

Contagion: Risk perception during pandemics

Compared to other risk domains, such as environmental risks, far less is known about how the public perceives risks associated with emerging infectious diseases (de Zwart et al. 2009). Most of the evidence on risk perception has come from studies during previous pandemics, most notably the H1N1 swine flu pandemic in 2009 (e.g. Fischhoff et al., 2018; Rudisill 2013; Prati, Pietrantoni, and Zani 2011), the Ebola outbreak (e.g. Prati and Pietrantoni 2016; Yang and Chu 2018) and the SARS and Avian influenza (bird flu) epidemics (Leppin and Aro 2009). Although this research has been important and informative, reviews have pointed out that a common characteristic of rapid-response studies is that many of them are exploratory and descriptive in nature and therefore a) do not rely on established theory-based models of risk perception, b) almost exclusively rely on single-item measures of risk perception selectively tapping into either cognitive or emotional dimensions, and c) fail to include important international comparisons (de Zwart et al. 2009; Leppin and Aro 2009).

Accordingly, here we adopt a theory-based approach to the study of risk perception. In an attempt to integrate over 50 years of risk perception research, van der Linden's (2015, 2017) risk perception model recommends the inclusion of clusters of variables that correspond to the cognitive tradition (e.g. people's knowledge and understanding about risks), the emotional and experiential tradition (e.g. personal experience), the social-cultural paradigm (e.g. the social amplification of risk, cultural theory, trust, and values), and relevant individual differences (e.g. gender, education, ideology). This "holistic" approach to modelling the determinants of risk perception prevents overreliance on a single paradigm, helps mitigate concerns about the questionable reliability of single-item constructs, and has also been adopted in recent studies of disease outbreaks (e.g. see Prati and Pietrantoni 2016). As such, we measure risk perception with an index covering the cognitive (likelihood), emotional (worry), and temporal-spatial dimensions of risk (see also Leiserowitz 2006; Xie et al. 2019). In short, in the current paper we are the first—to the best of our knowledge—to report an international analysis of COVID-19 holistic risk perception amongst $N = 6,991$ individuals surveyed across 10 different countries between mid-March and mid-April 2020.

Methods

Participants and procedure

We surveyed people in 10 different countries around the world (United Kingdom, United States, Australia, Germany, Spain, Italy, Sweden, Mexico, Japan, and South Korea). These countries were chosen for their cultural and geographic diversity and to represent countries at different stages of the pandemic, with different government policies. Data collection took place between mid-March and mid-April 2020 (Table S21). Participants were recruited through several different platforms/agencies: Prolific (US and UK; prolific.co), Dynata (AU; Dynata.com) and Respondi.com (all other countries). Prolific provided nationally representative quota samples of the US and UK stratified by age, gender, and ethnicity. We employed interlocking age and gender quotas in all other countries to ensure broadly representative samples, with a target of 700 participants per country (exact sample sizes and demographic characteristics for all samples are listed in Table S1 of the supplementary materials). The survey was conducted in a web browser via Qualtrics and took about 20 minutes to complete. Participants were paid £0.80-£2.05 ($1.00-$2.57), varying between countries. Participants completed the surveys in their native local language. Translators were fluent in both English as well as each local language to help ensure appropriate adaptation of the survey items in each country**.**

Measures. Following Leiserowitz (2006), van der Linden (2015), and Xie et al. (2019), our dependent measure "COVID-19 Risk Perception" was measured as an index, covering affective, cognitive, and temporal-spatial dimensions to provide a holistic measure of risk perception. The index included items capturing participants' perceived seriousness of the COVID-19 pandemic, perceived likelihood of contracting the virus themselves over the next 6 months, perceived likelihood of their family and friends catching the virus, and their present level of worry about the virus (pooled alpha across countries, $\alpha = .72$; alphas per country, αs .60-.82). All risk perception items are detailed in Table 1. For a full list of all items, correlations, and alphas across countries please see Tables S2–S14, supplementary material.

Psychological predictors. Our psychological predictor variables were broadly mapped based on the model by van der Linden (2015), and included measures of cognition, affect/personal experience, and social/cultural norms (Table 1). Specifically, we included items on knowledge, both personal knowledge and social knowledge, direct personal experience with the virus[1] (ranging from 9% to 28% of the sample depending on the country), a measure of social amplification of risk (via friends and family), as well as prosocial values and individualistic worldviews (via the individualism-communitarianism dimension of the cultural cognition scale (Kahan 2012)). We further extended the model of van der Linden (2015) by including measures of trust (trust in government, trust in science, trust in medical professionals), and efficacy (personal and collective), as recommended by van der Linden (2015) and Xie et al. (2019), especially since these were

Table 1. Dependent and independent variables (example items).

