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A case study in Ningbo, China

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Influence of Environmental Values on the Typhoon Risk Perception of High School Students: A Case Study in Ningbo, China

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Abstract: Typhoon is a severe natural disaster that would bring huge economic losses and casualties to society. High school students are more vulnerable compared with adults during typhoon. Improving risk perception of typhoon can assist high school students effectively respond to typhoon and reduce related losses. Environmental values play an important role in human's perceptions and actions. Although typhoon is related with environment, few studies have investigated the influence of environmental values on typhoon risk perception of high school students. This study investigates typhoon risk perception of high school students in Ningbo, China, and further analyzes the influence of environmental values on the perception with structural equations model. Results reveal that environmental values have significantly positive impacts on the typhoon risk perception. The findings also demonstrate that disaster threats and the disaster management ability of the government have significant positive impacts on the typhoon risk perception. This study proposes suggestions and measures to improve the typhoon risk perception among high school students and provides a reference for typhoon prevention and reduction education in China.

Keywords: Risk perception; Environmental values; Typhoon; Structural equation model; High school students

1. Introduction

Typhoons (Hurricanes) are formed on the tropical and subtropical ocean surface. Typhoons are characterized by their strong and deep cyclonic vortices, strong winds, and heavy rainfalls, all of which may lead to storm surges, floods, landslides, debris flows, and other natural disasters. Typhoons account for 41% of all deaths caused by the 10 major natural disasters in the world [1]. China is seriously threatened by typhoons and relevant secondary disasters due to long coastline,

adjacent oceans, and climate conditions. EM-DAT database reveals that from 2000 to 2020, an average of 10 typhoon-related tropical cyclones were registered in China per year, which resulted in an average of 255 deaths, an average 19,146,179 people impacted, and average annual economic losses of \$44,304.55 million [2]. China's southeast coastal cities (eg. Ningbo) are located on the Pacific Ocean, with developed economy and dense population, which are more likely to cause serious losses due to typhoon [3]. For example, Typhoon Fitow caused serious waterlogging in many places of Ningbo, and long-term and large-scale interruption of traffic and power [4]. Ningbo suffered economic losses of more than 33.3 billion yuan, and the affected population reached 2.48 million [4]. Chinese governments at all levels have prepared pre-warning and taken emergency plans for typhoon such as timely release of early warning information, publicity of typhoon prevention technical measures, storage of disaster relief materials, opening of emergency shelters, and relocation of personnel in dangerous areas [5]. Although public are highly aware of the typhoon outbreaks, they do not have necessary precautionary actions [6]. Adam et al. and Miceli et al. have found that there is a positive relationship between risk perception and effective response of public [7, 8]. Therefore, in order to effectively prepare and mitigate typhoon, public perception of typhoon should be investigated and improved.

School students are more vulnerable compared with adults during disaster [9]. Each time a disaster occurs, masses of school students are victimized and many of them never return [10]. For example, a total of 5335 students were dead or missing in Wenchuan earthquake. Compared with earthquake, typhoon is more predictable and have fewer casualties. But students are still at a high risk of post-traumatic stress disorder (PTSD), depression disorder and other health problems after typhoon [9, 11]. Severe levels of PTSD and depressive reactions were found among adolescents in the two most heavily affected cities after Hurricane Mitch [12]. Yang et al. found that the prevalence of PTSD related to Typhoon Morakot was 25.8% after investigating 271 adolescents in Taiwan [13]. Tang et al. further found that PTSD has a direct influence on suicide risks of adolescents who have experienced typhoon [11]. Although junior school students are also vulnerable, they do not effectively perceive typhoon risks due to immature disaster perception and less disaster training. High school students learn disaster prevention and mitigation knowledge and skills from school education, which can not only shape their own effective perceptions of disaster but also play a crucial role in shaping attitudes of people in their family or communities [14, 15]. Adaption to the typhoon risk is crucial for the livelihood of the vulnerable people living near sea [16], especially for students in typhoon prone areas, who will contribute for future typhoons' emergency actions. Therefore, in order to reduce the negative impacts of typhoon, high school students should shape effective risk perception and understand more about disasters for prevention and mitigation [15, 17].

Previous studies have discussed the relationship between typhoon risk perception and its influencing factors such as age, gender, education, knowledge [18, 19], typhoon characteristics [20, 21], trust [22] and threat [23]. However, no studies have considered the influence of environmental values on risk perception of typhoon. Values are sense of worth that give a clear orientation to individuals and help them make decisions [24]. As a rational thinking and a value judgment of the environment among individuals or groups, environmental values reflect the public's views and concepts of the environment [25]. Environmental values play an important role in human's motivation and actions [26]. Dutcher et al. thought that environmental values derive from a sense of connectivity with nature hazards [27]. People who think that the risk situation is serious and willing to accepting the environmental value, and their acceptance of all kinds of risks is relatively low [28]. Leiserowitz found that environmental values may explain the relationship between climate change risk events and public perception of risk consequences [29]. Although the increases of typhoons intensity with climate change have been demonstrated by historical data studies and theory [30], no studies have systematically designed and investigated the influence of environmental values on risk perception of typhoon.

The risk perception of typhoon among high school students is still confusing, and the relationship between environmental values and risk perception of typhoon needs to be explored.

Therefore, this study aims to analyze the risk perception of typhoon among high school students and its relationship with environmental values. The rest of this paper is organized as follows: Section 2 reviews relevant existing studies of typhoon risk perception and environmental values and provides a basis for this research. Section 3 introduces the research method, which includes the research hypothesis, model construction, research design, and data analysis. Section 4 presents the findings of this research. Lastly, Section 5 provides an in-depth discussion and proposes relevant suggestions. Section 6 concludes the research results and proposes the limitation of the paper.

