Risk perception of COVID-19: A comparative analysis of China and South Korea

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ABSTRACT

The novel coronavirus (COVID-19) has become a pandemic and the risk perception plays an important role in self-protection and spread prevention. This study attempts to explore the intrinsic characteristic of risk perception and the spatial distribution of it, which have not been involved in previous studies. To attach this purpose, data from questionnaire conducted in China and Korea (samples of 897 respondents in China and 340 respondents in South Korea) are used to produce risk perception of COVID- 19. Results reveal four principal findings: (1) risk perception of COVID-19 can be categorized into perceived social risk and perceived risk of being infected; (2) the internal differences are most pronounced in perceived risk of being infected about oneself in China, and in perceived social risk disorder about local community in South Korea; (3) the spatial distribution of risk perception is not consistent with that of epidemic severity, for high-risk perception spread out beyond the epicenter with different performance in the two categories; and (4) among the influence factors, trust in information, familiarity with epidemic situation, and interpersonal distance from suffers in the epicenter are found to have a significant influence on different aspects of risk perception. The theoretical and practical implications of this study enrich the understanding of risk perception of epidemic, and provide specific suggestions for preventing this ongoing epidemic spread across the population.

1. Introduction

The outbreak of the new coronavirus (COVID-19), which has now escalated to a pandemic, was first confirmed in Wuhan city, China. New cases and deaths continued to rise worldwide since December 2019, reaching approximately 100 million confirmed cases and 2.4 million deaths a year later, in December 2020 [1], while cases and deaths continue to rise, despite the massive effort undertaken by WHO and countries. The consensus on prevention is that wearing a mask, physical distancing, and avoiding crowds are crucial to protect people from COVID-19, because public agency and engagement with self-protection from the virus play an important role in deterring the spread of the disease across the population [2,3]. Researches in different countries and cases provide evidences that behavioral patterns can change so that individuals can avoid infection from emerging diseases (N. M. [4–7], and that those behavioral responses to the risk of infection are related to

the individuals' risk perception [8–10]. A recent survey indicates that unreasonable fear may occur if risk perception is unrealistically high, thus leading to social unrest and pressure on healthcare [11]. However, individuals tend not to adopt protective measures if their risk perception is low [12], which is not conductive to avoid cross-infection, especially when real risks are underestimated. Therefore, an analysis of risk perception can provide insight into perspectives of psychological and social science for policymakers, which is conducive to risk management of the ongoing pandemic in terms of mental and physical health.

To date, research on risk perceptions of the pandemic include the Severe Acute Respiratory Syndrome [13,14] and the Middle East Respiratory Syndrome [15], which belong to the same kind of coronavirus. However, as COVID-19 is a new disease, there is no similar experience that can be used as a reference. In addition to infection and death, the pandemic poses severe challenges to the economy, daily life, and social order, with highly contagious and fatal consequences. Whereas research

on risk perception focuses on perceived death and infection risks, very few researchers have examined the perception of socio-economic risks [16]. Relevant theoretical and empirical studies on COVID-19 suggest that risk perception has a significant impact on individual preventive behaviors [17,18], adherence to precautionary guidelines [19], mental and emotional health [20], and the effectiveness of preventive measures, such as lockdowns and quarantine [21]. It is essential to understand the public risk perception of COVID-19, its manifold dimensions and contributing factors. By targeting recommendations and management only to those with unreasonable risk perception, pandemic can be contained more effectively without unnecessary misallocation of resources. In this paper we identify the characteristics and contributing factors of risk perception of COVID-19 by means of a comparative analysis between China and South Korea, to determine similarities and differences in specific aspects of risk perception. Furthermore, we investigate factors that affect individuals' risk perception of COVID-19.

The main contributions of our work are summarized as follows. First, the results of our research shed light on the formation of risk perception of this ongoing pandemic and the ensuing crisis, thus contributing to the discussion over effective prevention of the disease's spread. Second, contrary to previous research, we investigate the spatial distribution characteristics of risk perception and our work can serve as a guideline for psychotherapists and policymakers to identify susceptible and vulnerable areas. Finally, this is an international comparison of risk perceptions of COVID-19. Concerns over COVID-19 affect individuals globally in numerous ways and extents. Comparison between countries is essential to provide insight into pandemic prevention and control around the world, so that policymakers both in the United Nations and individual countries can better understand mass psychology when deciding to implement measures, such as quarantine.

The paper is structured as follows. Section 2 contains a literature review on risk perception and its contributing factors. Section 3 presents our methodology, including questionnaire design, entropy weight, and data collection. Section 4 describes the results of our analysis, the characteristics of the spatial distribution of risk perception in China and South Korea, the specific representations of risk perception in different contents, and the contributing factors to risk perception. Finally, Section 5 discusses the results and their implications.