Type	Variable name	Example item	Scale
DV	Risk perception	How worried are you personally about the following issues at present? - Coronavirus/COVID-19	7 point Likert scale, 1 = not at all worried, 7 = very worried
		How likely do you think it is that you will be directly and personally affected by the following in the next 6 months? - Catching the coronavirus/COVID-19	7 point Likert scale, 1= not at all likely, 7 = very likely
		How likely do you think it is that your friends and family in the country you are currently living in will be directly affected by the following in the next 6 months? - Catching the coronavirus/COVID-19	7 point Likert scale, 1= not at all likely, 7 = very likely
		How much do you agree or disagree with the following statements? - The coronavirus/COVID-19 will NOT affect very many people in the country I'm currently living in	Reverse coded, 5 point Likert scale, 1 = strongly disagree, 5 = strongly agree
		How much do you agree or disagree with the following statements? - I will probably get sick with the coronavirus/COVID-19	5 point Likert scale, 1 = strongly disagree, 5 = strongly agree
		How much do you agree or disagree with the following statements? - Getting sick with the coronavirus/COVID-19 can be serious	5 point Likert scale, 1 = strongly disagree, 5 = strongly agree
Predictors	Personal knowledge	How much do you feel you understand the government's strategy to deal with the coronavirus/COVID-19 pandemic?	7 point Likert scale, 1 = not at all, 7 = very much
	Social knowledge	To what extent do you think scientists have a good understanding of the coronavirus/COVID-19?	7 point Likert scale, 1 = very limited understanding, 7 = very good understanding
	Direct experience	Have you ever had, or thought you might have, the coronavirus/COVID-19?	binary yes-no coding
	Social amplification	Have you come across information about coronavirus/COVID-19 from: - Friends and family	binary yes-no coding
	Prosociality	To what extent do you think it's important to do things for the benefit of others and society even if they have some costs to you personally?	7 point Likert scale, 1 = not at all, 7 = very much so
	Individualism worldview	The government interferes far too much in our everyday lives.	6 point Likert scale, 1 = strongly disagree, 6 = strongly agree
	Trust in government	How much do you trust the country's politicians to deal effectively with the pandemic?	7 point Likert scale, 1 = not at all, 7 = very much
	Trust in science	How much do you trust each of the following? – Scientists	5 point Likert scale, 1 = cannot be trusted at all, 5 = can be trusted a lot
	Trust in medical professionals	How much do you trust each of the following? - Medical doctors and nurses	5 point Likert scale, 1 = cannot be trusted at all, 5 = can be trusted a lot
	Personal efficacy	To what extent do you feel that the personal actions you are taking to try to limit the spread of coronavirus make a difference?	7 point Likert scale, 1 = not at all, 7 = very much
	Collective efficacy	To what extent do you feel the actions that your country is taking to limit the spread of coronavirus make a difference?	7 point Likert scale, 1 = not at all, 7 = very much
	Political ideology	Where do you feel your political views lie on a spectrum of left wing (or liberal) to right wing (or conservative)?	7 point Likert scale, 1 = very left wing/ liberal, 7 = very right wing/ conservative

deemed important in the context of risk perception of COVID-19 and previous pandemics (de Zwart et al. 2009; Prati and Pietrantoni 2016). Lastly, basic demographic variables known to influence risk perception were also incorporated into the model. These included gender (binary: male, female), age, political ideology (liberal-conservative), and education (ranging from "no formal education above 16" to "PhD"). A full list of items with details on item inter-correlations, reliabilities, and variable distributions across countries are available in the supplementary materials.

Results

We start by plotting mean risk perception scores around the world (Figure 1). Risk perception across the ten sampled countries varied between 4.78 and 5.45 on a 7-point scale, and were thus fairly high across all countries in Europe, Asia, and North America. A one-way analysis of variance on the risk perception index across countries showed a significant difference in risk levels ($F(9, 6904) = 33.12$, $p < 0.001$, $\eta^2 = 0.041$). Tukey HSD pairwise-comparisons revealed several significant differences between countries (please see Supplementary Table S15). Notably, risk perception was highest in the UK ($M = 5.45$, $SD = 0.98$), followed by Spain ($M = 5.19$, $SD = 0.87$, $p < 0.001$). Both countries were significantly higher in risk perception compared to all other countries.