2. Literature Review

2.1. Typhoon risk perception and its influencing factors

Risk perception refers to how people judge risks [31]. When people perceive an event to be risky, they develop an intuitive judgment that describes their social attitudes and general assessment of such risks [31, 32]. Therefore, individuals' self-perception of external risks is an important part of understanding risk [33]. Three main theoretical paradigms have been developed to investigate risk perception. First, the psychological measurement paradigm mainly uses individuals' subjective risk assessment to quantify and predict their risk perception. These studies are mainly based on the theory of "personality," which assigns "personality characteristics" to certain risk events and quantifies the risk according to their controllability and familiarity [32]. A scale is designed to measure risks, wherein individuals assign a score according to their subjective feelings and use such scores as the basis to evaluate the risk perception [34]. Second, the social and cultural paradigm defines the occurrence of cognitive risk events as a type of "social and cultural construction" and argues that social and cultural factors can influence individuals' risk perception. Renn and Rohrman inspired by culturalism theory, explored the impacts of social group norms and value systems on risk perception from the perspective of macro sociology [35]. Third, social risk amplification considers that in a society, risk is integrated into the social system, culture, and individual psychology to a certain extent. Social risk amplification is observed in the transmission of risk information and the response of social mechanisms [36]. In this slow and continuous process, the risk perception of the public can be strengthened or weakened, which in turn affects their risk response behavior.

The typhoon risk perception is affected by various factors. As for individual factors, age, gender, education, income, attitude and knowledge are related with the risk perception of typhoon [18]. Shen et al. found that the age of respondents positively affects the risk perception of typhoon, while the education level and the income negatively affect risk perception of typhoon [19]. Walter et al. found that females and minorities have higher levels of perceived typhoon risk [37], but Shen et al. found that there is no significant influence between gender and typhoon risk perception [19]. In addition, the previous disaster experience of the public can affect their typhoon risk perception [38]. Experience with evacuation, financial loss, or emotional impacts heightened negative affective risk perceptions of typhoon [39]. People focus more on the losses caused by risk events than on the probability of disaster occurrence. Public with disaster experience have higher risk perception than people without disaster experience [39, 40]. But Walter et al. revealed that reported hurricane experience, and reported hurricane knowledge seem to have no impact on hurricane perceptions when investigating Florida's single family homeowners [37]. Moreover, trust of respondents in authorities and experts have the substantial impact on risk perception of flood and typhoon [22].

Objective risks or characteristics of typhoon are also good predictors of victims' risk perception toward typhoon [20]. People gradually believe that the risks in their environment has increased with more exposures. Shao, Gardezi, & Xian found that hurricane risks and land area exposed to historical storm surge flooding positively affect risk perceptions [21]. In addition, the public pays attention to the damages caused by typhoons, and the risk information they obtain from typhoon increases their risk perception. For instance, the information that a tourist receives about the hurricane characteristics, such as storm intensity, the track of the storm, the time to landfall, and landfall location strongly influences their risk perceptions [41]. Moreover, the degree of risk threat can directly

affect the public's typhoon risk perception and subsequently influence their risk response behavior [18, 23]. But the age can reduce the positive influence of threat on typhoon risk perception as the elders know that, even if the typhoon has an impact on their lives, the government will provide subsidies in time [19]. That means the governments may play important roles in mitigating public risk perception. The government and relevant departments are well equipped for pre-disaster prevention and mitigation work, thereby substantially influencing the risk perception of the public and assisting them to perceive and avoid future losses [42].

Overall, most previous studies have focused on the influence of demographic characteristics [19], personal experience [38], trust [22], threat [23] and risk features [20] on risk perception of typhoon. Few studies have investigated the influence of environmental values on risk perception of typhoon. Besides, most studies focused on the typhoon risk perception of adults [18, 19, 38], no study has paid attention to the typhoon risk perception of high school students.

2.2. Environmental values and its influence on risk perception

Environmental values essentially involve the value judgment of individuals or groups and the relationship between human beings and the natural environment [43, 44]. These values are mainly used to explain how individuals or the public view their environment and to check whether their environmental behaviors are desirable [44]. Environmental values can be used as references for individuals or social organizations as types of supportive behavior that refer to the concern and responsibility of the public to their environment [45, 46]. Scholars have measured environmental values from different dimensions. One of the most widely applied environmental values scales is the New Environmental paradigm (NEP), which was originally constructed by Dunalp and Van [47]. For example, Albrecht et al. used the revised new environmental paradigm scale to measure environmental views and summarized this scale into three dimensions via principal component analysis (PCA), namely, human influence on the balance of nature, growth limit, and human control over nature [48]. Kim et al. applied NEP scale to explore the impact of environmental values on tourism motivation [49]. Although the NEP scale has been widely used to measure people's environmental concerns, its dimensionality remains debatable. Stern et al. found that NEP scale measures perception of human's environmental action rather than environmental values [43]. Besides, the degree of the original NEP scale remains a valid and reliable measurement tool is open to discussion [50]. Due to the limited ability to predict pro-environmental behaviors, Liu and Chen examined the validity of the Two Major Environmental Values (2-MEV), which considered in two dimensions (preservation and utilization) [51]. Moreover, 2-MEV has developed and successfully explored the environmental values of children in Western Europe and South Asia by using questionnaires [52].

