A Pandemic Risk Perception Scale

Kelmar Mendes Vieira, Ani Caroline Grignon Potrich, Aureliano Angel Bressan, Leander Luiz Klein, Breno Augusto Diniz Pereira, and Nelson Guilherme Machado Pinto

We propose a Pandemic Risk Perception Scale. Our scale comprises two constructs, Dread Risk and Personal Exposure, divided into five dimensions: Infection Risk, Emotional Health Risk, Health System Risk, Financial Risk, and Alimentary Risk. Using multidimensional item response theory, confirmatory factor analysis, and structural equation modeling on two samples of respondents, our results show that Alimentary Risk, Health System Risk, and Emotional Health Risk are the main dimensions of risk perception for the COVID-19 pandemic. Furthermore, Infection Risk has a minor impact on the pandemic’s risk perception, suggesting the presence of different dynamics between personal and general risk perceptions for the COVID-19 pandemic.

KEY WORDS: COVID-19; Health crisis; pandemic events; risk perception

1. INTRODUCTION

The COVID-19 pandemic has brought major changes to several fields. Health and economic concerns have gained prominence, with consequences for how humanity deals with everyday issues. This extreme event and the reactions that people experience are important aspects that demand a greater understanding of how the perceived risks of a pandemic event can be measured. In addition, the aftermath of a pandemic such as COVID-19 can provide important insights into the psychology of risk and the best course of action that policymakers and technical experts can develop to deal with the perception of the general public (Slovic & Weber, 2002).

The literature on risk perception presents several pieces of evidence that this perception is influenced by an association of affect-driven processes, reason-based processes (Loewenstein, Weber, Hsee, & Welch, 2001; Slovic, 1987), and some specific components, such as unnatural risk (Sjöberg, 2000), an experiential component (Ferrer, Klein, Persoskie, Avishai-Yitshak, & Sheeran, 2016), and the hazard probability and its consequences (Wilson, Zwickle, & Walpole, 2018). However, COVID-19 brings a novel feature to risk perception since it is a worldwide event capable of changing the behavior toward and relationship with risk in previously unimagined ways.

In this study, we propose an instrument to measure pandemic risk perception, based on five dimensions, that applies to pandemic health crisis, such as the one posed by COVID-19. Our proposal is related to the psychometric paradigm of

1Department of Administrative Science, Federal University of Santa Maria, Santa Maria, Brazil (E-mail: breno.percira@ufsm.br.)
2Department of Business Administration Science, Federal University of Santa Catarina, Florianópolis, Brazil (E-mail: ani.potrich@ufsc.br.)
3Management Sciences Department, Federal University of Minas Gerais, Belo Horizonte, Brazil (E-mail: bressan@face.ufmg.br.)
4Academic Coordination - Engineering courses, Federal University of Santa Maria, Brazil (E-mail: leander.klein@ufsm.br.)
5Department of Administration, Federal University of Santa Maria, Brazil (E-mail: nelson.pinto@ufsm.br.)

Address correspondence to Kelmar Mendes Vieira, Department of Administrative Sciences, Federal University of Santa Maria, avenue Roraima, 1000, 4212 Santa Maria, Brazil, Zip Code 97105-900; kelmar@terra.com.br
Slovic, Fischhoff, and Lichtenstein (1986) and the multidimensional approach to risk perception (Kasperson et al., 1988) in the sense that it relates the assessment of risk perception to the psychological, sociological, and economic perspectives of risk perception.

The motivation for our proposal is the idea that a specific socioeconomic risk perception instrument for pandemic crisis events can help policymakers to identify the perception of the risks faced by laypeople. To this intent, we propose a scale that comprises specific risk related to the following dimensions: Infection Risk, Emotional Health Risk, Health System Risk, Financial Risk, and Alimentary Risk.

Our main finding is that in the case of the COVID-19 pandemic’s risk perception is associated basically with the Alimentary Risk, Health System Risk, and Emotional Health Risk dimensions. This result can be viewed as a reflection of the socioeconomic conditions of the respondents, as suggested by Bronfman, Cifuentes, and Gutiérrez (2008), but it also sheds light on the consequences that this health crisis produces for the general public’s perception. The other two dimensions, financial risk and infection risk showed minor impacts that may be related to the different dynamics of personal and general risk, as proposed by Sjöberg (2003).

Our proposal is innovative in the sense that no other scales of pandemic risk perception have been found in the literature that also propose a socioeconomic approach of risk perception for pandemic events. Scales of fear (Ahorsu et al., 2020), vulnerability to disease (Duncan, Schaller, & Park, 2009), emotional distress (Zimmermann, Chong, Vechiu, & Papa, 2020) and health risk perception (Rimal et al., 2009), despite having points in common with our proposal, are developed with two major differences. First, the majority of the other disease risk perception scales focus on psychological issues (Ahorsu et al., 2020), vulnerability to disease (Duncan et al., 2009, Leppin & Aro, 2009) as well as health related cognitive perception (Freimuth, & Hovick 2012, Rimal et al., 2009, Timmermans, Ockhuysen-Vermeey, & Henneman, 2008). Ahorsu et al. (2020), for instance, developed and validated in Iran a scale assessing the fear of coronavirus—the Fear of COVID-19 Scale (FCV-19S)—composed of seven items to assess and deal with the psychological issues emanating from COVID-19. The FCV-19S scale is related with depression, anxiety, perceived infectability, and germ aversion and has been adopted in other countries, such as Israel (Bitan et al., 2020) the United Kingdom, and Bangladesh (Harper, Satchell, Fido, & Latzman, 2020, Sakib et al., 2020).

Second, there is no evidence in the literature of a risk perception scale for pandemic events that focus on socioeconomic dimensions using the psychometric paradigm of Slovic et al. (1986), and thus that enable the evaluation of how the subjective judgments that people make about the socioeconomic risks of a pandemic event are perceived. In addition, scales of perception of health risk and disasters, despite having points in common with our proposal, are developed and appropriate for contexts with some important differences. Disasters, such as plane crashes, collapsing dams, tsunamis, are rapid events, with immediate impacts and located in a specific city or region. While the pandemic is a long-lasting and wide-ranging event, “an epidemic occurring worldwide, or over a very wide area, crossing international boundaries and usually affecting a large number of people” (Doshi, 2011).