Next, we ran a pooled linear regression model[2] across all countries to provide a 'big picture' overview of the predictors that play a role in COVID-19 risk perception (Table 2). To provide detail on the determinants of risk perception in each country we also ran separate models per country[3]. We investigated the determinants of risk perception in the pooled model first. Within the full predictor model pooled across all countries, our indicators of experience with the virus, social amplification through information received from family and friends, prosociality, individualistic worldviews, personal as well as collective efficacy, all trust variables, as well as personal knowledge, were all significantly associated with risk perception, in addition to a gender effect, such that males perceive less risk compared to females (please refer to Table 2 for regression outputs and statistics).

Specifically, people who have had direct personal experience with the virus perceive more risk compared to those who have not had direct experience ($\beta = 0.39$, [95%CI; 0.34, 0.45]) and people who have received information on the virus from family and friends perceive more risk compared to those who have not ($\beta = 0.24$, [95%CI; 0.18, 0.30]). The more people think that it is important to do things for the benefit of others and society even if they have some costs to them personally, the more risk they perceive ($\beta = 0.12$, [95%CI; 0.10, 0.15]). Conversely, the more individualistic worldviews people hold the less risk they perceive ($\beta = -0.18$, [95%CI; -0.20, -0.15]). Efficacy results show a positive correlation of personal efficacy with risk perception ($\beta = 0.10$, [95%CI; 0.07, 0.13]) but a negative correlation for collective efficacy ($\beta = -0.15$, [95%CI; -0.19, -0.12]). Trust in science ($\beta = 0.08$, [95%CI; 0.05, 0.11]), medical practitioners ($\beta = 0.09$, [95%CI; 0.06, 0.12]) and personal knowledge ($\beta = 0.09$, [95%CI; 0.06, 0.12]) were all positively correlated with risk perception, while trust in government was negatively correlated such that on average, people have lower risk perceptions when they have higher trust in government ($\beta = -0.06$, [95%CI; -0.09, -0.03]). The only significant demographic was gender such that males generally displayed lower risk perceptions than females ($\beta = -0.15$, [95%CI; -0.19, -0.10]). The patterns that emerged in the overall pooled model are also reflected in the per country models. The signs of the reported effects are consistent between the pooled model and all country models in which those predictors play a role, i.e. the way in which the predictors are correlated with risk perception is stable across countries. In addition, although each country shows a unique set of significant predictors, many predictors emerge to have an effect in several countries (for a detailed overview please see Table S18 in the supplementary materials).

Although results from multiple regression models are informative on their own, scholars now frequently recommend to supplement regression analyses with additional indicators of variable

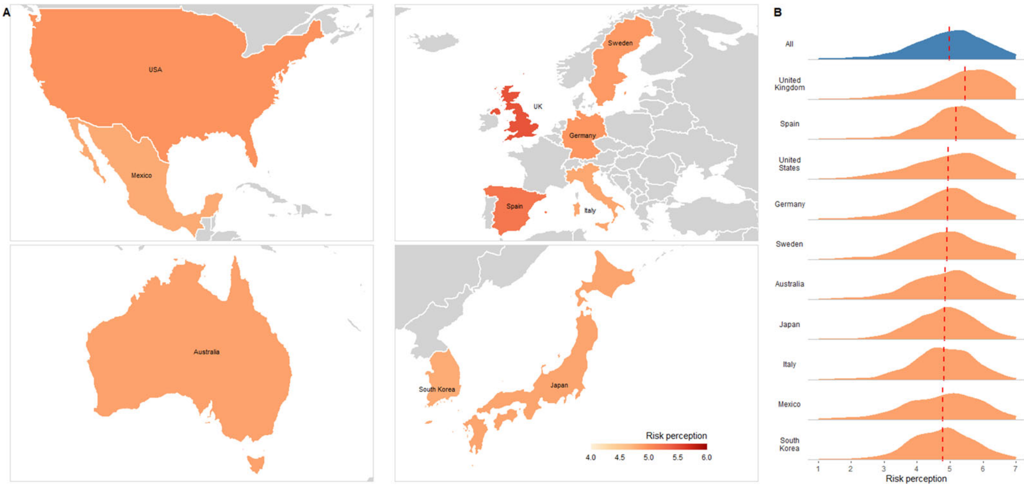

Figure 1. Map of COVID – 19 risk perception around the world (A) with density plots (B). *Note*: The risk perception colour gradient is truncated to better visualize variation on the higher end of the scale (full range 1–7).

importance (Darlington 1968; Tonidandel and LeBreton 2011). Accordingly, to assess the relative contribution of our predictor variables for the pooled and per country models in more detail, we followed Pratt's (1987)[4] variance partitioning method. Figure 2 details the contribution of each variable to the R^2 of our models.