Scholars have conducted many studies on environmental values, which play certain roles in specific situations [53-55]. When individuals face certain situations, their altruistic concerns are triggered. When individuals' altruistic goals are inconsistent with natural goals, environmental values produce a unique impact [56]. A close relationship exists between environmental values and behaviors. Environmental values can significantly affect environment-friendly behaviors when the tendency of individuals is in considerable conflict with their situation [57]. Stedman et al. took environmental values as sociological statistical features and applied them in the study of climate change risk perception [53]. A strong correlation may exist between environmental values and public perception of climate change risk events, risk sources, and risk consequences [29, 58]. Other scholars have confirmed that emotional factors affect public perception toward various environmental risks, including nuclear energy, nuclear waste, and global warming [54, 55]. Environmental risk perception is affected by emotions related to environmental perception and by irrelevant emotions and implicit associations. Therefore, environmental values, to an extent, affect public risk perception. However, no studies have investigated the influence of environmental values on risk perception of typhoon.

3. Research method

3.1. Hypotheses

Previous studies have found that the threats of typhoon [18], individual characteristics and governmental disaster management ability can directly affect the risk perception of typhoon [19, 42]. Specially, the threat of typhoon disaster will affect the public's perception of typhoon risk. Some scholars pointed out that the higher the threat degree of typhoon disaster felt by the public, the higher their typhoon risk perception would be [41, 23]. High school students are more vulnerable than adults, threats will also affect the perception and judgment of risk for high school students. In addition, the government's disaster management ability also has an impact on the public's perception of typhoon disaster risk. The government's grasp of disaster information and the government's control of disaster will affect the public's cognitive level of risk [59]. A great disaster management ability of the government corresponds to the low awareness of the public about typhoon disaster risks [19, 60]. Moreover, environmental values may explain the relationship between typhoon and risk perception [29]. Each person holds a unique set of environmental values, different environmental values of high school students will lead to different levels of perception of typhoon risk. As a result, this research proposes the following research hypotheses.

H1: Typhoon disaster threat level positively affects the risk perception of high school students.

H2: The disaster management ability of the government negatively affects the risk perception of high school students.

H3: Environmental values positively affect the risk perception of high school students.

3.2. Variable measurement

The study investigates risk perception of typhoon disaster from perceiving its influences in terms of economic, liability, personal and environmental perspectives. The relevant indicators were extracted from existing studies. The severity of perceived risk was determined by directly asking respondents to rate the level (1-5) of different typhoons risks. Based on the previous research results, the characteristics of typhoon itself, and interview with relevant experts, this paper divides typhoon risk perception into four categories: perception of economic risk, liability risk, personal risk, and environmental risk.

Among these indicators, the measurement of economic risk, personal risk and environmental risks is taken from literature, news reports and interviews. The indicators of economic risk perception refer to the research of Acosta on the losses and damages caused by floods and landslides caused by typhoons in the Philippines [61], Wang et al. on direct and indirect economics loss assessment of typhoon disasters [62], Bouwer's on disaster losses and anthropogenic climate change [63]. Personal risk index is based on the study of typhoon risk perception of rural residents in Zhejiang by referring to Zhang et al [18]. Indicators of environmental risk perception are based on Dalisay [64]. These indicators were further solicited through interviews with meteorological experts, government staff, high school leaders in Ningbo and some teachers in March 2018. Based on the public's climate change risk perception and the actual situation of high school students in Ningbo, China, several indicators of liability risk are developed. These indicators were then revised according to the primary pilot study of the high school students in Ningbo, which was conducted from April 2nd to April 3rd, 2018. The measurement of disaster threat is based on Basolo et al., and Zhang, et al., [18, 23]. The establishment of government disaster management capability index is mainly based on Lei et al.'s research on adaptive governance to typhoon disasters for coastal sustainability [65], Blanco and Vicencie's research on disaster governance in the Philippines [66], and Fan's research on disaster governance and community resilience [67]. In order to improve the representativeness and reliability of the indicators, the indicators were rated by experts for three rounds, and the following indicators were finally determined. A five-point Likert scale was used to quantify the risk perception indicators, with the scores 1 and 5 indicating the weak and strong subjective feelings of the respondents,

respectively. The finalized measurement items of risk perception of typhoon disaster are demonstrated in Table 1.

Environmental values are measured by revising the NEP scale developed by Dunlap and Van Mere [47], which is the most authoritative and representative scale used in existing literature. Items in the NEP scale mainly reflect the views of respondents toward natural balance and the control of humans over nature. The respondents assigned values from 1 to 5 to each item to indicate their strong disagreement and strong agreement with each statement, respectively. The NEP scale was revised by Dunlap and Van Mere in 2000 to include five additional aspects, such as the relationship between humans and the environment, thereby resulting in a total of 15 items [68]. The revised NEP scale shows improved reliability and validity compared with its previous version. This study divides environmental values into two parts that are suitable for high school students, namely, the overall coordination and management science views. The overall coordination focuses on the view of partial and overall interests, whereas the management science pays attention to the relationship between immediate and long-term interests, as well as the view of management tools and objectives. A total of 10 measurement indicators are employed and measured using a five-point Likert scale, in which 1, 2, 3, 4, and 5 denote “strongly disagree,” “disagree,” “unclear,” “basic agreement,” and “strongly agree,” respectively. The finalized measurement items of environmental value are demonstrated in Table 1.