Although the pandemic can be included in the category of health risks, it has a different characteristic from many other health risks, which is the form of contagion. Important health risks, such as obesity, heart attacks, and other comorbidities, have individual behaviors and/or genetic characteristics as a source of risk. While the pandemic is a health phenomenon that, in addition to these sources, includes collective behavior, that is, the risk of the event is also associated with the behavior of other individuals, who can contribute to the containment or spread of the disease. Therefore, such differences justify the creation of a specific scale for the pandemic context.

2. LITERATURE REVIEW

2.1. Risk Perception

Risk perception is a construct characterized by a lack of consensus on its definition and measurement as pointed out by Leppin and Aro (2009) and Freimuth and Hovick (2012). Thus, the concepts of risk perception are more pragmatic than theoretically based, with a high degree of heterogeneity in conceptualizing risk perception. It also interacts with psychological, social, institutional, and cultural aspects, which can amplify or attenuate the social responses to a health crisis. Kasperson et al. (1988) define the social amplification of risk as the second and major stage of risk perception, which can be applied in this case. Thus, individual and group values can
determine which risks are deemed to be important and the nature of the signals that this event portends. These signals can show that the risk is associated with other risks that are not directly observed and that can be related to affect-driven processes as well as reason-based processes (Loewenstein et al., 2001). In this sense, Holtgrave and Weber (1993) show that a hybrid model of risk perception that incorporates affective and reason-based variables provides the best fit for risk perceptions in situations with highly uncertain outcomes in the financial and health domains.

Our article is also related to the recent empirical evidence on how traumatic experiences alter risk perception. The mixed results in the literature regarding how risk perception can be measured, and its effects also provide evidence that empirical studies can still bring important tests and insights to the construction of theoretical models of risk perception in extreme events. Schildberg-Hörisch (2018), for instance, highlights the importance of understanding how systematic changes in risk preferences can complicate policy advice and welfare analysis. The author also stresses the need for empirical research that generates instruments that can contribute to predicting risk perception, validated in the context under consideration, since the decision environment and the extreme events that may occur within it affect individual decisions.

In the same manner, Wilson et al. (2018) propose a multidimensional measure of risk perception across multiple hazards. Their results support the idea that risk perception is largely a function of individual reactions in the affective domain, that risk perception is multidimensional, and that there is no standard measure of risk perception that can be applied across hazards and disciplines.

The abovementioned studies highlight the fact that risk perception is a multidimensional construct, which still demands research to identify its dimensions in specific risk domains. As argued by Yates and Stone (1992), risk is inherently a subjective construct and represents the interaction between the event and the risk taker. Thus, the three essential risk elements—losses, the significance of these losses, and the uncertainty associated with these losses—are imprecise and subjective. As a consequence, it is not entirely clear how the various dimensions of risk can be aggregated to identify risk perception.

Despite the fact that the majority of the scales are based in health behavior or the emotional (Loewenstein et al., 2001) and cognitive (Rimal & Real, 2003) dimensions, our paper proposes that these cognitive and emotional dimensions affect risk perceptions through five major dimensions in independent ways: Infection Risk, Emotional Health Risk, Health System Risk, Financial Risk, and Alimentary Risk.

2.2. Pandemic Risk Perception Framework

Weber (2001) describes three paradigms that define risk perception. The first, based on the axiomatic measurement paradigm, focuses on how people combine the consequences of risky choice options and the probability of their occurrence. The second is the psychometric paradigm, which treats risk perception as a multidimensional construct and uses factor analysis to identify the underlying psychological dimensions, as proposed by Slovic et al. (1986). The third paradigm comprises the sociocultural theory of Douglas and Wildavsky (1983) in which risk perception is viewed as a collective phenomenon whereby each culture focuses on some risks and neglects others.

Our scale is based on the psychometric paradigm (Slovic et al., 1986) and also treats socioeconomic risk perception as the subjective judgment that people make about the socioeconomic risks of a specific event. In our study, we focus on a pandemic event following the definition of Doshi (2011) and Porta (2014). The Pandemic Risk Perception Scale is then a multidimensional scale composed of two constructs and five dimensions. The first construct, Dread Risk, is defined as the perceived lack of control or catastrophic potential of the hazard. It comprises the dimensions of Financial Risk and Alimentary Risk in our instrument. Personal Finance Risk may be understood as the risk that individuals’ finances will suffer a financial downturn due to the pandemic. This dimension is justified by the fact that pandemics have the potential to cause enormous financial impacts. The World Health Organization’s estimates indicate that the COVID-19 will directly affects sectors that represent up to one-third of GDP (Gross Domestic Product) in the main economies and that the unemployment rates will be much higher than at the peak of the 2008 global financial crisis (OECD, 2020). Therefore, issues such as reduced income, the inability to honor commitments and unemployment are possible financial risks in pandemic situations.

Alimentary Risk represents the risk that there will be a shortage of food for the population of the country. Pandemic events that demand the implementation of nonpharmaceutical security practices undermines food security both directly, by
disrupting food systems, and indirectly, through the impacts of lockdowns on household incomes and physical access to food (Devereux, Béné, & Hoddinott, 2020) The primary risks to food security are, at the country level related to possible disruptions in domestic food supply chains, supply shocks affecting food production, and loss of income which create food security risks issues in many countries (World Bank, 2020).

The second construct is Personal Exposure, which expresses the new, unknown, or unobservable harmful impacts that the hazard exerts (Bronfman et al., 2008; Slovic et al., 1986). The second construct of our instrument comprises the dimensions of Infection Risk, Emotional Health Risk, and Health System Risk.

Infection Risk is the risk of being infected by the pandemic disease. Considering that pandemics has characteristics of transmission between people with different levels of risk according to several variables, a more comprehensive view of infection risk is used in our study, which includes infection and worsening of the individual’s health condition, and the infection risk of others in their social life, such as children, relatives, and friends.

Emotional Health Risk refers to the risk of developing emotional diseases due to the pandemic event. The COVID-19, for instance, has triggered a wide variety of emotional problems, such as anxiety and depression and have varying degrees of stress disorders (Cao et al., 2020; Qiu et al., 2020, Wang et al., 2020). These findings are similar to those reported during the 2002 SARS pandemic (Cheng, Wong, Tsang, & Wong, 2004) and in the 2009 H1N1 pandemic (Wheaton, Abramowitz, Berman, Fabricant, & Olatunji, 2012).

