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Modeling compliance with COVID-19 prevention guidelines: the critical role of trust in science

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ABSTRACT

The coronavirus pandemic is one of the biggest health crises of our time. In response to this global problem, various institutions around the world had soon issued evidence-based prevention guidelines. However, these guidelines, which were designed to slow the spread of COVID-19 and contribute to public well-being, are (deliberately) disregarded by some individuals. In the present study, we aimed to develop and test a multivariate model that could help us identify individual characteristics that make a person more/less likely to comply with COVID-19 prevention guidelines. A total of 525 attentive participants completed the online survey. The results of structural equation modeling (SEM) show that COVID-19 risk perception and trust in science both independently predict compliance with COVID-19 prevention guidelines, while the remaining variables in the model (political conservatism, religious orthodoxy, conspiracy ideation and intellectual curiosity) do so via the mediating role of trust in science. The described model exhibited an acceptable fit ($\chi^2(1611) = 2485.84$, $p < .001$, CFI = .91, RMSEA = .032, SRMR = .055). These findings thus provide empirical support for the proposed multivariate model and underline the importance of trust in science in explaining the different levels of compliance with COVID-19 prevention guidelines.

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COVID-19; COVID-19 prevention guidelines; compliance; adherence; predictors; trust in science

Introduction

According to the World Health Organization (2020), the world is currently witnessing a global pandemic of the 2019 novel coronavirus (SARS-CoV-2) which causes the disease COVID-19. Current data, which likely underscore the actual prevalence of the disease (Lipsitch et al., 2020; Sohrabi et al., 2020), support this notion; as of now (May 17th, 2020), COVID-19 has spread to at least 213 countries and territories and has recently exceeded more than 4,750,000 confirmed cases and 313,000 deaths (Worldometer, 2020). Due to the highly contagious nature of the virus and the exponential growth of infections observed in many countries (e.g. Italy; Remuzzi & Remuzzi, 2020), a high level of compliance with prevention guidelines, such as those issued by the World Health Organization, is necessary to 'flatten the curve' and slow the spread of the virus (Anderson et al., 2020). In spite of this, there have been numerous reported instances of people ignoring these instructions all over the world (Bhanot, 2020), likely exacerbating the problem.

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While the previous literature has begun to unravel important medical and epidemiological information about the severity of the disease and the transmissibility of the virus, the psychosocial responses of the public are still relatively unknown (for one of the rare peer-reviewed articles, see Wang et al., 2020), and this is particularly true when it comes to individuals' reactions to the COVID-19 prevention guidelines. We argue that exploring the antecedents of compliance with these guidelines could potentially be of great practical importance as it could help us identify high-risk groups and take the necessary steps towards improving the rate of compliance.

Development of the model

To investigate the predictors of compliance with COVID-19 prevention guidelines, we developed a theoretical model (Figure 1) that includes several variables (education level, political conservatism, religious orthodoxy, conspiracy ideation, intellectual curiosity, trust in science, perception of COVID-19 risk and compliance with COVID-19 prevention guidelines), previously identified as relevant (e.g. Lau et al., 2007; Nadelson & Hardy, 2015), and relates them in a meaningful way.

The first likely predictor of compliance with COVID-19 guidelines is COVID-19 risk perception (i.e. the extent to which a person believes that the novel coronavirus poses a serious threat). More specifically, we predict that those who are generally more concerned about COVID-19 are more likely to adhere to preventive measures as shown by previous studies, conducted in similar contexts (e.g. Chen et al., 2007; Lau et al., 2007; Maughan-Brown & Venkataramani, 2018). Since it is scientific organizations and scientists who are often the source of both, prevention guidelines and messages informing the public about COVID-19 risks, those who trust science and scientists are more inclined to perceive COVID-19 as an actual risk and follow the risk-mitigating