Table 1. Measurement of involved variables and reference sources of this study

Variable	Category	Items	Reference sources
Risk perception	Economic risk (EC)	EC01: Loss of personal and family property	News reports and interviews; [61-63]
		EC02: Ship loss at sea	
		EC03: House and building destruction	
		EC04: Infrastructure loss	
		EC05: Crop loss	
		EC06: Service industry losses	
		EC07: Industrial loss	
		EC08: Insurance compensation	
	Liability risk (LI)	LI01: Government responsibility	[1]; Interview
		LI02: Insurance company responsibility	
		LI03: Media responsibility	
		LI04: Environmental organization responsibility	

		LI05: Individual responsibility	
		LI06: School responsibility	
	Personal risk (PE)	PE01: Personal safety	
		PE02: Personal mental health impact	
		PE03: Family member safety	News reports and interviews;
		PE04: Life Quality	[18]
		PE05: Daily schooling impact	
		PE06: Daily travel impact	
	Environmental risk (EN)	EN01: landslides and mudslides	
		EN02: Risk of power outage	
		EN03: Trees and telephone poles are blown down by the wind, and the risk of falling objects is high.	
		EN04: Traffic accident risk	News reports and interviews;
		EN05: The sewer cover is washed away.	[64]
		EN06: Ponding risk.	
		EN07: Possibility of infectious diseases caused by typhoon	
		EN08: Possibility of flood caused by heavy rainfalls	
Environmental Value (EV)	Overall coordination view	EV01: Limited carrying capacity	
		EV 02: Nature serves man	
		EV 03: Balance in nature	
		EV 04: Growing the economy	[47]
	Management science	EV 05: Abuse of the environment	
		EV 06: Economic efficiency	
		EV 07: Management factors	
		EV 08: Natural damage	

	EV 09: Subject to the laws of nature	
	EV 10: Enhance positive coping behaviors	
Disaster threat	DT 1: The severity level of life threaten by typhoon	[18, 23]
	DT 2: The severity level of daily living threaten by typhoon	
Disaster management ability of government	DM1: The government's ability to conduct disaster mitigation	
	DM2: The government's ability to conduct disaster preparedness	[18, 23, 67]
	DM3: The government's ability to conduct disaster response	
	DM4: The government's ability to conduct disaster recovery	

The general concerned influencing factors include disaster threat and disaster management ability of government. Disaster threat is measured by estimating the threat degree of typhoon disaster and its secondary disaster brought to life and daily life. A five-point Likert scale is used to quantify the disaster threat, with the scores 1 and 5 indicating the weak and strong respectively. The disaster management capacity of local governments is measured from assessing the government's ability to conduct disaster mitigation, preparedness, response and recovery. A five-point Likert scale is used to quantify the disaster threat, with the scores 1 and 5 indicating the weak and strong respectively.

3.3. Participants

This study takes high school students in Ningbo as the research subjects. Ningbo is a municipality under the jurisdiction of the Zhejiang Province, located along the southeast coast of China with a total area of 9,365.58 square kilometers. The specific location of Ningbo City is shown in Figure 1. As a coastal city, Ningbo has an average of 4.6 typhoons affecting the city all the year round, and 3.1 typhoons are obviously affected. Since 2007, Ningbo has been continuously hit by strong typhoons, which bring severe challenges to flood and typhoon emergency management, and also bring great losses to industrial and agricultural production and people's lives. Big data from China Weather Network shows that typhoon landfall sites are mainly concentrated in the central and southern coastal cities [69]. Ningbo landed six times, ranking second in Zhejiang [69]. In 1956, the most destructive typhoon (Wanda) in China's history made landfall in Ningbo, which caused serious damage. In Zhejiang province, 4,925 people died and more than 150,000 were injured, 2,573 houses collapsed and 196,648 houses partially collapsed, 400,000 hectares of farmland became flooded, and more than 100 ships sank [70].