2. Literature review

2.1. Risk perception

Risk perception refers to an individual's subjective identification of risk that one may face [22], determined by uncertainty and fear [23]. Risk perceptions of the pandemic differ significantly due to a wide range of perceptions of life, death, severity and uncertainty [24]. A nation-wide survey in the U.S.A. reveals that differences in perceived risk of infection are more significant than considerations of perceived fatality at the initial stage of the COVID-19 pandemic [25]. Regarding uncertainty, healthcare professionals are deemed more familiarized with COVID-19 both in terms of experience and knowledge, and their perception of risk infection is higher than that of the general population [11]. The situation is different than in the case of Ebola, for which healthcare professionals express lower levels of risk perception [26]. A survey among COVID-19 patients in Wuhan, China, during the early stage of the outbreak finds that individuals aged 20 to 44 and older age groups show significantly different risks. Compared with the older respondents, perceived risk of infection among younger patients is lower, but the perceived risk of death is higher [27]. Moreover, political views affect risk perceptions of the pandemic, as some groups show more confidence in leaders' ability to handle COVID-19 [28].

2.2. Factors that affect risk perception

Identifying the factors that influence risk perception is essential to

our understanding of risk structure and formation [29]. Risk perception of the pandemic depends on several factors, such as the level of trust in authorities [15,28,30], sources of information, professional knowledge [27], and sociodemographic characteristics [31,32]. Governments and WHO dominate the prevention against COVID-19 at a global scale and high levels of popular satisfaction with governments can relieve individuals' risk perception [33]. Government guidelines are the most important factor in shaping individuals' intention to indulge to preventive measures, especially when people regard such guidelines as positive and motivational [12]. The formation of risk perception of uncertain risk is related to information [34], because people tend to search for information when they face an unknown and uncertain calamity [32] and the public can only rely on mass media, their own knowledge and experience. Public trust in the accuracy of pandemic-related information can influence risk perception [35]. Trust in local governments has a greater influence on risk perception than that of the central government, because people believe that the former can be more receptive towards local communities, their perceptions and sensitivities [36].

As for sociodemographic characteristics, it has been convincingly argued that differences in professional knowledge, gender, age, education, and income related to different risk perceptions. Professional knowledge influences the way people assess risk. The general public largely depends on personal experience to evaluate risk, while experts tend to rely on professional traits and evaluate the situation by employing analytical skills [37]. Empirical studies show that risk assessment models can shape individuals' risk perception, and that perceived health risks differ between experts and the general populace [38]. Risk perception over health risks hazard in females is higher than that of males [39,40], partly because of different social roles [41] and exposure to environmental disruption [42]. Elderly people are more likely to have high levels of risk perception, especially for health risks [43] and death [44]. Research on environmental risk has long found that education is positively related to perceptions of environmental risk [45], but no direct relationship between education and risk perception of the pandemic has been detected. Finally, research shows that income is a significant factor in individuals' risk perception of COVID-19, and that it is associated with the availability of healthcare resource.

Besides, the psychological typhoon eye effect reveals the relationship between risk perception and distance, including geographical distance from the epicenter, interpersonal relationship distance from the sufferer [46,47], and the involvement in threat of danger [48]. This effect is different from the ripple effect. Moreover, a survey about risk perception of COVID-19 indicates that both the psychological typhoon eye effect and ripple effect are at play, which dominated in different distance from Wuhan, China [49]. Accordingly, this paper explores the relationship between risk perception of COVID-19 and geographical distance, including the distance from residence to the epicenter and the interpersonal relationship distance from the sufferer in the epicenter.

3. Methodology

3.1. Questionnaire design

This paper investigates the contributing factors and the characteristics of individuals' risk perception of COVID-19. Preliminary dimensions and factors of risk perception are obtained by previous research on COVID-19 and other epidemics. And then, we conducted a questionnaire survey. The survey consists of three sections. The first captures demographic information of participants. The second comprises seven questions regarding risk perception, which is classified into social risk perception and infection risk perception. A five-point Likert scale is applied to measure the perceived extent of each question, from 'extremely high' (5) to 'extremely low' (1). Finally, the third section investigates the factors that affect risk perception. Drawing on previous literature, we propose the following categorization of contributing

factors: trust in information, familiarity with COVID-19, level of satisfaction with governments, sociodemographic characteristics of respondents, and distance (Table 1). The epicenter of COVID-19 in China is Wuhan and the epicenter in South Korea is Seoul, as indicated by the confirmed cases. Also, we investigate risk perception in areas around the epicenters in particular to detect the presence of the ripple effect and/or the psychological typhoon eye effect.

3.2. Data collection

The survey was conducted online during February 2020 in China and October 2020 in South Korea. Both countries enacted cost-effective measures quicker than other countries, especially in Europe, and were more severely affected than most other countries during the period of our survey. Therefore, it is representative for crisis management and pandemic control. We chose February to circulate the questionnaire in China, one month after the COVID-19 outbreak in Wuhan, precisely because at that time the disease was at its peak and risk perception was representative of the real situation. In South Korea the disease rebounded in October significantly and we chose this month because of the severity of the situation and individuals' risk perception is noteworthy. A total of 897 valid questionnaires have been received from China and 340 from South Korea; Table 2 illustrates demographic information of respondents.