Health System Risk is defined as the risk that the health system will collapse due to the pandemic event. Since the beginning of the pandemic in several countries around the world the National Healthcare Services were near a collapse. There are several variables that put the system at risk, such as the possibility of lack of beds and equipment, the shortage of medication and the lack of sufficient health personnel to meet all the demand arising from the pandemic.

We then hypothesize that the five dimensions interact to define the perception of pandemic risk perception, as depicted in Fig. 1. Following Holtgrave and Weber’s (1993) recommendation, to achieve the best fit of risk perception in situations with uncertain outcomes, such as the pandemic.

Our measurement study is also based on the social amplification of risk theory of Kaspersion et al. (1988) and Renn, Burns, Kaspersion, Kaspersion, and Slovic (1992) since it tries to link the measurement of risk perception to items that intend to capture the psychological, social, institutional, and cultural processes that may amplify or attenuate the responses to the pandemic risk event. Table I presents the items developed for each dimension of the model.

Therefore, the theoretical model of the Pandemic Risk Perception Scale is built upon two second order constructs, Dread Risk and Personal Exposure. The Dread Risk construct is formed by two first order constructs (Financial Risk and Alimentary Risk) whereas the Personal Exposure construct by the Infection Risk, Emotional Health Risk, and Health System Risk first order constructs. A set of 22 items form the scale measurement model.

3. MEASUREMENT STUDY

3.1. Data and Empirical Strategy

The Pandemic Risk Perception Scale development process started with a literature review on the perception of risk, which allowed the definition of the scale and its constructs and the construction of the initial set of items. The literature review was followed by a qualitative approach to validate and refine the definitions and items. In this qualitative stage, two studies were conducted. Subsequently, a quantitative step was taken, which involved two more studies. The first, of an exploratory nature, aimed to validate the set of items and the five dimensions proposed. The second, with a broader and more diversified sample, sought to validate the structural model of the scale. Table II summarizes the scale development process.

All the studies were conducted in Portuguese as it is the native language of Brazilians, and they were later translated into English by professional translators whose native language is English.

The exploratory factor analysis was performed using the Factor program version 10.10.01 (Ferrando & Lorenzo-Seva, 2017). A polychoric correlation matrix was used with the robust diagonally weighted
Theoretical model and dimensions. Source: Elaborated by the authors.

![Diagram](image)

least squares factor extraction method (RDWLS; Asparouhov & Muthen, 2010) and promin robust rotation (Lorenzo-Seva & Ferrando, 2019). The estimation of the number of factors was made using the parallel analysis of eigenvalues (Horn, 1965). To increase the accuracy of the method, the 95% confidence interval for random eigenvalues was considered (Crawford et al., 2010). Internal consistency was assessed by calculating McDonald's omega (ω; McDonald, 1999), for which values equal to or greater than 0.7 were considered to be adequate (Hair, Black, Babin, & Anderson, 2014).

The quality of the items was also assessed using the multidimensional item response theory (MIRT) model. Specifically, the difficulty and discrimination of the items were investigated, and the discrimination...
Table I. Dimensions of the Pandemic Risk Perception Scale

| Dimension              | Item | Code | Item Alternatives                  |
|------------------------|------|------|------------------------------------|
| Infection Risk         | Item 1 | You catch COVID-19. | 1-Not at all likely |
|                        | Item 2 | You die due to COVID-19. | 2-Unlikely |
|                        | Item 3 | Your spouse catches COVID-19. | 3-Likely |
|                        | Item 4 | Your children catch COVID-19. | 4-Very likely |
|                        | Item 5 | Your parents catch COVID-19. | 5-Totally likely |
|                        | Item 6 | Your general health condition worsens due to the COVID-19 pandemic. | 6-Not applicable |
| Emotional Health Risk  | Item 7 | You feel depressed due to the COVID-19 pandemic. |
|                        | Item 8 | You feel stressed due to the COVID-19 pandemic. |
|                        | Item 9 | You feel distressed due to the COVID-19 pandemic. |
| Health System Risk     | Item 10 | The health system does not have enough beds to care for all those infected who need hospitalization. |
|                        | Item 11 | The drugs are insufficient for patients with COVID-19. |
|                        | Item 12 | The health system may run out of COVID-19 tests. |
|                        | Item 13 | The health system may run out of respirators for some COVID-19 patients who need them. |
| Financial Risk         | Item 14 | You lose your job. |
|                        | Item 15 | You have to borrow money from the bank. |
|                        | Item 16 | The company that you work for will go bankrupt. |
|                        | Item 17 | Your financial situation worsens dramatically. |
|                        | Item 18 | You receive financial aid from the government. |
| Alimentary Risk        | Item 19 | People buy more food than they really need. |
|                        | Item 20 | There will be a lack of food in supermarkets for several days. |
|                        | Item 21 | There may be an increase in the price of food. |
|                        | Item 22 | There will be an increase in the percentage of people with nothing to eat. |

Note: In case of another pandemic, replace COVID-19 with another one.
Source: The authors.

Table II. Stages and Steps of the Scale Construction Process

| Stage        | Step | Goal                                                                 |
|--------------|------|----------------------------------------------------------------------|
| Qualitative  | Step 1: Five experts from different areas of knowledge evaluated the instrument. | The instrument was assessed for the dimension represented by the item: The degree of relevance and the adequacy of the formulation. |
|              | Step 2: Five individuals with different socioeconomic and demographic profiles. | Pretest. Semantic analysis to assess the understanding of the scale by all levels of the target population. |
| Quantitative | Step 3: 1,000 individuals residing in the state of Rio Grande do Sul, with different socioeconomic profiles. | Validation of items and dimensions through the application of exploratory factor analysis. |
|              | Step 4: 3,516 individuals, from all regions of Brazil and with different socioeconomic profiles. | Validation of the model through the application of confirmatory factor analysis. |

Source: Elaborated by the authors.

values were considered to be adequate when they were greater than 0.65 (at least moderate), in accordance with the criterion of Baker (2001). The analysis was performed using a generalization of the Samejima model for polytomous items (Samejima, 1969) using the Metropolis–Hastings Robbins–Monro extracion algorithm (MHRM; Cai, 2010) and quasi-Monte Carlo integration (Chalmers, 2012). For the MIRT models, the R program and the mirt package version 1.30 (Chalmers, 2012) were used.