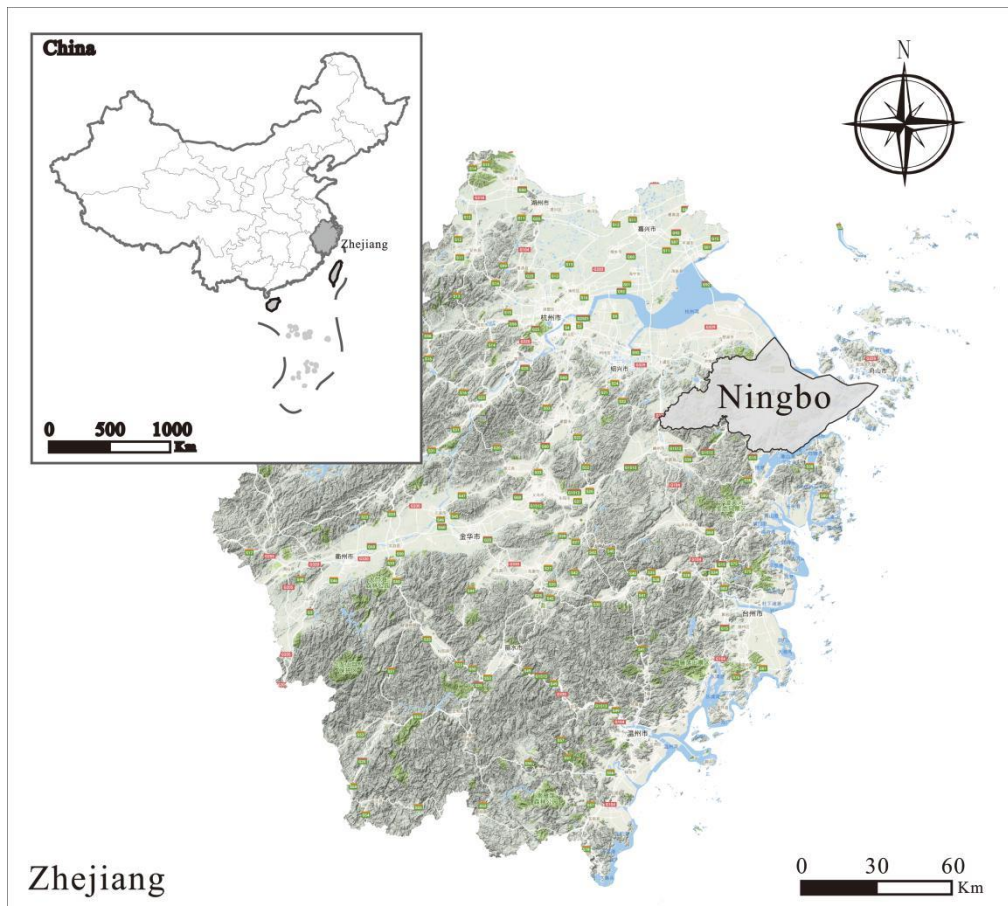


Figure 1. The geographical location of Ningbo

The object of this study is high school students in Ningbo. High school in China is divided into junior high school students (Grade 7-9) and senior high school students (Grade 10-12), who almost aged between twelves and nineteen. Adolescents gradually form mature perception in high school, which can make basic judgments on potential risks. High school students are not only easily affected by disasters, but also important participants in implementing disaster prevention and mitigation measures. Therefore, it is necessary to guide high school students to have a correct understanding of typhoon and typhoon prevention and mitigation. Ningbo has 2,058 schools of various levels, including 85 senior high schools, 42 secondary vocational schools, and 208 junior high schools, of which 84 junior high schools and colleges are located in urban areas [71]. The student population in this area comprises 68,764 junior and 28,911 senior high school students, among which 29,961 and 13,556 come from urban areas, respectively [71]. The distribution statistics of high schools in urban areas of Ningbo are shown in Table 2 below.

Table 2. Statistics on the number of urban high schools in Ningbo

District	Haishu District	Jiangdong District	Jiangbei District	Beilun District	Zhenhai District	Yinzhou District
Junior high school	8	6	10	18	7	29
Senior high school	0	0	1	5	4	14

Stratified random sampling method with grade-level and school distribution stratification is adopted for the sample selection. Stratified sampling is a method of randomly sampling samples (individuals) from a population which can be divided into different sub populations (or layers)

according to the specified proportion [72]. The advantage of stratified random sampling is that the sample is representative and the sampling error is small [72,73]. The questionnaire was developed based on the specified variable measurement. Pilot study was conducted to collect questionnaires from April 15 to May 15, 2018. In order to make the sample representative, this study selected schools in the administrative regions originally divided by Ningbo City for questionnaire survey. The distribution of schools and geographical locations investigated in this study are shown in Figure 2.