3.3. Data analysis

3.3.1. Principal component analysis

Principal component analysis represents a transfer and projection of original data, which is conducted by SPSS version 25 in this paper to complete dimension reduction of risk perception. In the process of its transformation, every original data contributes different to principal components, and objects that have the largest variance can be maintained. Steps in this process are summarized as follows:

Consider there are n samples and every sample has m variables. The

Table 1
Influence factors of risk perception.

Category	Details	Symbol	Mean	
			China	South Korea
Information	Trust in TV news	T1	4.147	3.781
	Trust in government website	T2	4.285	3.872
	Trust in social software	T3	4.058	3.081
Familiarity	Familiarity with COVID-19	F1	3.934	3.687
	Familiarity with situation in epicenter	F2	3.619	3.981
	Familiarity with situation in local community	F3	3.896	–
Satisfaction with governments	Satisfaction with the government in epicenter	S1	2.324	3.028
	Satisfaction with the local government	S2	3.562	3.171
	Satisfaction with the central government	S3	3.765	3.412
Sociodemographic characteristics	Live in rural or urban area	Residence	–	–
	Education level	Education	–	–
	career	Career	–	–
Distance	Geographical distance from residence to epicenter	D1	4.491	4.507
	Interpersonal relationship distance from the sufferer in epicenter	D2	1.952	1.962

Table 2
Demographic information about respondents.

Characteristic	Type	Percentage (%)	
		China	South Korea
Gender	Male	54.80	50.70
	Female	45.20	49.30
Age	16–18	1.80	24.60
	18–36	50.50	25.60
	37–55	39.00	25.60
	55+	8.70	24.20
Education	With or below junior high school	2.90	14.70
	Senior high school and college	14.50	13.30
	Undergraduate	45.00	60.20
	Post-graduate	37.60	11.80
Residence	Urban	58.70	52.10
	Rural	14.30	47.90
Career	Medical worker	6.24	2.41
	Civil server	24.53	3.59
	Researcher	17.73	0.51
	Self-employed	5.57	10.09
	Others	45.93	83.40

assessment matrix X_{ij} is established in Eq. (1). In this paper, samples are respondents and variables are questions about risk perception in questionnaire, which are measured by five-point Likert scale.

$$X = \left(x_{ij}\right)_{n \times m}, \ i = (1, 2, ..., n), \ j = (1, 2, ..., m) \tag{1}$$

The correlation matrix $R = (r_{jk})_{m \times m}$ can be obtained by calculating the mean $\bar{x}_j$ and standard deviation S_j of factor j in matrix X:

$$y_{ij} = \frac{x_{ij} - \bar{x}_j}{S_j} \tag{2}$$

$$r_{jk} = \frac{1}{n-1} \sum_{i=1}^{n} \frac{\left(x_{ij} - \bar{x}\right)}{S_j} \frac{\left(x_{ik} - \bar{x}_k\right)}{S_k} \ (j = 1, 2, ..., m), \ k = (1, 2, ..., m) \tag{3}$$

The eigenvalue and eigenvector of matrix R can be determined by Eq. (4):

$$(R - \lambda_i I)l_i = 0 \tag{4}$$

where λi (i = 1, 2, ..., m) and l_i(i = 1, 2, ..., m) are the eigenvalues and eigenvectors of matrix R, respectively, l_i corresponds to the principal components, and λi corresponds to the variance obtained from each principal component. The effect of each eigenvalue is given by the contribution rate. A larger contribution rate indicates a larger eigenvalue. The largest eigenvalues represent the principal components regarding most of the variability in the observed data. The cumulative contribution rate α for a specific eigenvalue λk (i = 1, 2, ..., m) can be obtained by Eq. (5):

$$\alpha = \frac{\lambda_1 + \lambda_2 + ... + \lambda_k}{\lambda_1 + \lambda_2 + ... + \lambda_m} \times 100\% \tag{5}$$

If the value of α is equal to or more than 90%, k principal components are considered to contain sufficient information to represent the complex original data array. The matrix $(F_{ij})_{n \times k}$, composed of k principal components, can be expressed by Eq. (6):

$$F_{ij} = \sum_{i=1}^{m} y_{it} l_{tj} \ (i = 1, 2, ..., n), j = (1, 2, ..., k), t = (1, 2, ..., m) \tag{6}$$

In this matrix, the largest contribution rate is given by the first principal component, followed by the other components, which have gradually decreasing contribution rates.

3.3.2. Entropy weight

Entropy weight is applied to analyze the internal variation in risk perception, which is a measure of system disorderliness that originates

from thermodynamics. The smaller the entropy weight is, the larger the internal variance will be [50]. In this paper, we applied this method to see the variance of different aspects of risk perception.