Several of our predictors emerged as important in our pooled and per country models (see Figure 2 for full details). In particular, the extent to which people hold individualistic views explained the most variance in our pooled model (4.78%, 95% CI [3.77, 6.01]) and in five out of the ten countries surveyed (UK, Germany, Sweden, Spain and Japan; full results of all analyses are reported in supplementary Table S17). It also explained a substantial proportion of variance in four of the remaining ten countries. The notable exception was South Korea, where this construct did not appear to be an important predictor (0.18%, [-0.04, 1.65]). Prosociality was the second most important predictor in the pooled model, explaining 3.19% [2.32, 4.18] of the total variance. At the country level, prosociality explained the most variance in the models for Italy, Australia, and Mexico, and was also a comparatively important predictor in our other countries. Again South Korea was an exception; prosociality was of comparatively little importance as a predictor (0.54%, [0.04, 2.42]).

Direct experience with the virus was the third most important predictor in the pooled model (2.34%, [1.73, 3.03]) and emerged as the most important predictor in the US (5.65% [3.02, 8.99]) and comparatively important in most countries surveyed, including South Korea (2.39% [0.78, 4.90]), although it appeared a less important predictor in Australia (0.81% [0.11, 2.28]) and Sweden (0.75%, [-0.02, 2.5]), perhaps due, in part, to the relatively low number of confirmed cases in these countries at the time of the survey. Various trust variables were also important in the pooled model (trust in medical practitioners: 1.73%, [1.02, 2.51]; trust in science: 1.62%, [0.86, 2.51]) and some were also important in South Korea (trust in government: 2.87% [0.77, 5.9]; trust in medical professionals: 2.47% [0.45, 5.59]). However, out of the other countries, trust was only of some importance in the US (trust in medical practitioners: 2.28%, [0.03, 5.28]).

Personal efficacy explained 1.62% of the variance in the pooled model [0.98, 2.42] but appeared to only have substantial importance in Germany (4.13% [1.07, 8.7] and Sweden (7.3% [3.6, 12.14]), and to a lesser extent Spain (1.72%, [0.1, 4.41]) and the US (1.67% [0.26, 4.4]). Collective efficacy was far less important in the pooled model (0.41% [0.02, 1.00]) and indeed only emerged as a comparatively important predictor in Japan (1.98% [0.19, 5.19]), Mexico (2.87% [0.53, 7.42]) and the US (4.33% [1.38, 8.69].

Table 2. Regression outputs and statistics.