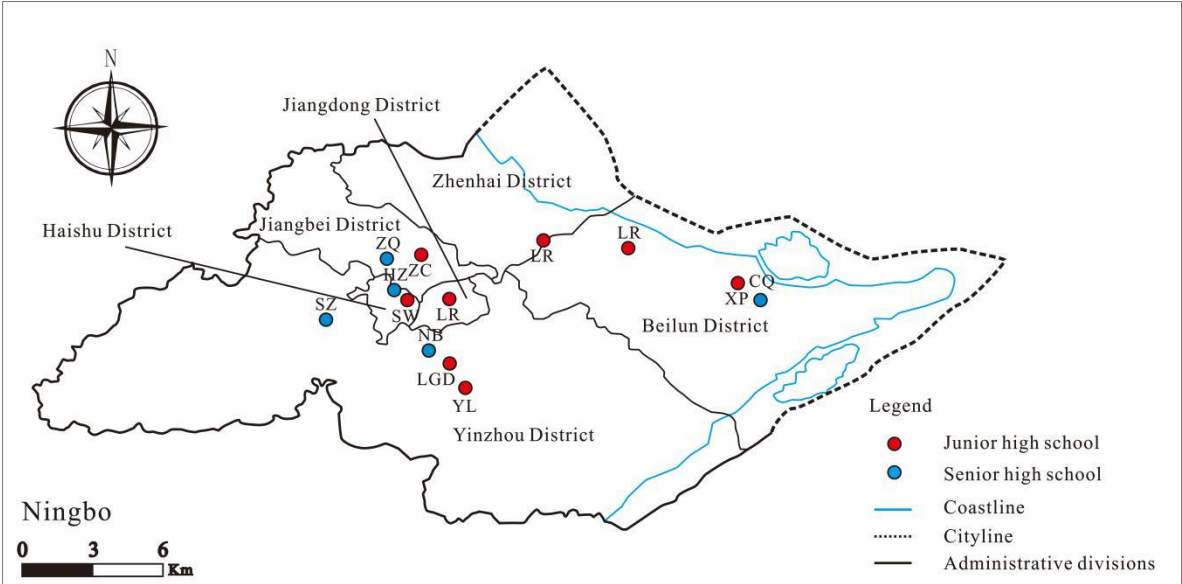


Figure 2. Administrative district division map of Ningbo city and sample schools

Since the objects of this study are Chinese high school students, the authors conducted the survey in Chinese in the questionnaire survey stage. In the paper writing stage, the Chinese indicators in the questionnaire were translated into English [74]. The principals or teachers of the participating schools sent out the questionnaires during afternoon self-study, and evening self-study. Students had enough time to fill in the questionnaires during these periods and further ensure the quality of the data collected. In the questionnaire survey stage, this paper set up a special research team to provide detailed answers to the questions the interviewees encountered in the questionnaire survey to ensure the authenticity and effectiveness of the questionnaire. Teachers supervised and answered questions about the filling process to the high school students. Apart from conducting the questionnaire survey, certain teachers were interviewed to verify the background knowledge of the participating students, understand the present education situation of their schools, and examine the effects of typhoons and other natural disasters on education in these schools. A total of 1,200 questionnaires were distributed, among which 824 valid questionnaires were returned, thereby achieving an effective recovery rate of 68.67%. The questionnaire survey in this study follows the wishes of high school students and carries out the questionnaire survey under the condition of high school students' willingness.

Table 3 reveals the basic information of the respondents. The number of valid questionnaires collected for this paper is equal, with 50 percent of male and 50 percent of female, but this is not intentional. The distribution of respondents in grade is relatively balanced. The number of respondents in grade three is relatively small due to the heavy academic pressure. Most of the high school students surveyed live in Ningbo all year round.

Table 3. Analysis of basic data of respondents

Individual characteristics	Amount	Effective percentage (%)
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Gender	Male	412	50.00
	Female	412	50.00
Grade	Junior One	221	26.85
	Junior Two	178	21.63
	Junior Three	129	15.67
	Senior One	138	16.77
	Senior Two	132	16.04
	Senior Three	26	3.16
	Duration of residence in Ningbo	0-5 years	59
6-10 years		152	18.47
11-15 years		366	44.47
over 16 years		247	30.01
Parents' occupation	freelance	222	26.97
	State units and public servants	106	12.88
	Enterprise staff	285	34.63
	Else	211	25.64
Parents' education level	High school and below	443	53.83

	Technical secondary school	92	11.18
	junior college	130	15.80
	Undergraduate	121	14.70
	Postgraduate and above	38	4.62
Annual household income	¥50,000 or less	110	13.37
	¥50000-100000	209	25.39
	¥100000-150000	203	24.67
	¥150000-200000	108	13.12
	¥20000 and above	194	23.57

3.4. Data analysis method

Analyses were conducted in two stages. The first stage is the primary analysis, including the reliability test of the questionnaire and descriptive statistics of the survey results. This stage provides a foundation for the next stage of empirical analysis. SPSS 22.0 was used for this phase of analysis and validation.

The second stage mainly verifies the influencing factors of high school students' risk perception of typhoon disaster and their mutual relationship. The general linear regression or Logit regression method cannot effectively explain the relationship among factors when many factors are given. Thus, the structural equation modeling (SEM) approach was selected to test the proposed model. AMOS 24.0 was employed to estimate parameters. Analysis was based on the raw data, and the maximum likelihood (ML) method was employed. When the ML estimation method is adopted, the minimum sample size should not be lower than 200. The present study had a sufficient number of samples for the SEM analysis. From the perspective of application analysis, this study belongs to the confirmatory factor analysis. Model fitting, validation, parameter estimation, and hypothesis testing are included in this stage.

4. Results

4.1. Primary analysis

The Cronbach's alpha coefficient estimation method is used to test the internal consistency of typhoon disaster risk perception and the risk perception influencing factor [75]. Table 4 shows the test results. With regards to latent variable of risk perception, the Cronbach's alpha for economic risk,

liability risk, personal risk and environmental risk are all greater than 0.8. With regards to latent variable of influence factors, the Cronbach's alpha for threat, disaster management ability, and environmental values are greater than 0.65. Nunnally and Bernstein pointed out that a Cronbach's alpha coefficient that is greater than 0.6 is feasible for exploratory research [76]. The results of the reliability analysis reveal that the reliability of the data collected through questionnaires has reached an acceptable level.

Table 4. Reliability test of variables

Risk Perception	α	Influence factors	α
Economic risk	0.859	Threat	0.859
Liability risk	0.806	Disaster management ability	0.963
Personal risk	0.835	Environmental values	0.666
Environmental Risk	0.852		

Then, the typhoon disaster risk perceptions and influence factors of high school students in Ningbo are explored. Table 5 presents the results of risk perception and influence factors collected in this research. Table 5 indicates that the average risk perception level of high school students for environmental risk perception is 3.711, which is the highest score among all risk perception index. By contrast, personal risk perception is the lowest average score. That is, given that high school students in Ningbo experience several typhoons every year, a typhoon disaster has minimal negative effects on their mental health. The average level of economic risk perception is slightly lower than that of the overall risk perception. The average perception level of liability risk perception is close to that of the overall risk perception. Among the influence factors, disaster management ability is the highest average score. Environmental values have the lowest average score, which implies that high school students need to improve their environmental values.