For V_{ij} is the value of the j_{th} aspect of risk perception of the i_{th} respondent, and the score matrix of risk perception can be expressed as follows.

$$V_{ij} = \begin{pmatrix} v_{11} & \cdots & v_{1j} \\ \vdots & \ddots & \vdots \\ v_{i1} & \cdots & v_{ij} \end{pmatrix} j = (1, 2, ..., m) \; i = (1, 2, ..., n), \tag{7}$$

The eigenvalue and entropy weight are calculated using Eq. (8) and (9), Z_{ij} is the eigenvalue and e_j is the entropy weight.

$$z_{ij} = \frac{v_{ij}}{\sum\limits_{i=1}^{n} v_{ij}} \tag{8}$$

$$e_j = -\frac{1}{\ln n} \sum\limits_{i=1}^{n} z_{ij} \ln z_{ij} \tag{9}$$

3.3.3. ANOVA

Analysis of Variance (ANOVA) is conducted with SPSS to identify the critical factors that affect risk perception, which has been wildly applied in the field of research on risk perception [21,51]. The 5% and 1% level of significance are used for our test. Factors with the significance value (p-Value) of 5% are considered to have a significant impact, and factors with the value of 1% are considered to have an extremely significant impact.

4. Results

4.1. Preliminary analysis

The internal consistency of the questionnaire measured by Cronbach's alpha is 0.704 in the Chinese sample and 0.681 in the South Korean sample, thus indicating acceptable consistency that supports further analysis. Besides, dimension reduction analysis divides the seven questions on risk perception into two categories: perceived infection and perceived social risk (as shown in Table 3).

4.2. Characteristics of risk perception in China and South Korea

4.2.1. The internal variance of risk perception

The internal variance of risk perception measured by entropy weight is shown in Table 4 and the comparison of China and South Korea is presented in Fig. 1. The more the internal variance weight, the more significant impact it has on risk perception of COVID-19. Among Chinese respondents, the perceived infection risk about oneself (RP6) accounts for the largest number of internal variance (0.257), followed by the

Table 4
The internal variance of risk perception.

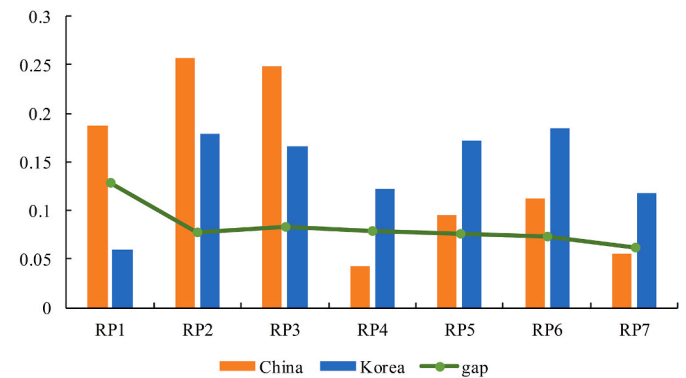| Risk perception		Internal variance		The gap
		China	South Korea	
Perceived social risk	RP1	0.1878	0.0596	0.13
	RP2	0.0433	0.1221	0.08
	RP3	0.0954	0.1717	0.08
	RP4	0.1118	0.1842	0.07
	RP5	0.0557	0.1178	0.06
Perceived risk of being infected	RP6	0.2570	0.1791	0.08
	RP7	0.2491	0.1656	0.08

Fig. 1. The comparative internal variance of risk perception in China and South Korea.

perceived infection of family members (RP7) (0.2491), indicating that perceived risk of infection is a significant aspect in general risk perception of COVID-19. The lowest variance of risk perception relates to the perceived risk of daily life (RP2) and of social disorder in Wuhan (RP5), which indicates that individuals shared similar perceptions of social risk in the epicenter during the period of the investigation.

Among South Korean respondents, the perceived risk of social disorder in the local community (RP4), of disruption in daily life in the local community (RP3), and of infection of oneself (RP6) are the three risk perceptions with the most significant impact on general risk perception (their respective internal variance weights are 0.1842, 0.1717, and 0.1791). Anxiety over the pandemic returned the lowest internal variance.

The internal difference in the perception of social risk in China is bigger than in South Korea, while one in risk perception of infection in South Korea is bigger than that in China. The gap of internal variance is miniscule except for the one in anxiety, and the variance of anxiety in China is much higher than in South Korea. The minimum gap exists in the perceived social disorder about epicenter, with the variance in South

Table 3
The rotated component matrix of risk perception.

	Category	Details	Symbol	Component 1	Component 2
China	Perceived social risk	Anxiety about the epidemic situation	RP1	0.562	
		Perceived risk of day-to-day life about Wuhan	RP2	0.744	
		Perceived risk of day-to-day life about local community	RP3	0.802	
		Perceived social disorder about local community	RP4	0.810	
		Perceived social disorder about Wuhan	RP5	0.792	
	Perceived risk of infection	Perceived infection about oneself	RP6		0.947
		Perceived infection about families	RP7		0.948
South Korea	Perceived social risk	Anxiety about the epidemic situation	RP1	0.538	
		Perceived risk of day-to-day life about Seoul	RP2	0.802	
		Perceived risk of day-to-day life about local community	RP3	0.782	
		Perceived social disorder about local community	RP4	0.771	
		Perceived social disorder about Seoul	RP5	0.781	
	Perceived risk of infection	Perceived infection about oneself	RP6		0.886
		Perceived infection about families	RP7		0.854

Korea being higher than in China. Besides, the internal variance relating to anxiety and perceived risk of infection in China are higher than in South Korea, indicating that differences in severity and risk perception of infection are more pronounced in China. The gap indicates that risk perception in China and South Korea differ in specific aspects, even though both countries fight against the same pandemic.