For the data analysis of the fourth validation step, we used confirmatory factor analysis (CFA) and
structural equation modeling (SEM). First, CFA was performed to validate the constructs through the verification of the convergent validity, discriminant validity and unidimensionality.

After the validation of the constructs, the theoretical model was built and evaluated employing SEM. The statistical significance of the estimated regression coefficients was verified to assess the hypothesized theoretical structure and the model’s adjustment statistics (Kline, 2015). These statistics were the same as those already used to validate the measurement model. In order to check alternative specifications, we developed two alternative models: alternative model 1, named 2nd Order Model, in order to find other indicators of the impact of the five dimensions directly on Pandemic Risk Perception, and alternative model 2, named Correlation Model, in which the five dimensions are correlated with each other.

Finally, a comparison was made between the nonnested models or competing models (those that differ in structure and not just in individual paths). For this, we use information criteria, such as AIC–Akaike’s Informational Criteria and ECVI–Expected Cross-validation Index, with the lowest AIC and ECVI values signaling the best adjusted model (Byrne, 2016, Hu & Bentler, 1999, Kline, 2015).

### 3.2. Empirical Results

From the theoretical background, the qualitative assessment step of the scale began. In step 1, five specialists were invited to participate, all of whom are researchers with experience in behavioral studies, two have experience in risk perception, and one has experience in health. Each specialist received the instrument and an instruction document in which evaluations were requested regarding the dimension represented, the degree of relevance of the item, the adequacy of the formulation of each item, and the adequacy of the scale (1-not at all likely, 2-unlikely, 3-likely, 4-very likely, 5-totally likely, and 6-not applicable). At this stage, three of the five experts indicated that the statement “you die due to COVID-19” (Item 2) should not be part of any of the five dimensions provided. Small adjustments were also made to improve the text. Thus, at the end of study 1, it was decided to exclude question 2 from the scale. In step 2, a pretest was carried out with five individuals, three women and two men, aged between 20 and 50 years and with different levels of education and income. At this stage, there was no need to make any semantic changes to the items.

To start the quantitative stage, the instrument was built on an online platform. In step 3, participants were contacted through social networks and e-mail. The survey was available for a period of five days at the beginning of April 2020. A thousand valid responses were obtained. All the respondents live in the Brazilian state of Rio Grande do Sul. The majority (66%) are female, married (59%), have children (57%), and have an average age of 40 years.

In the first phase of the quantitative step, aiming to validate the dimensionality of the scale and the refinement of the items, exploratory factor analysis was applied. The Bartlett test (statistic = 3,196.9, df = 210, sig. < 0.001) and the Kaiser-Meyer-Olkin test (0.825) indicated the factorability of the data. Table III shows the results of the eigenvalue estimates.

Horn’s parallel analysis indicates that five dimensions should be extracted from the scale, which corroborates the initial theoretical model. The
dimensions together explain 67.09% of the data variance. Table IV shows the composition of the dimensions.

The five dimensions derived from the factor analysis coincide with the dimensions provided in the theoretical model. All the factor loads are greater than 0.40, and no cross-loads were identified, indicating that all the items on the scale must be maintained. All the McDonald’s omegas are greater than 0.70, demonstrating the internal consistency of the dimensions. Therefore, the results of step 3 initially confirm the existence of the five proposed dimensions and their respective items. For an extra assessment of the role of the items in the scale, the multidimensional item response theory (MIRT) was applied. Table V shows the estimated parameters.

The \( M^2/df = 2.05, CFI = 0.963, TLI = 0.953, \) and RMSEA = 0.058 statistics lead us to infer to an adequate adjustment of the model. In Table V, the discrimination values, all of which are high and above 1, present a desirable pattern for \( \alpha \), and the \( \beta \) estimates, in general, are ordered, with smaller categories requiring a lower theta to endorse the content of the items.

Subsequently, for the evaluation of the proposed model of the scale, step 4 was carried out, which consisted of the online application of the scale. To perform this step, we sent invitations via social networks and e-mail to the target population of this study in the last ten days of April 2020. We obtained 3,516 valid responses considering the different socioeconomic profiles existing in the country. The final sample consisted of 68.2% women and 31.8% men, married (56.4%) and single (33%). Most of the respondents have children (55.2%) and have an average age of 38 years, with a minimum age of 18 years and a maximum age of 90 years. As for the practices of social isolation due to the pandemic, most respondents (57.1%) said they were fully following the guidelines, 33.2% are partially following, 8.5% are not following, as they work on essential services and only 1.1% of Brazilians said not following social isolation guidelines.

After determining the profile of the respondents, we sought to develop the validation of the Pandemic Risk Perception Scale by validating the constructs found in the previous steps through confirmatory factor analysis. It should be noted that item 2 was excluded in the qualitative stage, so just twenty-one...
items followed this stage. Thus, following the proposed strategies of this study, the measurement models of the five proposed dimensions were adjusted (Table VI).

The proposed models of each dimension that form the Pandemic Risk Perception Scale shown in Table VI refer to the model that includes all the items of the scale found in the exploratory factor analysis stage. The results indicate that all the proposed models are inadequate because the chi-square/degrees of freedom value is higher than the recommended maximum limit (five) and some adjustment indexes do not reach the minimum values. Thus, in the search for more suitable models, two main measures were adopted: (i) the removal of an item with a standardized factor load close to 0.3 (Hair et al., 2014) of the Infection Risk dimension (Item 6) and (ii) the insertion of correlations among the errors of the variables, which were suggested by the software and which made theoretical sense.

After these changes, all the final models showed adequate adjustment since there was: (i) convergent validity, given that the GFI, CFI, NFI, and TLI statistics were higher than 0.95 and the RMSR and RMSEA statistics were lower than 0.06; and ii) unidimensionality, given that the values of all the standardized residuals were lower than 2.58. Furthermore, the chi-square was no longer significant at the 5% level, confirming the adjustments of the estimated and observed matrices.

In addition, to assess the appropriateness of the items to the constructs, the correlation of each item with each of the constructs was assessed (Table VII).