Table 5. Statistical comparison of scores of typhoon disaster risk perception and influence factors among high school students in Ningbo

Risk Perception	Mean	Influence factors	Mean
Economic risk	3.382	Threat	3.542
Liability risk	3.443	Disaster management ability	3.7806
Personal risk	3.197	Environmental values	3.244
Environmental Risk	3.711		

Individuals who give different scores for each index show different judgments and perceptions to their environments. The statistical analysis reveals that the identification degree of high school students on the view that "the limited disaster-bearing capacity of Ningbo cannot bear the typhoon disaster trauma" (EV01) is mainly distributed between relative disagreement and general disagreement. Most of the participating high school students do not agree with the view that "people are the most important players and that nature serves human beings" (EV02). The proportion of participants who strongly disagree with these items is 55.9%. The degree of agreement with the view that "a typhoon disaster likely disrupts the balance of nature" (EV03) is mainly concentrated between generally agree and slightly disagree, thereby indicating that high school students are highly confident in the balance of nature. More than half of the students do not agree with the view that "economic development is more important than environmental protection" (EV04), which obtains

the lowest mean value. In addition, 39.9% of the students strongly agree with the statement “human beings are abusing and destroying the environment” (EV05), with an average value of 3.812. Nearly half of the participating students agree that “environmental rights take precedence over economic efficiency in the long run” (EV06). Moreover, approximately 40% of the participants agree with the view that “the management factor is more important than the technical factor” (EV07) and “the human destruction of nature often leads to disastrous consequences” (EV08). The degree of agreement of the participants with the views that “although human beings can cope with disasters, they continue to be subject to the laws of nature” (EV09) and “if we do not improve our active responses to typhoon, we will become vulnerable to such disasters” (EV10) are mainly concentrated between relatively agree and strongly agree. Table 6 presents the results in detail.

Table 6. Statistics on the scores of environmental value

		Very disagree (%)	Less agree (%)	general (%)	Comparative agree (%)	Very agree (%)	Mean	Variance
Overall	EV01	17.2	20.1	31.6	18.0	13.1	2.896	1.586
coordinatio n view	EV02	55.9	12.3	14.9	8.6	8.3	2.010	1.798
	EV03	18.9	20.5	30.7	16.3	13.6	2.851	1.648
	EV04	56.8	14.1	13.1	8.7	7.3	1.956	1.704
Managemen t science	EV05	4.5	11.9	21.5	22.2	39.9	3.812	1.460
	EV06	5.6	8.3	17.0	22.0	47.2	3.970	1.475
	EV07	5.1	14.4	39.8	20.9	19.8	3.358	1.222
	EV08	3.2	8.5	21.1	25.0	42.2	3.947	1.256
	EV09	5.0	10.0	24.8	25.4	35.0	3.754	1.384
	EV10	4.2	8.1	21.7	26.8	39.1	3.883	1.304

4.1. Hypothesis testing

The measurement and structural models constitute a unified model. Therefore, special attention should be paid to the execution order of these two models in the actual operational analysis. A two-stage strategy is most commonly adopted. In the first stage, the factor structure of the model fitting is determined. In the second stage, the setting of the structural model is added, and its fitting is evaluated without changing the measurement model. In evaluating latent variables, the two-stage strategy is more appropriate than the one-time parameter estimation analysis. Therefore, the two-stage model analysis method is adopted for the parameter estimation and model analysis in this study. This method standardizes the path coefficients in the model during the model analysis to enable a direct comparison of the standardized path coefficients (or standardized load coefficients) of different variables. After analyzing and adjusting the model, the estimation results of the adjusted model path coefficient are presented in Table 7, and the model fitting conditions are shown in Table 8.

Table 7. Standardized path coefficient estimation results

			Estimate	S.E.	C.R.	P
Risk perception	←	Environmental values	0.161	0.05	4.495	***
Risk perception	←	Threat	0.725	0.038	15.506	***
Risk perception	←	Disaster management ability	0.08	0.029	2.252	0.024
Liability risk	←	Risk perception	0.553	0.054	14.817	***
Personal risk	←	Risk perception	0.713	0.058	19.126	***
Economic risk	←	Risk perception	0.747			
Environmental Risk	←	Risk perception	0.77	0.047	20.578	***
Overall Coordination View	←	Environmental values	0.612			
Management Science	←	Environmental values	0.902	0.146	10.025	***
Life threat	←	Threat	0.854			
Living threat	←	Threat	0.843	0.04	24.664	***
Recovery	←	Disaster management ability	0.829			
Response	←	Disaster management ability	0.916	0.032	32.822	***
Preparedness	←	Disaster management ability	0.882	0.032	31.171	***
Mitigation	←	Disaster management ability	0.704	0.041	22.282	***

(P value is significant, P<0.05 is significant, P<0.001, indicated by the symbol "***")

Table 8. Calculation results of commonly used fitting indices

Fitting index	CMIN/DF	RMR	RMSEA	GFI	AGFI	IFI	CFI	NFI
Result	2.274	0.053	0.039	0.953	0.939	0.970	0.970	0.948
Judgment value	<3	The smaller the better	<0.08	>0.9	>0.9	>0.9	>0.9	>0.9

Blunch argued that if all fitting indexes meet the requirements of judgment values in Table 7 [77], then the model has a good degree of fit. According to the model fitting data shown in Table 8, all of which have reached their ideal standards. Therefore, the fitting degree of the modified model has greatly improved compared with the original model. The estimated values of all parameters in the path diagram are substituted into the model to obtain the path diagram of high school students' typhoon disaster risk perception, as depicted in Fig. 4.