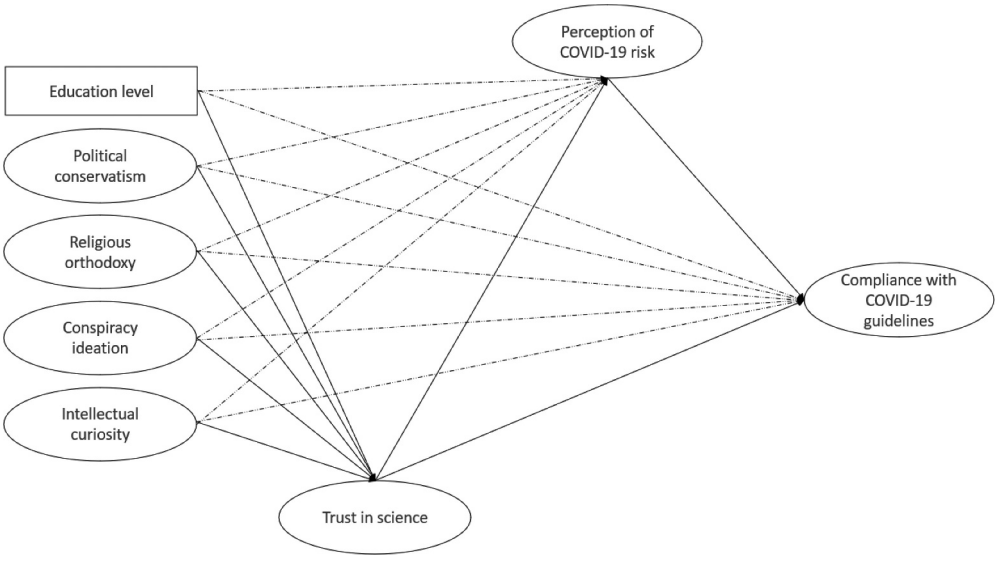

Figure 1. Theoretical model.

guidelines. Support for this assumption can, for example, be found in the vaccination literature (e.g. Keelan et al., 2010) and other studies that highlight the role of trust in determining the perception of various emotionally charged scientific issues (Nadelson & Hardy, 2015).

In addition, previous studies have highlighted numerous correlates and antecedents of trust in science and science skepticism, that could, directly or indirectly via trust in science, predict compliance with COVID-19-related prevention guidelines. Key variables among these are political conservatism (e.g. Rutjens et al., 2018; Wilgus & Travis, 2019), religiousness/religious orthodoxy (e.g. Chan, 2018; Rutjens et al., 2018), conspiracy thinking (e.g. Lewandowsky et al., 2013; Rutjens & van der Lee, 2020) and, to some extent, education level (e.g. Morgan et al., 2018). While more general and stable personality traits are less present in the previous literature on predictors of trust in science, we believe that aspects of open-mindedness, especially intellectual curiosity (i.e. the extent to which an individual has intellectual interests and enjoys thinking; Soto & John, 2017), could also play an important role in predicting both – trust in science and compliance with evidence-based prevention guidelines. Hence, this aspect was additionally added to the theoretical model.

Objectives

The aim of this study was to develop and examine the theoretical model that could help us explain the different responses to the COVID-19 prevention guidelines. In this model, particular attention was paid to the role of trust in science, which could act as a mediator between more general sociopsychological predictors and compliance with preventive measures related to COVID-19.

Method

Participants

International participants were recruited through advertisements on various social media websites, especially Reddit, which allows users to share and discuss different stories and links (including links to surveys) and vote on submitted content (Shatz, 2017). Anyone aged 18 years or above who can speak and comprehend English was invited to participate in the online study. Upon completion of the study, participants had the chance to participate in a raffle to win one of the two Amazon gift cards worth 25 USD (or the equivalent amount in other currencies). No sample size calculations were performed prior to the study.