It may be observed that for all items the correlation is greater within the construct (in bold—Table VII), indicating that the items were properly allocated to the constructs. Finally, to assess discriminant validity, correlations between the constructs and the square root of the Average Extracted Variance (AVE) were estimated and analyzed (Table VIII).
Table VII. Correlation Coefficients of Items with Constructs

| Dimensions / Item | Infection Risk | Emotional Health Risk | Health System Risk | Financial Risk | Alimentary Risk |
|-------------------|----------------|-----------------------|--------------------|----------------|-----------------|
| Item 1            | 0.791          | 0.133                 | 0.130              | 0.099          | 0.154           |
| Item 3            | 0.869          | 0.146                 | 0.143              | 0.109          | 0.169           |
| Item 4            | 0.648          | 0.109                 | 0.107              | 0.081          | 0.126           |
| Item 5            | 0.611          | 0.102                 | 0.101              | 0.077          | 0.119           |
| Item 7            | 0.148          | 0.885                 | 0.270              | 0.206          | 0.319           |
| Item 8            | 0.145          | 0.862                 | 0.263              | 0.201          | 0.311           |
| Item 9            | 0.142          | 0.845                 | 0.258              | 0.197          | 0.305           |
| Item 10           | 0.137          | 0.255                 | 0.834              | 0.191          | 0.295           |
| Item 11           | 0.135          | 0.251                 | 0.820              | 0.188          | 0.290           |
| Item 12           | 0.121          | 0.225                 | 0.736              | 0.168          | 0.260           |
| Item 13           | 0.149          | 0.278                 | 0.909              | 0.208          | 0.321           |
| Item 14           | 0.066          | 0.122                 | 0.120              | 0.525          | 0.174           |
| Item 15           | 0.100          | 0.186                 | 0.182              | 0.796          | 0.264           |
| Item 16           | 0.065          | 0.120                 | 0.118              | 0.516          | 0.171           |
| Item 17           | 0.103          | 0.191                 | 0.188              | 0.819          | 0.272           |
| Item 18           | 0.047          | 0.088                 | 0.086              | 0.376          | 0.125           |
| Item 19           | 0.126          | 0.233                 | 0.229              | 0.214          | 0.646           |
| Item 20           | 0.121          | 0.224                 | 0.220              | 0.206          | 0.621           |
| Item 21           | 0.109          | 0.202                 | 0.198              | 0.185          | 0.559           |
| Item 22           | 0.143          | 0.266                 | 0.261              | 0.245          | 0.739           |

Source: Research results (2020).

Table VIII. Discriminant Validity for the Dimensions of Infection Risk, Emotional Health Risk, Health System Risk, Financial Risk, and Alimentary Risk

| Constructs            | Discriminant Validity |
|-----------------------|-----------------------|
|                       | IR        | ER        | HR        | FR        | AR        |
| Infection Risk (IR)   | 0.732     |           |           |           |           |
| Emotional Health Risk (ER) | 0.168     | 0.867     |           |           |           |
| Health System Risk (HR) | 0.164     | 0.305     | 0.828     |           |           |
| Financial Risk (FR)   | 0.126     | 0.233     | 0.229     | 0.679     |           |
| Alimentary Risk (AR)  | 0.194     | 0.361     | 0.354     | 0.332     | 0.559     |

Note: Off-diagonal elements are the correlations among constructs. Diagonal elements (italic) are the square root of the variance shared between the constructs and their measures (AVE).

Two constructs are considered distinct when the square root of the AVE is lower than the correlation between the two constructs (Fornell & Larcker, 1981) and the correlations among the constructs are lower than 0.85 indicating the Discriminant Validity. Therefore, the results of the correlations and the discriminant validity give support to the decision to maintain the measurement model.

By analyzing the final dimensions, it can be seen that only the dimension Infection Risk had one of the initially established items excluded. The excluded item deals with worsening general health status due to COVID-19. The items that have the greatest impact on this dimension are those claiming that the respondent himself or his partner will be infected.

Three items compose the measurement model for Emotional Health Risk. All of them have similar impacts when dealing with feelings of depression, stress, or distress due to COVID-19. The model for Health System Risk is formed by four proposed items. The greatest impact on this risk concerns the lack of respirators for all patients who need them.

It is noted that five items are part of the final model for the Financial Risk dimension. In this dimension, two items have the greatest impact: the fact that the financial situation worsens dramatically and the need to borrow money. Finally, our results demonstrate that four items compose the Alimentary Risk dimension. Here, the greatest impact is exercised by the item that measures the situation of the increasing percentage of the population that will starve.

Thus, after validating the five dimensions and the items that make up the Pandemic Risk Perception Scale, we developed the integrated models that join the measurement models and the structural model. The theoretical model has five dimensions that seek to reflect the risk that is assessed by the instrument, suggesting that they reflect the unobserved constructs Personal Exposure and Dread Risk. In addition to this main model (Theoretical Model), we have developed two alternative models to test the robustness of our proposal. Alternative model 1 (2nd Order Model), in order to find other indicators of the impact of the dimensions directly on Pandemic Risk Perception, and alternative model 2 (Correlation Model), with the five dimensions correlated with each other. The evaluation of the integrated models was carried out based on the adjustment statistics and the statistical significance of the estimated regression coefficients (Table IX).

The values of the correlations between the constructs in Table VIII are lower than the square root of the AVE (italic), and the correlations among the constructs are lower than 0.85 indicating the Discriminant Validity. Therefore, the results of the correlations and the discriminant validity give support to the decision to maintain the measurement model.

Two constructs are considered distinct when the square root of the AVE is lower than the correlation between the two constructs (Fornell & Larcker, 1981) and the correlations among the constructs are lower than 0.85 (Kline, 2015).
### Table IX. Adjustment Statistics for the Integrated Models

| Statistic                        | Appropriate Adjustment levels | Theoretical Model: Main Model | 2nd Order Model: Alternative Model 1 | Correlation Model: Alternative Model 2 |
|----------------------------------|-------------------------------|--------------------------------|-------------------------------------|---------------------------------------|
| Chi-square (value)               | -                             | 1,140.509                      | 1,209.055                           | 950.264                               |
| Chi-square (probability)         | > 0.050                       | 0.000                          | 0.000                               | 0.000                                 |
| Degrees of freedom               | -                             | 160                            | 163                                 | 157                                   |
| Chi-square/Degrees of freedom    | < 5.000                       | 7.128                          | 7.418                               | 6.053                                 |
| GFI—Goodness of Fit              | > 0.950                       | 0.967                          | 0.965                               | 0.972                                 |
| CFI—Comparative Fit Index        | > 0.950                       | 0.966                          | 0.964                               | 0.973                                 |
| NFI—Normed Fit Index             | > 0.950                       | 0.961                          | 0.959                               | 0.967                                 |
| TLI—Tucker Lewis Index           | > 0.950                       | 0.960                          | 0.958                               | 0.967                                 |
| RMR—Root Mean Square Residual    | < 0.080                       | 0.043                          | 0.050                               | 0.032                                 |
| RMSEA—R. M. S. Error of Approximation | < 0.060 | 0.042                          | 0.043                               | 0.038                                 |
| AIC—Akaikes Information Criterion | Smaller         | 1,520.795                      | 1,303.055                           | 1,056.264                             |
| ECVI—Expected Cross-Validation Index | Smaller         | 0.433                          | 0.371                               | 0.301                                 |

Note: 1. Appropriate levels for the Adjustment Statistics based on Hooper et al. (2008) and Hu and Bentler (1999).