4.2.2. Spatial distribution of risk perception

We measure risk perception of COVID-19 by the weighted average of seven questions presented in the preliminary analysis, and use entropy weight to calculate the weight for every question. In China, the spatial distribution of risk perception is inconsistent with that of confirmed cases, and the distributions of perceived social risk and infection risk in specific provinces also differ (as shown in Fig. 2). During the time of our investigation the epicenter of COVID-19 was located in Hubei, which does not coincide with the epicenter of risk perception, as the general risk perception in the southern and eastern regions is higher than that in the northwest region. Regarding the two aspects of risk perception, both perceived social risk and infection risk are high in Jilin, Jiangsu, Shanghai, Zhejiang, Guangdong, Jiangxi, Shaanxi, Beijing, and Hubei; all these areas could benefit from more concentrated efforts to meet individual psychological requirements. Perceived social risk in Liaoning, Henan, Hunan, and Guizhou is higher than the perceived risk of being infected, thus indicating preventive measures should be focused more on mitigating social risk and management, such as working to maintain social stability.

In South Korea two epicenters for the severity and risk perception of COVID-19 clearly emerge (Fig. 3). The most confirmed cases were reported from Seoul and Gyeonggi-do, but risk perception peaked in

Gyeongsangbuk-do and Daejeon. A number of precautionary measures to control the spread of the pandemic and mitigate anxiety can be implemented in accordance to the specific characteristics to tackle high levels of risk perception. In Daejeon, the focus should be on mitigating unreasonable fear and anxiety, because the perceived social risk and risk of infection are high. As for Gyeongsangbuk-do, precautionary measures should focus on improving perceptions of risks on daily life and social order risks, because the perceived social risk is higher than the perceived risk of infection. Additionally, Gangwon-do should be monitored closely, because it reports the lowest numbers of confirmed cases, together with the lowest levels of general risk perception and perceived social risk, but high levels of perceived risk of infection.

4.3. Contributing factors in risk perception

4.3.1. China

Fig. 4 illustrates ANOVA results for risk perception, which indicate the contributing factors to risk perception in China. Level of satisfaction with local governments at the epicenter (S1) and with the central government (S3), trust in government websites (T2), and education level strongly correlate with the vast majority of risk perception of COVID-19. Regarding sociodemographic characteristics, place of residence has little impact on risk perception, whereas career can significantly influence the perception of risk of infection, either for oneself or their family. In terms of distance, geographical distance (D1) significantly affects perceived social risk in local communities, whereas interpersonal relationship distance (D2) is important for the perceived risk of being infected. Contributing factors affect different aspects of risk perception, thus indicating that the risk perception management should tailor measures
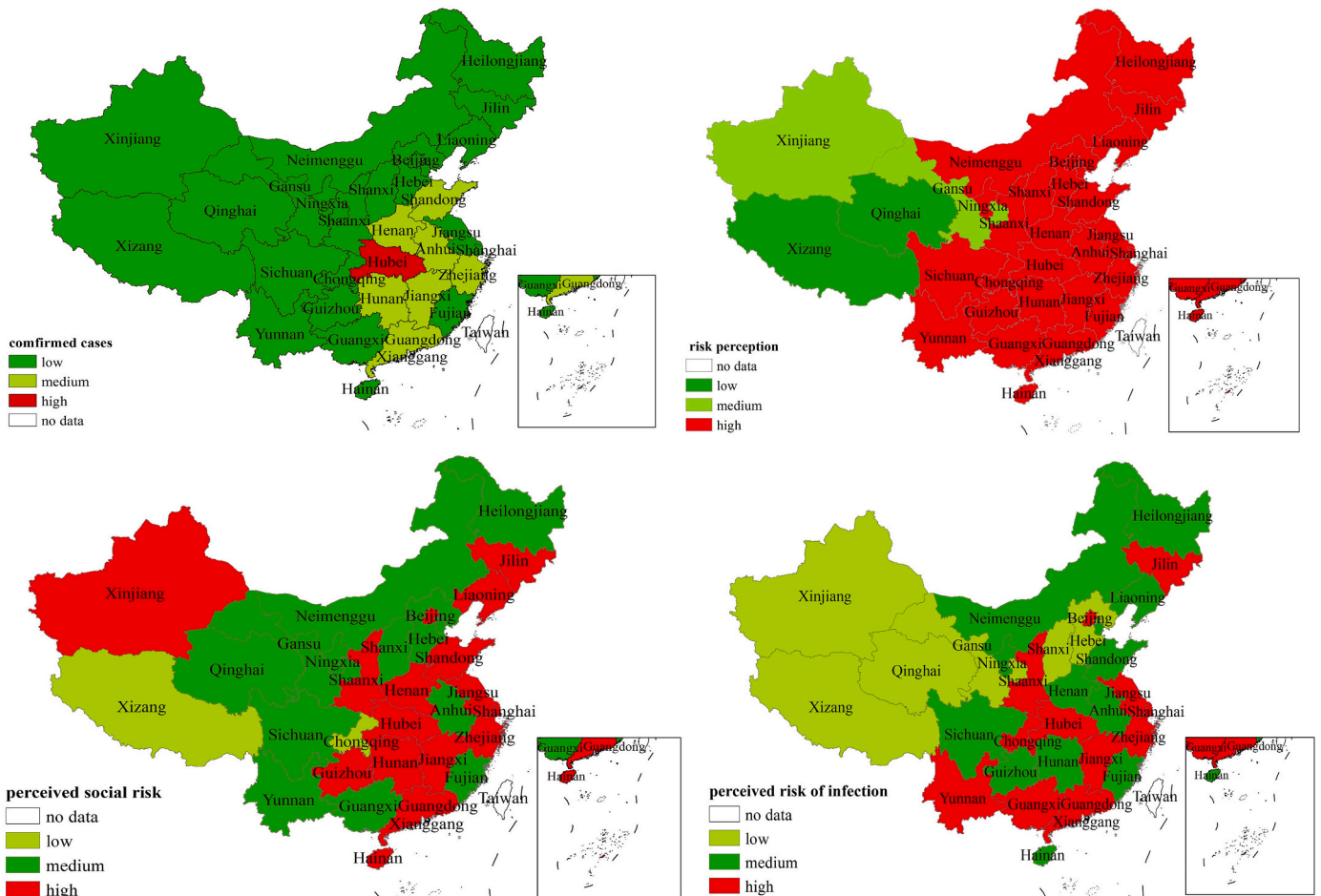