A total of 617 participants started to fill out the survey, but participants with missing data (N = 76; 12.3% of all respondents who started filling out the survey) and inattentive participants (N = 16; 3.0% of all respondents without missing data) were excluded from the analyses. The final sample thus consists of 525 participants (48.8% male, 49.3% female, 1.9% non-binary) aged between 18 and 74 years (M = 32.53, SD = 10.41). More precisely, 48.0% of the participants were aged between 29 and 49 years, 44.0% between 18 and 28 years and 8.0% of the participants were older than 50 years. The participants were generally relatively highly educated; most of

them had a bachelor's degree or an equivalent level of education (41.3%), a master's degree or an equivalent level of education (26.5%) or had completed higher secondary education (24.0%). In addition, more than a third of the sample (34.7%) noted that it is neither easy nor difficult for them to make the monthly payments, while the remaining participants stated that it is easy (24.6%), very easy (23.0%), difficult (14.3%) or very difficult (3.4%) for them to make the monthly payments. The majority of the sample currently lives in North America (48.1%), followed by participants currently living in Europe or transcontinental countries with territory in both Europe and Asia (38.5%) and Australia or New Zealand (5.5%). Most participants described their English language skills as at least upper-intermediate (B2; 98.5%).

Materials

Participants were asked to provide basic socio-demographic data and to complete several questionnaires related to religious orthodoxy, conspiracy ideation, intellectual curiosity, trust in science, perception of COVID-19 risk and compliance with COVID-19 prevention guidelines.

Socio-demographic data

Various socio-demographic data were collected during the study (e.g. gender, age, nationality, education, income level, political conservatism). Education was measured by asking participants to provide their highest level of education, with response options ranging from '*primary education or less*' to '*doctoral degree or equivalent*'. On the other hand, political conservatism was measured using the following two questions: '*How would you describe your political outlook with regard to (1) social/(2) economic issues*?', answered on a response scale from one ('*very liberal*') to seven ('*very conservative*'; e.g. Talhelm et al., 2015). Since the two questions were highly correlated, they were treated as indicators of political conservatism ($\alpha = .74$).

Religious orthodoxy

Religious orthodoxy was measured using the 7-item Orthodoxy subscale of the Post-Critical Belief scale (Duriez & Hutsebaut, 2000; Hutsebaut, 1996). All items (e.g. '*Religion is the one thing that gives meaning to life in all its aspects*') were answered on a 7-point scale from '*strongly disagree*' to '*strongly agree*'. In order to provide the most inclusive measurement possible, the content of three items was slightly adjusted to fit both of the two most common religions – Christianity and Islam (see Ghorbani et al., 2009). For example, while one of the original items only mentions the Bible ('*I think that Bible stories should be taken literally, as they are written*'), the modified version refers to either the Bible or the Quran ('*I think that Bible or Quran stories should be taken literally, as they are written*'), depending on the religious affiliation of the participant. The scale exhibited good internal consistency ($\alpha = .77$).

Conspiracy ideation

The 15-item Generic Cospiracist Beliefs scale (Brotherton et al., 2013) was used to measure conspiracy ideation. The scale includes items related to government malfeasance, extraterrestrial cover-up, malevolent global conspiracies, personal wellbeing and

control of information. Items were answered using the 5-point scale from '*Definitely not true*' to '*Definitely true*'. While all subscales exhibited acceptable reliability (α > .60), we were more interested in general conspiracy ideation; as such, all subscales were combined into the second-order factor 'conspiracy ideation' (e.g. '*The spread of certain viruses and/or diseases is the result of the deliberate, concealed efforts of some organization*'; α = .91), as had been done in many previous studies (e.g. Brotherton et al., 2013; Pennycook et al., 2015).

Intellectual curiosity

Intellectual curiosity was measured with only 4 items of the Big Five Inventory 2 (BFI-2; Soto & John, 2017), specifically those designed to measure intellectual curiosity (an aspect of Open-Mindedness; e.g. '*I am someone who is curious about many different things*'; α = .63). These items were answered on a 5-point scale, ranging from '*Disagree strongly*' to '*Agree strongly*'.