Source: Estimation results (2020).

square/degrees of freedom value were higher than the recommended maximum limit (five). As a result, we adopted the strategy of including correlations between the variable errors that made theoretical sense. The final models presented adequate adjustment.

In addition, after validating and adjusting the theoretical model and the two alternative models, we identified which of the three models best explains Pandemic Risk Perception in our sample. For this, the AIC (Akaikes Informational Criteria) and ECVI (Expected Cross-Validation Index) criteria were used.

Our theoretical model presented the best adjustment and therefore pandemic risk perception evaluation can be based on two second-order constructs (Dread Risk and Personal Exposure), as suggested by the prior literature on risk perception. For this, the AIC (Akaikes Informational Criteria) and ECVI (Expected Cross-Validation Index) criteria were used.

Our theoretical model presented the best adjustment and therefore pandemic risk perception evaluation can be based on two second-order constructs (Dread Risk and Personal Exposure), as suggested by the prior literature on risk perception. For this, the AIC (Akaikes Informational Criteria) and ECVI (Expected Cross-Validation Index) criteria were used.

4. DISCUSSION

The analysis of the final model for measuring Pandemic Risk Perception showed that both Personal Exposure (coefficient 0.990) and Dread Risk (coefficient 0.912) have a high impact on Pandemic Risk Perception, the first risk being slightly higher. When analyzing the dimensions that compose these risks, we found that Emotional Health Risk is the one that most affects Personal Exposure, followed by Health System Risk, and the smallest impact comes from Infection Risk. These results indicate that the risk of not receiving support from the health care system and the risk of suffering emotional health damage both have a significant impact on the perception of risk that individuals experience when they face a pandemic. These dimensions confirm that the Personal Exposure construct is relevant to Pandemic Risk Perception, extending the results of Bronfman et al. (2008).

In addition, we found that Alimentary Risk has a greater impact on Dread Risk than Financial Risk. Based on this, we infer that Pandemic Risk Perception is associated with Alimentary Risk, reflecting individuals’ fear of not being able to supply the basic need to feed themselves during a pandemic. Therefore, risk perceptions are influenced mainly by affect-driven processes rather than reason-based processes since this dimension reflects the Dread Risk construct (Loewenstein et al., 2001).
Fig 2. Final model of Pandemic Risk Perception with standardized relationship coefficients and significance. Note: *p < 0.01; the z-value was not calculated when the parameter was set as 1, due to the model’s requirements. For simplicity, correlations between errors are not represented.

We identified the total effects that each dimension has on Pandemic Risk Perception and found that the greatest impact concerns Alimentary Risk (total effect 0.652), followed by Emotional Health Risk (0.553) and Health System Risk (0.542). The dimensions with smaller impacts on Pandemic Risk Perception are those related to financial risk, with a total effect of 0.422, and the risk of infection, which has the smallest impact on Pandemic Risk Perception, with a coefficient of only 0.298. This result may be indirect empirical evidence supporting the hypothesis proposed by Sjöberg (2003). He argues that personal risks are perceived to be smaller than the general risks of a specific hazard.

Finally, after verifying the results of the Pandemic Risk Perception model and for greater robustness to the research results, Fig. 3 presents the alternative model 1 (2nd Order Model) and alternative model 2 (Correlation Model), with standardized coefficients and the significance of the relationships.

The analysis of the alternative models shows that the associations between the five dimensions of Pandemic Risk Perception are significant at 1%, but with a low association between them, with
negligible correlation (values lower than 0.3) and low positive correlation (values between 0.3 and 0.5), according to the classification suggested by Mukaka (2012). Specifically, the strongest associations are related to Alimentary Risk, the highest being between this dimension and Health System Risk (0.485), followed by the correlation with Financial Risk (0.428) and Emotional Health Risk (0.370). The lowest associations were found in the dimension that relates Infection Risk to the other dimensions.

We also found that Pandemic Risk Perception in a pandemic event is mainly associated with Alimentary Risk, denoting the fear of individuals during a pandemic, of not being able to supply the basic need for food. This finding can be corroborated with the results found in the alternative second order model, which presents the Alimentary Risk dimension as having the greatest direct impact on Pandemic Risk Perception (coefficient 0.733).

In addition to Alimentary Risk, the dimensions that have high impacts on Pandemic Risk Perception are Health System Risk (coefficient 0.538), followed by Emotional Health Risk (coefficient 0.503), denoting that the risk of not being able to be met by the health system, should it need to, or even the risk of
their emotional health, have a significant impact on the perception of risk that individuals point out when going through a pandemic.

Finally, the dimensions with the lowest associations, as well as the smallest impacts on Pandemic Risk Perception, are those related to financial risk and risk of infection. Highlighting the risk of infection, which had the least impact on Pandemic Risk Perception, with a coefficient of only 0.279.

5. CONCLUSIONS

The main objective of this study was to build a novel Pandemic Risk Perception Scale. In order to validate the model and due to the absence of related Pandemic Risk Perception scales, a strategy of testing alternative models was chosen, which demonstrated the prevalence of the proposed theoretical model.

Our scale indicate that, in a pandemic event, individuals consider that there is less risk of a worsening financial situation or even of being infected than of having emotional problems resulting from quarantine measures or problems with the health system or with the supply of food. These results highlight the importance of unexpected consequences experienced due to the pandemic. Many government officials are only concerned with isolating individuals from being infected, but they cannot neglect to meet some of the basic needs of the population, such as alimentary and emotional health issues.