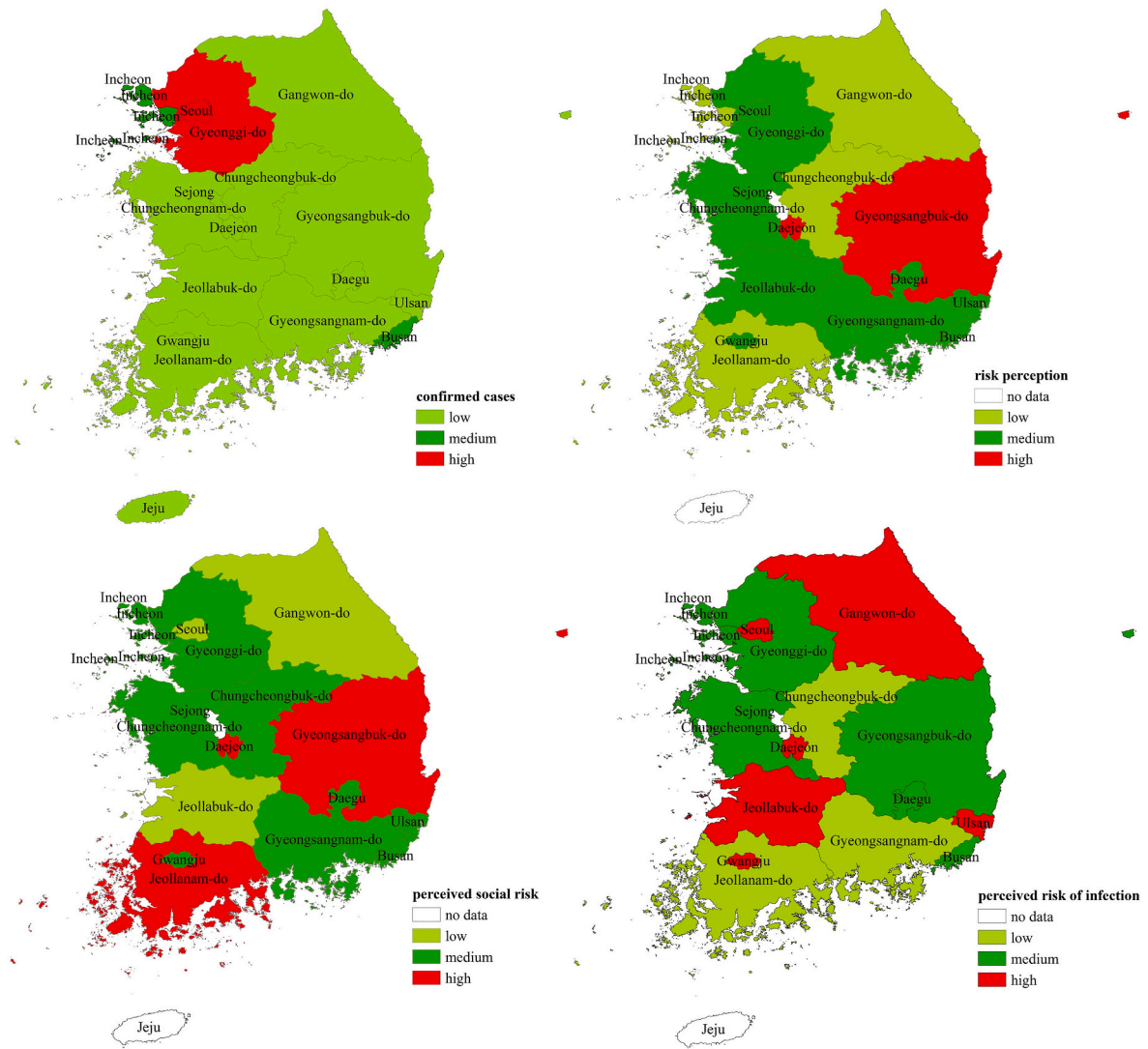**Fig. 2.** Characteristics of risk perception and its spatial distribution in China.