Trust in science

The next variable, trust in science, was measured with the Trust in Science and Scientists Inventory (Nadelson et al., 2014). The scale originally contains 21 items (e.g. '*Scientific theories are trustworthy*'), answered on a 5-point agreement scale from one ('*Strongly disagree*') to five ('*Strongly agree*'). The originally proposed measure exhibited great internal consistency (α = .89) but had to be slightly adjusted to achieve an acceptable measurement model. Specifically, items 1, 5, 7, 8, 13, 14 and 16 were excluded from the analyses. The adjusted version thus contains 14 items (α = .81) and correlates very highly with the original version (r = .97, p < .001), suggesting it is a similarly valid but more parsimonious version of the originally proposed inventory.

COVID-19 risk perception

COVID-19 risk perception was measured using a self-construed scale consisting of 6 items (e.g. '*I believe that COVID-19 poses a serious threat*'; α = .72), which were answered using a 7-point scale (1 – '*Strongly disagree*', 7 – '*Strongly agree*'). The scale items are adapted versions of items that comprise similar measures, such as those that measure HIV risk perception (e.g. Napper et al., 2012) and SARS risk perception (e.g. Brug et al., 2004). See Appendix A for the full scale.

Compliance with COVID-19 prevention guidelines

As with the previous variable, compliance with COVID-19 prevention guidelines was measured using a self-construed scale (see Appendix B). In this case, the scale consisted of 11 preventive behaviors outlined by the World Health Organization, Centers for Disease Control and Prevention and/or European Center for Disease Prevention and Control (e.g. '*Frequently washing your hands with soap and water for at least 20 seconds*'; α = .76). Respondents were asked to what extent they act in accordance with the selected COVID-19 prevention guidelines, to which they responded using a 4-point scale from '*Not at all*' to '*To a great extent*'.

Attention checks

Three attention checks were embedded into the survey, approximately every 2–3 pages. In particular, we used the so-called 'directed questions', which tell the participants to give specific answers (e.g. '*This is a control question. Mark "Agree" and move on.*'; Maniaci & Rogge, 2014). This scale was scored by summing the number of mistakes each subject made on these items to create scores ranging from 0 to 3.

Procedure

The data were collected online, via the SurveyMonkey platform (https://www.surveymonkey.com). Participants were given a brief overview of the study, including basic information about the objectives and methodology of the study, and were informed that their participation was completely anonymous (IP addresses were not collected), voluntary, and could be terminated at any time without any repercussions. For individuals who decided to participate in the study, the study procedure took approximately 10 minutes.

The study was conducted in accordance with the Declaration of Helsinki. Ethical review and approval were not required for this study in accordance with the national and institutional guidelines.

Statistical analyses

Statistical analyses were performed using IBM SPSS Statistics 26.0 and Mplus 8.0. First, participants with missing data (one or more missing data points) and inattentive participants (one or more incorrect responses to attention checks) were excluded from all analyses.

In the following analyses, we used structural equation modeling (SEM) – a confirmatory approach of model validation that allows simultaneous analysis of the impact of multiple independent (latent) variables on multiple dependent (latent) variables, accounting for estimation and measurement error (Bryne, 2012; Seekatz et al., 2016). All items of the reported instruments were used as indicators of the respective latent variable in the SEM (except for trust in science), and a few pairs of items with similar content (within the same scale) were allowed correlated measurement errors (Meece et al., 1990; Seekatz et al., 2016).