	All	Australia	Germany	Spain	Italy	Japan	South Korea	Mexico	Sweden	United Kingdom	United States
Predictors	*std. Beta (standardized CI)*	*std. Beta (standardized CI)*	*std. Beta (standardized CI)*	*std. Beta (standardized CI)*	*std. Beta (standardized CI)*	*std. Beta (standardized CI)*	*std. Beta (standardized CI)*	*std. Beta (standardized CI)*	*std. Beta (standardized CI)*	*std. Beta (standardized CI)*	*std. Beta (standardized CI)*
Gender [Male]	−0.15 *** (−0.19 – −0.10)	−0.08 (−0.23 – 0.07)	−0.16 * (−0.29 – −0.02)	−0.28 *** (−0.41 – −0.14)	−0.09 (−0.25 – 0.07)	−0.11 (−0.26 – 0.04)	−0.16 * (−0.30 – −0.02)	−0.18 * (−0.34 – −0.03)	−0.11 (−0.25 – 0.04)	−0.18 * (−0.32 – −0.04)	−0.05 (−0.19 – 0.08)
Age	−0.01 (−0.04 – 0.01)	0.00 (−0.08 – 0.08)	−0.08 * (−0.16 – −0.01)	−0.06 (−0.12 – 0.01)	−0.12 ** (−0.20 – −0.04)	−0.12 ** (−0.20 – −0.05)	0.02 (−0.05 – 0.09)	−0.01 (−0.09 – 0.06)	0.06 (-0.01 – 0.13)	−0.02 (-0.09 – 0.06)	0.03 (-0.04 – 0.09)
Education	−0.01 (−0.04 – 0.01)	−0.03 (−0.11 – 0.05)	−0.02 (−0.09 – 0.05)	0.04 (−0.03 – 0.11)	0.06 (−0.02 – 0.14)	−0.05 (−0.13 – 0.02)	−0.03 (−0.10 – 0.05)	0.01 (−0.06 – 0.09)	−0.06 (−0.13 – 0.01)	−0.05 (−0.12 – 0.02)	0.00 (−0.07 – 0.07)
Political ideology (liberal-conservative)	0.01 (−0.01 – 0.03)	−0.05 (−0.13 – 0.02)	0.02 (−0.05 – 0.09)	0.01 (−0.06 – 0.08)	0.07 (−0.01 – 0.15)	0.01 (−0.07 – 0.09)	0.11 ** (0.03 – 0.19)	0.07 (−0.01 – 0.14)	0.02 (−0.05 – 0.09)	−0.05 (−0.12 – 0.03)	−0.08 (−0.16 – 0.01)
Personal knowledge	0.09 *** (0.06 – 0.12)	0.16 ** (0.06 – 0.26)	0.07 (−0.02 – 0.16)	0.21 *** (0.12 – 0.30)	0.04 (−0.07 – 0.15)	0.10 * (0.02 – 0.19)	0.14 ** (0.03 – 0.25)	0.03 (−0.07 – 0.14)	0.06 (−0.04 – 0.16)	0.06 (−0.03 – 0.14)	0.07 (−0.01 – 0.15)
Social knowledge	−0.01 (−0.03 – 0.02)	−0.05 (−0.14 – 0.03)	−0.08 (−0.16 – 0.00)	0.02 (−0.05 – 0.09)	−0.04 (-0.12 – 0.04)	0.02 (−0.07 – 0.11)	0.05 (−0.03 – 0.13)	0.06 (−0.02 – 0.14)	−0.03 (−0.12 – 0.05)	−0.05 (−0.12 – 0.03)	−0.05 (−0.12 – 0.02)
Direct experience [Yes]	0.39 *** (0.34 – 0.45)	0.32 * (0.06 – 0.58)	0.38 *** (0.21 – 0.55)	0.48 *** (0.33 – 0.63)	0.45 *** (0.27 – 0.63)	0.36 *** (0.19 – 0.53)	0.40 *** (0.22 – 0.59)	0.37 *** (0.15 – 0.58)	0.23 ** (0.07 – 0.40)	0.37 *** (0.19 – 0.55)	0.61 *** (0.42 – 0.80)
Social amplification [Yes]	0.24 *** (0.18 – 0.30)	0.35 *** (0.17 – 0.53)	0.26 * (0.04 – 0.49)	0.39 ** (0.15 – 0.63)	0.00 (−0.17 – 0.18)	0.23 * (0.05 – 0.41)	0.16 (−0.05 – 0.36)	0.17 (−0.10 – 0.44)	0.30 ** (0.12 – 0.48)	0.26 * (0.04 – 0.49)	0.08 (−0.14 – 0.30)
Prosociality	0.12 *** (0.10 – 0.15)	0.15 *** (0.06 – 0.23)	0.11 ** (0.04 – 0.19)	0.12 ** (0.04 – 0.20)	0.23 *** (0.14 – 0.32)	0.12 ** (0.03 – 0.20)	0.06 (−0.01 – 0.14)	0.17 *** (0.09 – 0.25)	0.10 ** (0.03 – 0.18)	0.17 *** (0.10 – 0.25)	0.10 ** (0.02 – 0.18)
Individualism worldview	−0.18 *** (−0.20 – −0.15)	−0.14 *** (−0.22 – −0.06)	−0.29 *** (−0.37 – −0.21)	−0.19 *** (−0.27 – −0.11)	−0.17 *** (−0.27 – −0.07)	−0.15 *** (−0.23 – −0.07)	−0.04 (−0.11 – 0.04)	−0.11 ** (−0.19 – −0.03)	−0.23 *** (−0.31 – −0.16)	−0.21 *** (−0.29 – −0.13)	−0.15 *** (−0.23 – −0.07)
Trust in government	−0.06 *** (−0.09 – −0.03)	0.00 (−0.11 – 0.10)	−0.03 (−0.13 – 0.07)	−0.21 *** (−0.31 – −0.12)	0.01 (−0.09 – 0.12)	−0.07 (−0.18 – 0.04)	−0.21 *** (−0.30 – −0.12)	−0.01 (−0.12 – 0.10)	−0.07 (−0.18 – 0.04)	−0.04 (−0.14 – 0.06)	0.00 (−0.09 – 0.09)
Trust in science	0.08 *** (0.05 – 0.11)	0.08 (−0.01 – 0.17)	0.03 (−0.06 – 0.12)	0.09 (−0.00 – 0.18)	0.01 (−0.10 – 0.11)	0.05 (−0.04 – 0.15)	0.06 (−0.04 – 0.15)	0.07 (−0.02 – 0.17)	0.04 (−0.05 – 0.13)	0.08 (−0.00 – 0.17)	0.09 (−0.01 – 0.18)
Trust in medical professionals	0.09 *** (0.06 – 0.12)	−0.01 (−0.10 – 0.08)	0.05 (−0.03 – 0.14)	0.04 (−0.04 – 0.13)	0.08 (−0.02 – 0.18)	0.09 (−0.00 – 0.18)	0.12 ** (0.03 – 0.21)	0.07 (−0.02 – 0.16)	0.05 (−0.04 – 0.14)	0.08 (−0.00 – 0.17)	0.10 * (0.01 – 0.19)
Personal efficacy	0.10 *** (0.07 – 0.13)	0.08 (−0.02 – 0.17)	0.16 *** (0.07 – 0.25)	0.10 * (0.01 – 0.18)	0.03 (−0.08 – 0.14)	−0.02 (−0.11 – 0.07)	0.09 (−0.01 – 0.19)	0.07 (−0.01 – 0.16)	0.24 *** (0.15 – 0.32)	0.04 (−0.04 – 0.11)	0.12 ** (0.04 – 0.19)
Collective efficacy	−0.15 *** (−0.19 – −0.12)	−0.07 (−0.19 – 0.05)	−0.04 (−0.15 – 0.06)	−0.13 * (−0.23 – −0.02)	−0.03 (−0.16 – 0.09)	−0.15 ** (−0.26 – −0.04)	−0.1 (−0.22 – 0.01)	−0.20 ** (−0.32 – −0.08)	−0.08 (−0.20 – 0.04)	−0.11 * (−0.21 – −0.01)	−0.20 *** (−0.30 – −0.10)
Observations (N)	6482	646	656	669	531	617	690	621	656	699	697
R^2 / R^2 adjusted	0.181 / 0.179	0.166 / 0.146	0.233 / 0.215	0.262 / 0.245	0.199 / 0.176	0.154 / 0.132	0.157 / 0.139	0.166 / 0.145	0.240 / 0.222	0.198 / 0.181	0.263 / 0.247