Thus, the individual perception of risk enhanced by COVID-19 can affect the general level of risk perception in society, with impacts on macroeconomic and public health issues. Specifically, the stress, fear, and cognitive overload of an extreme event like this induce higher levels of risk aversion, which have important implications for the design of basic income programs and public health policies. In addition, we find evidence that the risk perception of pandemic events encompasses both general and domain-specific components, as suggested by Frey, Pedroni, Mata, Rieskamp, and Hertwig (2017).

The qualitative and quantitative analysis allow us to infer the validity of our Pandemic Risk Perception Scale is valid. Researchers, public officials, health system managers, and other interested parties can use it to identify the perception of Pandemic Risk Perception as long as the construction of the instrument and the application meet the psychometric recommendations for the application of instruments.

Our proposal of a Pandemic Risk Perception Scale can be a useful assessment tool, as pandemic risk perception influences citizens' predisposition to adopt non-pharmaceutical security practices. In a pandemic, such as COVID-19, where a vaccine isn't currently available, the use of non-pharmaceutical security measures, such as social distancing, and such measures tend to be more effective in populations with a high perception of pandemic risk. Thus, the scale can become a useful tool both to identify the perception of a pandemic’s risk and as a predictor of the acceptance and adoption of nonpharmaceutical security measures.

It is also noteworthy that the use of Pandemic Risk Perception Scale is a broader measure of risk perception in a pandemic scenario than the use of simpler instruments or even just one question (for instance, a question such as how likely are you to be infected?) As demonstrated in our proposal, there are other risks involved in a pandemic that cannot be ignored, such as financial and food risks, that must be considering when evaluating risk perception.

In short, in a pandemic situation, individuals consider it less risky to worsen their financial situation or be infected, than to have emotional problems, in the health system or in relation to food. This fact opens an important discussion when analyzing an atypical situation experienced due to the pandemic, in which many government officials are only concerned with isolating individuals from being infected, but they cannot forget to meet the basic needs of the population, such as alimentary and mental health policies.

The items of our scale were adapted based on a review of the literature in order to ensure that the factors were associated with threats related to pandemic events. However, we recognize the limitation that is associated with this strategy, in the sense that other behavioral risk or protective factors exist that have not been examined in our instrument, an issue that can be analyzed in further studies. It also demands cross-cultural validation. Future research can either deal with these issues or focus on assessing the scale for different demographic and socioeconomic profiles.

ACKNOWLEDGMENT

The authors thank the National Council for Scientific and Technological Development (CNPq) for the financial support (grant number 303731/2018-4).
REFERENCES

Ahorsu, D. K., Lin, C., Imani, V., Saffari, M., Griffiths, M. D., & Pakpour, A. H. (2020). The fear of COVID-19 Scale: development and initial validation. International Journal of Mental Health and Addiction, 1–9. https://doi.org/10.1007/s11469-020-00270-8

Asparouhov, T., & Muthen, B. (2010). Simple second order chi-square correction. Unpublished manuscript. Retrieved from https://www.statmodel.com/download/WLSMV_new_chi21.pdf

Baker, F. (2001). The basics of item response theory. College Park, MD: ERIC Clearinghouse on Assessment and Evaluation, University of Maryland.

Bitan, D. T., Grossman-Giron, A., Bloch, Y., Mayer, Y., Shiffman, N., & Mendlovic, S. (2020). Fear of COVID-19 scale: Psychometric characteristics, reliability and validity in the Israeli population. Psychiatry Research, 289, 113100

Bronfman, N. C., Cifuentes, L. A., & Gutiérrez, V. V. (2008). Participant-focused analysis: Explanatory power of the classic psychometric paradigm in risk perception. Journal of Risk Research, 11(6), 735–753.

Byrne, B. M. (2016). Structural equation modeling with AMOS: Basic concepts, applications, and programming (3rd ed.). New York: Routledge.

Cai, L. (2010). Metropolis–Hastings Robbins–Monro algorithm for confirmatory item factor analysis. Journal of Educational and Behavioral Statistics, 35(3), 307–335.

Cao, W., Fang, Z., Hou, G., Han, M., Xu, X., Dong, J., & Zheng, J. (2020). The psychological impact of the COVID-19 epidemic on college students in China. Psychiatry Research, 287, 112934.

Chalmers, R. P. (2012). mirt: A multidimensional item response theory package for the R environment. Journal of Statistical Software, 48(1), 1–29.

Cheng, S. K., Wong, C. W., Tsang, J., & Wong, K. C. (2004). Psychological distress and negative appraisals in survivors of severe acute respiratory syndrome (SARS). Psychological Medicine, 34(7), 1187.

Crawford, A. V., Green, B. S., Levy, R., Lo, W., Scott, L., Svetina, D., & Thompson, M. S. (2010). Evaluation of parallel analysis methods for determining the number of factors. Educational and Psychological Measurement, 70(6), 885–901.

Deveveux, S., Béne, C., & Hoddinott, J. (2020). Conceptualising COVID-19’s impacts on household food security. Food Security, 12(4), 769–772.

Doshi, P. (2011). The elusive definition of pandemic influenza. Bulletin of the World Health Organization, 89, 532–538.

Douglas, M., & Wildavsky, A. (1983). Risk and culture: An essay on the selection of technological and environmental dangers. Berkeley, CA: University of California Press.

Duncan, L. A., Schaller, M., & Park, J. H. (2009). Perceived vulnerability to disease: Development and validation of a 15-item self-report instrument. Personality and Individual Differences, 47(6), 541–546.

Ferrando, P. J., & Lorenzo-Seva, U. (2017). Program FACTOR at 10: Origins, development and future directions. Psicothema, 29(2), 236–241.

Ferrer, R. A., Klein, W. M., Persoskie, A., Avishai-Yishak, A., & Sheeran, P. (2016). The tripartite model of risk perception (TRIRISK): Distinguishing deliberative, affective, and experiential components of perceived risk. Annals of Behavioral Medicine, 50(3), 653–663.

Fornell Claeys, L. & Rafter, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. Journal of Marketing Research, 18, (1), 39 http://doi.org/10.2307/3151312.

Freimuth, V. S., & Hovick, S. R. (2012). Cognitive and emotional health risk perceptions among people living in poverty. Journal of Health Communication, 17(3), 303–318.