First, confirmatory factor analysis (CFA) was used to test the proposed measurement models of the latent variables (i.e. to verify the 'fit' of the observed variables to each latent variable). Second, structural models were examined to assess the relationships between the latent variables. Model fit was assessed using the Chi-square goodness of fit test, Comparative Fit Index (CFI $\geq$ .90 recommended), Root Mean Square Error of Approximation (RMSEA $\leq$.08 recommended) and Standardized Root Mean Residual (SRMR $\leq$ .08 recommended; Kline, 2005), and the two models (M1 – the theoretical model, M2 – the adapted model) were compared using Akaike's Information Criterion (AIC) and Bayes Information Criterion (BIC). Standardized estimates for path coefficients, interpreted as regression coefficients, were calculated for all proposed relationships in the final model, as well as the relevant indirect effects to test the mediation hypotheses. Since some variables were ordinal and not normally distributed, we used the robust maximum likelihood estimator (MLR) throughout the analyses (Bryne, 2012).

Results

Preliminary analysis

After small adjustments (i.e. deletion of some items related to trust in science and allowing correlated measurement errors based on modification indices), confirmatory factor analyses showed acceptable to good model fit for all latent variables (political conservatism, religious orthodoxy, conspiracy ideation, intellectual curiosity, trust in science, COVID-19 risk and COVID-19 adherence; CFI ≥ .94, RMSEA ≤ .060, SRMR ≤ .052). This allowed us to work with latent variables and calculate correlations between them (Table 1). As shown in the table below, trust in science is significantly correlated with all of the other variables. Specifically, it is positively correlated with education and intellectual curiosity and negatively correlated with political conservatism, religious orthodoxy and conspiracy ideation. Similar patterns can be seen in the case of COVID-19 risk perception (which is positively correlated with trust in science), while correlation coefficients, related to compliance with COVID-19 prevention guidelines, generally show weaker relationships. Compliance is most strongly correlated with trust in science and COVID-19 risk perception.

Model testing

First, we tested the baseline model (Model 1) which contained all the variables presented in Table 1. The fit of this model is displayed in Table 2 below. Because of the low correlations between education level on one hand and trust in science, COVID-19 risk and COVID-19 adherence on the other hand (one correlation was not significant and the other two were only significant at the $p < .050$ level), as well as non-significant path coefficients between these variables, we also tested a more parsimonious model without education level (Model 2). This model exhibited a slightly better fit, as expressed by the AIC and BIC values.

The estimates of each structural relationship between the model variables are shown in Figure 2 below. As can be seen in the figure, political conservatism, religious orthodoxy, conspiracy ideation and intellectual curiosity are all significant predictors of trust in science.

Table 1. Descriptive statistics and correlations between variables.

	M	*SD*	1	2	3	4	5	6	7
1. Education level	4.08	0.95	-						
2. Political conservatism	2.57	1.25	−.14**	-					
3. Religious orthodoxy	1.80	0.92	−.03	.28***	-				
4. Conspiracy ideation	2.31	0.74	−.12**	.23***	.16***	-			
5. Intellectual curiosity	4.42	0.53	.13**	−.14**	−.07	−.09*	-		
6. Trust in science	4.12	0.51	.10*	−.41***	−.28***	−.46***	.24***	-	
7. COVID-19 risk	5.58	0.88	.09*	−.24***	−.10*	−.12**	.21***	.29***	-
8. COVID-19 compliance	3.60	0.33	.08	−.17***	−.10*	−.08	.14**	.26***	.38***

Notes. * $p < .050$, ** $p < .010$, *** $p < .001$.

Table 2. Fit indices for the two proposed structural models.

	χ^2	*df*	*p*-value	CFI	RMSEA	SRMR	AIC	BIC
Model 1	2563.64	1667	< .001***	.90	.032	.055	73 445.71	74 387.93
Model 2	2485.84	1611	< .001***	.91	.032	.055	73 442.06	74 371.48

Notes. * $p < .050$, ** $p < .010$, *** $p < .001$.