Note: * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

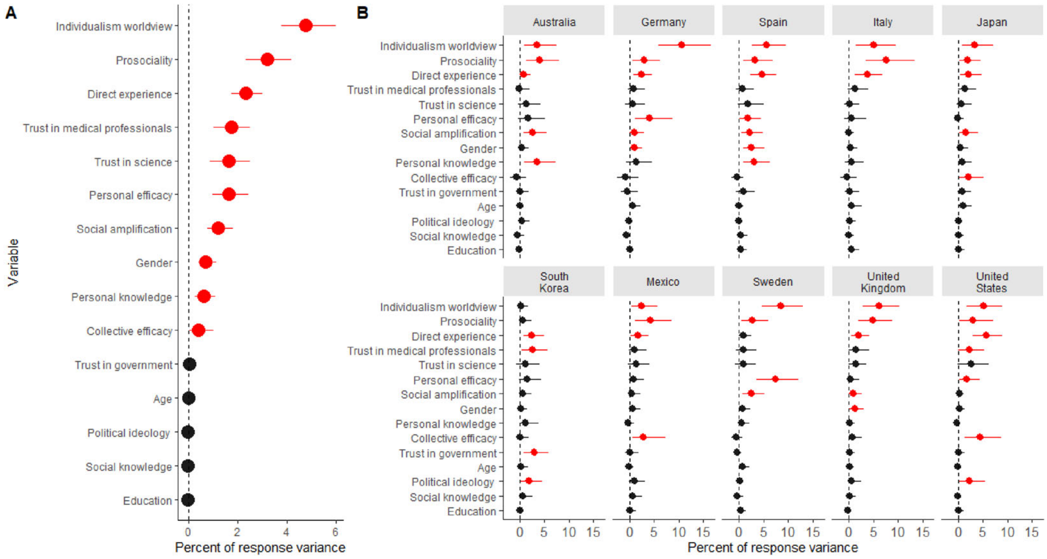

Figure 2. Relative importance of individual predictors for the pooled and per country models with 1,000 bootstrapped 95% confidence intervals. Red dots denote confidence intervals that do not include zero. *Note*: The figure visualizes the percent that each variable contributes out of the total variance explained in each model (R^2).

Social amplification explained 1.21% [0.75, 1.80] of the variance in the pooled model and showed some predictive importance in six of our ten countries (Australia, Germany, Spain, Sweden, Japan, UK). While, in the pooled model, gender (0.7% [0.39, 1.11]) and personal knowledge (0.6% [0.24, 1.07]) displayed some predictive importance, they were only relevant as predictors in a few countries (gender: Germany, Spain and the UK; personal knowledge: Australia and Spain).