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Fig. 3. Characteristics of risk perception and its spatial distribution in South Korea.

Fig. 4. ANOVA results for risk perception in China.

onto the factors that are significantly associated with those specific risks.

Furthermore, we identify the prevalent concerns of risk perception. Anxiety over the situation (RP1), perceived risk of disruption of the daily life of the local community (RP3), and perceived risk of infection of family members (RP7) are the main concerns of risk perception. Anxiety is a typical reaction on the face of stress, as the severity and spread of a pandemic that has disrupted people's lives dramatically, especially of those who lived in quarantine for long periods of time, aggravate stress across the population. As for the risk perception of infection, people seem to care more about the safety of their families.

4.3.2. South Korea

In South Korea, familiarity with the situation in the local community (F2), familiarity with COVID-19 (F1), and levels of satisfaction with the local government (S2) strongly correlate with the vast majority of risk perception Fig. 5. Sociodemographic characteristics have little impact on risk perception, except for the place of residence. Interpersonal relationship distance (D2) is an important factor contributing to perceived risk of infection about oneself and their family. Geographical distance (D1) has little effect on risk perceptions, which indicates that both psychological typhoon eye effect and ripple effect do not appear/ are of lesser importance in South Korea.

The prevalent concerns of risk perception in South Korea are the perceived risk of disruption to daily life in the epicenter (RP2), anxiety over the situation (RP1), and the risk of comprising social order in the epicenter (RP5). Therefore, people appeared more concerned over social risk during this pandemic, especially in Daegu, at the time of our investigation. Therefore, anxiety over the pandemic is a common major concern in China and South Korea and both central governments should focus their efforts in avoiding the spread of unreasonable fear.

5. Discussion and conclusion

The two categories of risk perception of COVID-19, over social risk and infection, show different internal variance. Risk perceptions with high internal variance suggest significant differences, and the specific aspects require more attention. Therefore, authorities in China should focus their efforts and resources more on targeting risk perception of infection, whereas in South Korea the focus should revolve around the perceived social risk close to epicenters of the pandemic.

As for spatial distribution, the characteristics of risk perception are not the same as the severity of epidemic. In China, areas where risk perception is highly correlated with population distribution, as southern

and eastern provinces are densely populated. In South Korea, the spatial distribution of population coincides with that of confirmed cases, but differs from the distribution of high-risk perceptions. Seoul and Gyeonggi-do are the most densely populated areas and reported the most confirmed cases during our investigation, but show medium levels of risk perception. High-risk perception areas are Gyeongsangbuk-do and Daejeon, yet they both reported relatively low numbers of confirmed cases. The distribution of high-level risk perceptions is more extensive than that of confirmed cases both in China and South Korea, and the representation of it performs differently in perceived social risk and infection. Measures tackling issues with risk perception cannot be limited exclusively in the epicenters, but combined efforts to improve physical and psychological healthcare are required to prevent further spread of the virus across the population.

Trust in TV news and information communicated by government websites and mass media are closely related to risk perception both in China and South Korea. This indicates that appropriate efforts to uphold public trust in communication of information can affect risk perception significantly. Governments play a leading role in the fight against the pandemic and people are more likely to abide by guidelines when their confidence in the government is high. In addition, the public lacks access to full evidence and knowledge of ongoing conditions, hence they rely on institutions they trust to obtain knowledge and evaluate risk [52], which can lead to changes in perceptions and behavior (especially the way and extend to which people employ protective measures). Therefore, improving public opinion of the government is conducive to prevent the spread of the virus across the population and enhance the confidence to combat COVID-19. Intensive efforts must be put into circulating reliable and timely information on the development of pandemic, the economic situation and the condition of the healthcare system, to help the public understand reality.