Frey, R., Pedroni, A., Mata, R., Rieskamp, J., & Hertwig, R. (2017). Risk preference shares the psychometric structure of major psychological traits. Science Advances, 3(10), e1701381.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). Multivariate data analysis (new int. ed.) Harlow, UK: Pearson Education.

Harper, C. A., Satchell, L., Fido, D., & Lattman, R. (2020). Functional fear predicts public health compliance in the COVID-19 pandemic. International Journal of Mental Health and Addiction, 1–14. https://doi.org/10.1007/s11469-020-00281-5

Hooper, D., Coughlan, J., & Mullen, M. R. (2008). Structural equation modelling: Guidelines for determining model fit. Electronic Journal of Business Research Methods, 6(1), 53–60.

Holm, D. R., & Weber, E. U. (1993). Dimensions of risk perception for financial and health risks. Risk Analysis, 13(5), 553–558.

Horn, J. L. (1965). A rationale and technique for estimating the number of factors in factor analysis. Psychometrika, 30(1), 179–185.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Structural equation modeling: A Multidisciplinary Journal, 6(1), 1–55.

Kasprowicz, R. A., Renn, O., Slovic, P., Brown, H. S., Emel, J., Goble, R., … Ratick, S. (1988). The social amplification of risk: A conceptual framework. Risk Analysis, 8(2), 177–187.

Kline, R. B. (2015). Principles and practice of structural equation modeling (4th ed.). New York: The Guilford Press.

Leonard, A., & Aro, A. R. (2009). Risk perceptions related to SARS and avian influenza: Theoretical foundations of current empirical research. International Journal of Behavioral Medicine, 16(1), 7–29.

Loewenstein, G. F., Weber, E. U., Hsee, C. K., & Welch, N. (2001). Risk as feelings. Psychological Bulletin, 127, 267–286.

Lorenzo-Seva, U., & Ferrando, P. J. (2019). Robust promax: A method for diagonally weighted factor rotation. Technical report. Tarragona, Spain: URV.

McDonald, R. P. (1999). Test theory: A unified treatment. Mahwah, NJ: Lawrence Erlbaum.

Mukaka, M. M. (2012). Statistics Corner: A guide to appropriate use of correlation coefficient in medical research. Malawi Medical Journal, 24(3), 69–71.

OECD (2020). OECD employment outlook 2020: Worker security and the COVID-19 crisis. Paris, France: OECD Publishing. https://doi.org/10.1787/1686ec758-en

Porta, M. (2014). A dictionary of epidemiology. Oxfords, UK: Oxford university press.

Qiu, J., Shen, B., Zhao, M., Wang, Z., Xie, B., & Xu, Y. (2020). A nationwide survey of psychological distress among Chinese people in the COVID-19 epidemic: Implications and policy recommendations. General Psychiatry, 33(2), e100213.

Renn, O., Burns, W. J., Kasprowicz, J. X., Kasprowicz, R. E., & Slovic, P. (1992). The social amplification of risk: Theoretical foundations and empirical applications. Journal of Social Issues, 48(4), 137–160.

Rimal, R. N., Brown, J., Mkandawire, G., Folda, L., Bose, K., & Creel, A. H. (2009). Audience segmentation as a social-marketing tool in health promotion: Use of the risk perception attitude framework in HIV prevention in Malawi. American Journal of Public Health, 99, 2224–2229.

Sakib, N., Bhuiyan, A. I., Hossain, S., Al Mamun, F., Hosen, I., Abdullah, A. H., … Mamun, M. A. (2020). Psychometric validation of the Bangla Fear of COVID-19 Scale: Confirmatory fac-
tor analysis and Rasch analysis. *International Journal of Mental Health and Addiction*, 1–12. https://doi.org/10.1007/s11469-020-00289-x

Samejima, F. (1969). Estimation of latent ability using a response pattern of graded scores. *Psychometrika*, 34(S1), 1–97.

Schildberg-Hörisch, H. (2018). Are risk preferences stable? *Journal of Economic Perspectives*, 32(2), 135–154.

Sjöberg, L. (2000). Factors in risk perception. *Risk Analysis*, 20(1), 1–12.

Sjöberg, L. (2003). The different dynamics of personal and general risk. *Risk Management*, 5(3), 19–34.

Slovic, P. (1987). Perception of risk. *Science*, 236(4799), 280–285.

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1986). The psychometric study of risk perception. In V. T. Covello, J. Menkes, & J. Mumpower (Eds.), *Risk evaluation and management* (pp. 3–24). New York: Plenum Press.

Timmermans, D. R., Ockhuysen-Vermey, C. F., & Henneman, L. (2008). Presenting health risk information in different formats: The effect on participants’ cognitive and emotional evaluation and decisions. *Patient Education and Counseling*, 73(3), 443–447.

Wang, C., Pan, R., Wan, X., Tan, Y., Xu, L., Ho, C. S., & Ho, R. C. (2020). Immediate psychological responses and associated factors during the initial stage of the 2019 coronavirus disease (COVID-19) epidemic among the general population in China. *International Journal of Environmental Research and Public Health*, 17(5), 1729.

Wheaton, M. G., Abramowitz, J. S., Berman, N. C., Fabricant, L. E., & Olatunji, B. O. (2012). Psychological predictors of anxiety in response to the H1N1 (swine flu) pandemic. *Cognitive Therapy and Research*, 36(3), 210–218.

Weber, E. U. (2001). Risk: Empirical studies on decision and choice. In N. J. Smelser & P. B. Bates (Eds.), *International encyclopedia of the social and behavioral sciences* (Vol. 13, pp. 347–313,351). Oxford, UK: Elsevier Science Ltd.

Wilson, R. S., Zwicky, A., & Walpole, H. (2018). Developing a broadly applicable measure of risk perception. *Risk Analysis*, 38(4), 777–791.

World Bank (2020). *Food security and COVID-19*. Retrieved from https://www.worldbank.org/en/topic/agriculture/brief/food-security-and-covid-19

Yates, J. F., & Stone, E. R. (1992). The risk construct. In J. F. Yates (Ed.), *Risk-taking behavior* (pp. 1–25). Chichester, England: Wiley.

Zimmermann, M., Chong, A. K., Vechiu, C., & Papa, A. (2020). Psychometric properties of a measure to assess beliefs about modifiable behavior and emotional distress. *Mental Health & Prevention*, 19, 200188.