Discussion

In this paper, we set out to map and model risk perception of COVID-19 in ten countries around the world. Across all of our national surveys, we find that risk perception of COVID-19 is uniformly high. Several psychological factors emerged as significant predictors across countries. Consistent with the literature in the domain of environmental risk (e.g. see Leiserowitz 2006; van der Linden 2015; Xie et al. 2019), experiential and socio-cultural factors explained most of the variance in our risk perception models across all countries in comparison to cognition (knowledge) and socio-demographic characteristics. Several specific predictors proved important, including the role of prosocial versus individualistic values and to a lesser extent our measure of social amplification (hearing about the virus from friends and family). Most notably, experience with the virus stands out across all countries, such that people who have had personal and direct experience perceive significantly higher risk.

These findings are generally consistent with the literature on "risk as analysis vs risk as feelings", where having had visceral contact with the virus strongly engages the affective experiential system which is known to be more dominant in the processing of risk under these conditions (Loewenstein et al. 2001; Leiserowitz, 2006; Slovic et al. 2004; van der Linden 2014, 2015; Weber 2006). Although not directly evaluated here, it could also be the case that experience with the virus helps to construe the situation as more concrete and closer to the self and thus heightens risk perceptions through construal level (Trope and Liberman 2010).

Interestingly, although comparative risk perception research on pandemics remains scant (de Zwart et al. 2009; Leppin and Aro 2009), existing research finds that whilst risk perceptions of the Asian influenza (AI) were higher in Asia than Europe, perceived risk was not high in absolute terms so the authors speculate that past experience with the SARS epidemic may have actually raised efficacy beliefs that new pandemics can be controlled thereby lowering risk perceptions (de Zwart et al. 2007). We also note in our study that higher collective efficacy beliefs reduced risk perceptions about COVID-19 in Spain, Japan, Mexico, the UK, and the US.

Other findings follow more specific patterns within and between countries, for example, around the role political ideology plays. Ideology was only a significant predictor in South Korea in the full model, though political ideology did also emerge as a significant factor in the demographics-only models[5] for Mexico, the UK, and the US. In the UK and US a more conservative leaning was associated with lower risk perception, while in Mexico and South Korea it was associated with higher risk perception. Being male was uniformly associated with lower risk perceptions in many countries, which is consistent with other risk perception work (Finucane et al. 2000) and particularly interesting as males are at objectively higher risk from COVID-19 (Jin et al. 2020). Another interesting finding is that although trust in government was significant in the overall model, it only seemed to play a role in South Korea and Spain, such that higher levels of trust are associated with lower levels of risk perception. It might be that in other countries how much people trust their government and politicians is not strongly related to COVID-19 on a perceptual level. Though past research on the 2001 foot and mouth disease and 2009 swine flu has shown that perceptions of government handling were related to trust judgments (Poortinga et al. 2004; van der Weerd et al. 2011) and failed risk management has generally contributed to declining trust in regulators (Löfstedt 2005; Slovic 1993). Importantly, recent research finds that being transparent about scientific uncertainty does not necessarily undermine public trust in facts or the communicator (van Der Bles et al. 2020). Nonetheless, it may be that compared to trust in government and scientific understanding, other factors play a more salient role.

Lastly, consistent with the literature on the important role of risk perception in motivating health protection behaviors (Floyd, Prentice-Dunn, and Rogers 2000), especially during pandemics (Bish and Michie 2010; Rudisill 2013; van der Weerd et al. 2011; Wise et al. 2020), we find that risk perception correlated positively and significantly with an index of preventative health behaviors (Tables S19-S20) such as washing hands, wearing a face mask, and physical distancing ($r_{pooled} = 0.28$, and $r = 0.24$ to $r = 0.39$ per country, $p < 0.001$). At the same time, it is important to note that both downplayed and exaggerated perceptions of risk can potentially undermine the adoption of protective health behaviors (Leppin and Aro 2009). Causality can also run both ways so that higher risk perceptions lead to more protective behaviors but that taking effective action can, in turn, also reduce risk perceptions (Brewer et al. 2004). We therefore stress the importance of evaluating accuracy in public risk perceptions.