Familiarity with the current condition of the pandemic has a significant influence on the perceived social risk, including anxiety and perceived risk over daily life, partly because of the numerous uncertainties regarding this new virus, effective treatment, and its negative impact on social economy. Many studies have detected a correlation between knowledge and risk perception of COVID-19, thus indicating that people with limited knowledge tend to be more pessimistic [21,53, 54]. Expert knowledge of the pandemic has been linked convincingly to higher willingness of individuals to comply with preventive measures [12,55]. Therefore, the popularization of science regarding COVID-19 and the implementation of reliable and acceptable preventive guidance can help individuals make more objective risk assessment.

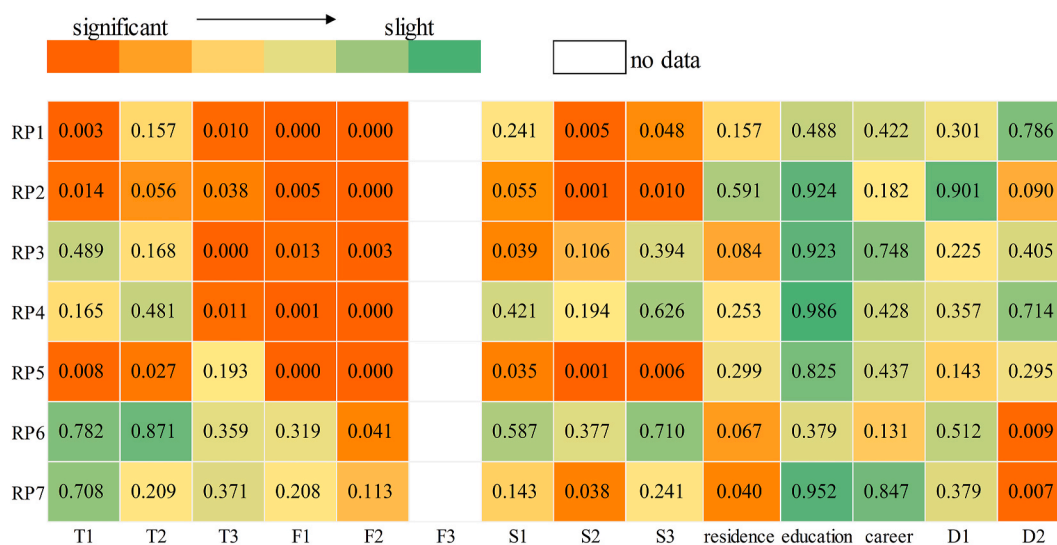|	T1	T2	T3	F1	F2	F3	S1	S2	S3	residence	education	career	D1	D2
RP1	0.003	0.157	0.010	0.000	0.000		0.241	0.005	0.048	0.157	0.488	0.422	0.301	0.786
RP2	0.014	0.056	0.038	0.005	0.000		0.055	0.001	0.010	0.591	0.924	0.182	0.901	0.090
RP3	0.489	0.168	0.000	0.013	0.003		0.039	0.106	0.394	0.084	0.923	0.748	0.225	0.405
RP4	0.165	0.481	0.011	0.001	0.000		0.421	0.194	0.626	0.253	0.986	0.428	0.357	0.714
RP5	0.008	0.027	0.193	0.000	0.000		0.035	0.001	0.006	0.299	0.825	0.437	0.143	0.295
RP6	0.782	0.871	0.359	0.319	0.041		0.587	0.377	0.710	0.067	0.379	0.131	0.512	0.009
RP7	0.708	0.209	0.371	0.208	0.113		0.143	0.038	0.241	0.040	0.952	0.847	0.379	0.007

Fig. 5. ANOVA results for risk perception in South Korea.

Our results also reveal that interpersonal relationship distance from carriers and patients in the epicenter can significantly affect the perceived risk of infection. The distance is classified into the following categories. The local people in the epicenter Wuhan or Seoul and live there during this epidemic. The local people in the epicenter but not live there during this epidemic. Not the local people but have families and friends there. Not the local people but have been there during this epidemic. And not the local people and have no interpersonal relationship with there. Local residents whose families live in the epicenter are more concerned over the risk of infection, because high numbers of confirmed cases increase the probability of infection and cause additional psychological pressure. Moreover, interpersonal relationship distance also makes influences the uncertainty of being the one who has close contact with COVID-19 patients. Intensive efforts should be targeted towards mental healthcare according to these kinds of relationship distance, to deter outbursts of public panic that would only be harmful to the prevention of the pandemic.

This paper expands the scope of previous research and investigates intrinsic characteristics of risk perception and its spatial distribution. ANOVA analysis reveals significant contributing factors and the major perceived risks, which can function as reference for governments in their attempt to deter outbursts of unreasonable public fear and panic over social risk and infection. To the best of our knowledge, this is the first study to analyze the risk perception of COVID-19 from both a comparative and a spatial perspective. We explore the internal mechanisms of the significant contributing factors, yet there remains ample room for further research. We show the impact of distance on risk perception, but future research can explore potential correlation to the ensuing psychological effects, such as the ripple or the psychological typhoon eye effect.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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