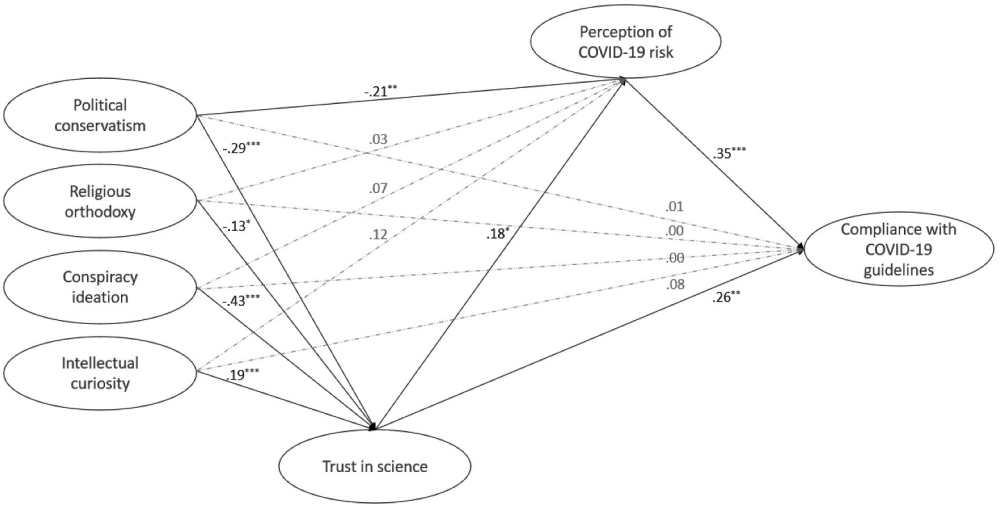

Figure 2. Structural equation model of Model 2.

Table 3. Estimation of indirect effects.

	Point estimate	*S.E.*	*p*-value
Political conservatism → Trust in science → Compliance	−.08	.03	.010*
Religious orthodoxy → Trust in science → Compliance	−.03	.02	.048*
Conspiracy ideation → Trust in science → Compliance	−.11	.04	.006**
Intellectual curiosity → Trust in science → Compliance	.05	.02	.008**

Notes. * $p < .050$, ** $p < .010$, *** $p < .001$.

Together, they explain 48.6% of the variance of this variable. Next, trust in science and political conservatism (but not religious orthodoxy, conspiracy ideation and intellectual curiosity) significantly predict COVID-19 risk perception ($R^2 = 0.128$). Finally, trust in science and COVID-19 risk perception (but not the other variables) contribute significantly and directly to explaining compliance with COVID-19 prevention guidelines ($R^2 = 0.265$).

Since we also wanted to investigate the mediating effect of trust in science in the relationship between political conservatism, religious orthodoxy, conspiracy ideation and intellectual curiosity as independent variables and compliance with COVID-19 prevention guidelines as the dependent variable, we also estimated indirect effects, which are presented in Table 3. The results suggest that all four variables exert an indirect effect on COVID-19 adherence via trust in science.

Discussion

The present study aimed to develop and test the theoretical model that could help us understand the differences in public compliance with COVID-19 prevention guidelines. The final model highlights at least two important findings. First, COVID-19 risk perception and trust in science (relatively independently) predict compliance with COVID-19 prevention guidelines; specifically, individuals who perceive COVID-19 as a serious threat and those who have greater trust in science and scientists are more likely to act in accordance with the proposed guidelines. Second, political conservatism, religious

orthodoxy, conspiracy ideation and intellectual curiosity do not directly affect compliance with COVID-19 prevention guidelines but do so indirectly through trust in science. To further elaborate on this finding – individuals who are higher on political conservatism, religious orthodoxy and conspiracy ideation trust science to a lesser degree, which in turn leads to a lower level of compliance with the preventive measures. The opposite is true in the case of intellectual curiosity; participants high on intellectual curiosity trust science more, which in turn leads to a higher level of compliance with COVID-19 prevention guidelines.