Of course, this research is not without limitations. It is important to note that although our samples were balanced on national quotas, they were not probability samples and therefore are not truly representative of the population in each country. In addition, some constructs, such as the individualism-collectivism dimension of the cultural cognition scale (Kahan 2012) proved less reliable in the Asian cultural context, consistent with other recent research (Xue et al. 2016) and the explained variance of the regressions (up to 26%) suggests that a significant portion of variation in risk perceptions of COVID-19 remains yet to be explained. Although we covered several major dimensions of risk perception research, our measures were imperfect, for example, we did not assess objective knowledge of COVID-19 nor include multi-item measures of social norms and values or affective evaluations about COVID-19. Thus, future research is well-advised to consider expanding upon our research.

Conclusion

Policy-makers often conceptualize risk as the probability of catching a disease multiplied by the magnitude of the consequences. Yet, our findings—which present the first comparative evidence of how people perceive the risk of COVID-19 around the world—clearly illustrate that risk perceptions of COVID-19 consistently correlate strongly with a number of experiential and socio-cultural factors across countries. At the same time, we also note the need to attend to cross-cultural variation in risk perception. In fact, our holistic approach to understanding the nature of risk perception is consistent with research that has identified important "sociocultural vectors" for effective risk communication (Wardman 2014), which involves much more than just "getting the numbers right" (Fischhoff 1995). The idea that risk is socially negotiated based on people's experiences, values, and trust in institutions (Rickard 2019) is reinforced here. More specifically, across multiple countries and analyses, we show that people's perception of the risk is higher in those with direct personal experience of the virus, and in those who hold more prosocial worldviews. The act of making sacrifices for the greater benefit of society is relevant to risk communication as it reveals the social nature of risk. As Fischhoff (1995) notes, "effective risk communication can fulfil part of the social contract between those who create risks and those who bear them" (p. 144). In fact, appealing to altruistic and prosocial motives can be an important aspect of solving social dilemmas during pandemics (Van Bavel et al. 2020). Relatedly, those who receive information about the virus from friends and family, those who think that their government's action is not being effective, and those who say that they believe it's important for governments to intervene and take collective action all perceive a higher risk. Health risk communication messages therefore tend to be most effective when they include information about the effectiveness of measures designed to protect people from the disease at both a personal and societal level (Leppin and Aro 2009; Bish and Michie 2010; Witte, Meyer, and Martell 2001). Thus, although the current evidence is only observational and could benefit from experimental testing, what does seem clear is that a better understanding of not only the knowledge that people have, but also the experiential, social, and cultural factors that drive COVID-19 risk perceptions around the world (and their role in motivating preventative health behaviors) could help policy-makers design evidenced-based risk communication strategies, and that insights from different countries around the world could be of relevance and use in designing those.

Notes

1. Participants who reported they had tested positive for the virus, or suspected that they were infected were coded as having direct experience with the COVID-19 virus. Suspected infections were included here as many countries do not undertake tests for low risk cases.
2. We checked for multi-collinearity between variables, as well as for homogeneity of variance, normal distribution of residuals, and the presence of influential outliers for all our models. Please see Figure S1 and the section "Model Diagnostics" in the supplement for more details. We tested the robustness of our pooled and individual country regressions by running all models using robust standard errors. Results were consistent with the OLS regressions reported here.
3. We also tested the appropriateness of a multi-level model (MLM) by including country as a random intercept (as the pooled model can mask significant between-country heterogeneity). However, the resulting ICC was near zero (0.04) indicating that most variability lied within groups (Gelman and Hill 2007). Furthermore, multi-level models can be unreliable when n is large for individuals in comparison to the second-level predictor (country). Specifically, Bryan and Jenkins (2016) recommend at least $n = 25$ for linear models. We therefore proceed with separate OLS regressions and discuss between-country differences qualitatively with caution.
4. The relative importance of an independent variable is defined as the product of its bivariate correlation with the dependent variable and its standardised coefficient in the multiple regression, with the sum of each variable's contribution equalling the R^2 of the overall model (see Pratt 1987; van der Linden 2015).
5. Please refer to Table S16 in the supplement for details on the demographic models.

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ORCID

Sarah Dryhurst http://orcid.org/0000-0002-7772-8492
Claudia R. Schneider http://orcid.org/0000-0002-6612-5186
John Kerr http://orcid.org/0000-0002-6606-5507
Alexandra L. J. Freeman http://orcid.org/0000-0002-4115-161X
Gabriel Recchia http://orcid.org/0000-0002-0210-8635
Anne Marthe van der Bles http://orcid.org/0000-0002-7953-9425
Sander van der Linden http://orcid.org/0000-0002-0269-1744

Data availability statement

All data are publicly available on the Open Science Framework (OSF) website: https://osf.io/jnu74

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