Although our results are highly consistent with the proposed theoretical model, it is worth noting that one variable, education level, had to be excluded from the theoretical model, as it did not significantly affect trust in science or any of the COVID-19-related variables. Moreover, even on a correlational level, education showed only weak associations with trust in science, perceived risk and compliance with COVID-19 prevention guidelines. This finding is rather surprising, but not unprecedented, since some previous studies have also found no relationship between education level and trust in science (e.g. Wilgus & Travis, 2019) and between education and disease-preventive behavior (e.g. Velan et al., 2011). It is also worth noting that this finding may be due to the somewhat limited variability of education in the present sample, as, for example, only 2.5% of the participants indicated '*primary education or less*' and '*lower secondary education*' as their highest level of education.

Limitations

The present study has some limitations, which are briefly outlined in the following paragraph. One of these limitations is that only self-report measures were used in the study, which could be problematic as some of the measured variables are very prone to socially desirable responding. However, it is worth noting that honest answers were encouraged by making the study completely anonymous. Some attention also needs to be paid to the shortcomings of the sample; since we used convenience sampling and promoted the study on social media websites such as Reddit (see Shatz, 2017 for a review of recruiting participants this way), it is possible that our sample is somewhat biased towards having higher trust in science (participants voluntarily chose to participate in an academic study). Finally, we acknowledge the fact that compliance with COVID-19 prevention guidelines is not as context-free as treated in the present study, but may be influenced by various variables outside the scope of this research article (e.g. having to go to work, participants' occupation, government policies and laws).

Implications

In conclusion, we have developed and tested a model that explains a significant proportion of the variance in compliance with COVID-19 prevention guidelines. Since the model outlines the critical role of trust in science as a predictor of compliance and as a mediator between more general sociopsychological characteristics and compliance with prevention guidelines, it is important to take steps towards improving the level of public trust in science and scientists. As this is not an easy endeavor, several actions are needed,

such as rapidly responding to real-life issues, actively participating in public discussions (by providing facts in a way that is easily understood by the public), informing the public about the key aspects of the scientific process, and promoting ethical and transparent research practices within the scientific community.

Disclosure statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Appendix A. COVID-19 risk perception scale

Please indicate your (dis)agreement with the following COVID-19-related items.

Appendix B. Compliance with COVID-19 prevention guidelines scale

To what extent do you act in accordance with the following COVID-19 prevention guidelines?

	Strongly disagree	Disagree	Somewhat disagree	Neither agree, nor disagree	Somewhat agree	Agree	Strongly agree
1. I feel vulnerable to COVID-19 infection.	1	2	3	4	5	6	7
2. I believe there is a chance that my family members get infected with COVID-19.	1	2	3	4	5	6	7
3. It is extremely unlikely that I will get infected with COVID-19.	1	2	3	4	5	6	7
4. Picturing self getting COVID-19 is something I find very hard to do.	1	2	3	4	5	6	7
5. I believe that COVID-19 poses a serious threat.	1	2	3	4	5	6	7
6. I worry about getting infected with COVID-19.	1	2	3	4	5	6	7

	Not at all	Very little	Somewhat	To a great extent
1. Regularly and thoroughly cleaning your hands with an alcohol-based hand rub.	1	2	3	4
2. Avoiding touching your eyes, nose and mouth with unwashed hands.	1	2	3	4
3. Covering your mouth and nose with your bent elbow or tissue when you cough or sneeze.	1	2	3	4
4. Frequently washing your hands with soap and water for at least 20 seconds.	1	2	3	4
5. Avoiding meetings, events and other social gatherings in areas with ongoing community transmission.	1	2	3	4
6. Practicing social distancing by doing your grocery shopping at off-peak hours and/or less often.	1	2	3	4
7. Maintaining at least 1 metre (3 feet) distance between yourself and others.	1	2	3	4
8. Practicing social distancing by avoiding crowds in confined and poorly ventilated spaces.	1	2	3	4
9. Avoiding contact with sick people.	1	2	3	4
10. Regularly cleaning and disinfecting frequently touched surfaces.	1	2	3	4
11. Staying home if you are sick, or, hypothetically staying home if you were sick (except to get medical care).	1	2	3	4