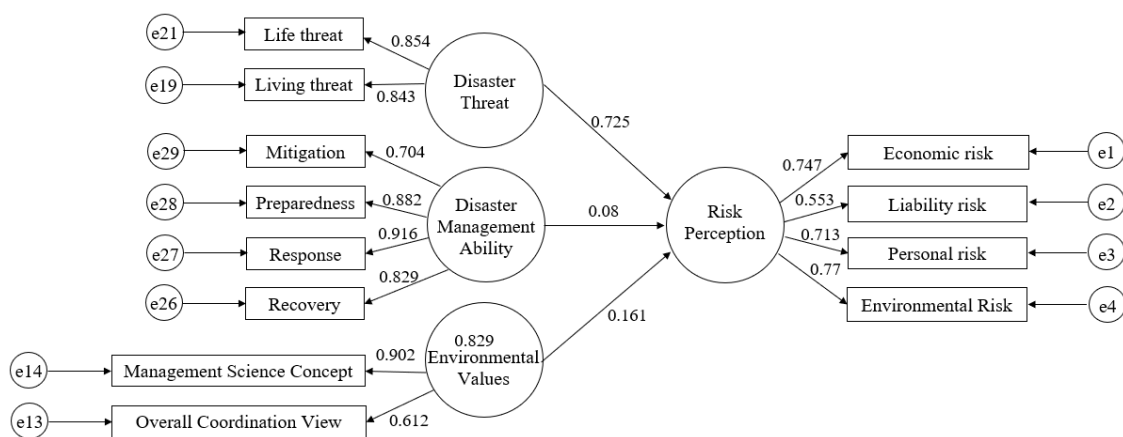


Figure 3. Path coefficient diagram of risk perception of typhoon for high school students

The path analysis results presented in Fig. 3 and Table 7 reveal that the path coefficient of threat to risk perception is 0.725 ($p = 0.000$), thereby suggesting that the greater the threat a typhoon poses to the daily life and surrounding environment of high school students, the higher the risk perception level of these students. Therefore, H1 is supported. The path coefficient of government management's risk perception is 0.08 ($p = 0.024$), thereby indicating that the management ability of the government positively affects the risk perception of typhoon among high school students. Therefore, H2 is not supported. The path coefficient of environmental values on risk perception is 0.161 ($p = 0.000$), revealing that the environmental values of high school students have positive and significant impacts on their typhoon disaster risk perception. A high level of environmental value corresponds to a high level of typhoon disaster risk perception. Therefore, H3 is supported.

5. Discussion

Environmental values have significant positive impacts on typhoon disaster risk perception. This finding is consistent with what has been found in other environmental risks such as global warming, nuclear energy, and nuclear waste [54, 55]. High school students have a high level of understanding of the scientific management concept based on the descriptive statistics of environmental values. According to the above analysis, the scores of EV05 (human beings are abusing and destroying the environment) and EV06 (environmental rights take precedence over economic efficiency in the long run) are relatively high, indicating that immediate and long-term interests is the indicator with the highest score, thereby suggesting that high school students focus on the relationship between immediate and long-term environment interests. Most of the large typhoon disasters cause different degrees of collapse of seawalls in coastal areas and the flooding of sea water. The students who have high scores of environmental values can perceive the damage of typhoon to urban environment and ecosystem. As a result, these students are highly aware of environmental protection initiatives and have a high level of risk perception. These students have a good understanding of existing environmental management tools and management objectives.

Disaster threat is the most important factor influencing the risk perception of typhoon among high school students. Typhoons cause extremely large damages to the environment, including public facilities and buildings, thereby posing large threats to high school students with varying degrees of economic losses [62, 78]. Secondary disasters caused by typhoons can bring certain losses to the society and the environment [63]. In addition, students can learn about such a threat by referring to news reports and various information channels. Therefore, when a typhoon disaster occurs, the threat felt by high school students is relatively straightforward and strong. This is echoed with existing studies. For instance, Basolo, Steinberg, & Gant, 2017 also found threat can directly affect the public's typhoon risk perception when investigating the hurricane risk perception of household in Florida

[23]. It is necessary for both adults, adolescents and children to learn more about typhoon and reduce the threats to typhoons.

The literature review reveals that the disaster management ability of the government negatively affects the risk perception level of individuals [19, 79]. However, the findings of this study reveal that such an ability has a positive and significant impact on the typhoon disaster risk perception of high school students. This difference can be ascribed to the target participants of these studies. Previous studies have focused on the general public from different age groups, types of work, typhoon experiences with highly distributed demographic differences [23, 42]. Yet, this study takes high school students as its research subject with relatively similar ages, disaster experiences, and identities. High school students do not have enough social experiences and have a high degree of trust in their parents, schools, societies, and government agencies. In most cases, these students follow the command and guidance of external authorities. When government departments organize disaster preparedness and mitigation activities, relevant media report on these initiatives. High school students can learn about the disaster preparation and mitigation activities of the government by referring to different information channels, thereby stimulating their information processing and risk perception. Therefore, the disaster management ability of the government has a positive and significant influence on the risk cognition level of high school students.

This work proposes further countermeasures for typhoon disaster prevention and mitigation from the perspective of risk perception based on the research results. First, the risk perception of typhoon prevention among high school students must be enhanced through disaster education and training. Knowledge on the precursors of typhoon must be disseminated, which can effectively reduce the typhoon threats of students. Through the field survey, this study found that the popularization of typhoon disaster prevention and mitigation education in Ningbo is not as good as other disasters such as earthquake, and fire. Only 8 schools have typhoon disaster education in the disaster education system, and the other 4 schools have not carried out typhoon education. Through the interview, we know that Ningbo high school students can understand the characteristics of all kinds of disasters through disaster education, and understand the basic skills of preventing and avoiding disasters, but their practical ability needs to be further improved. Most of the schools do not train disaster coping behaviors specifically for typhoon, only one school has carried out typhoon coping training. The process, mechanism, and consequences popularize the methods of disaster prevention and effective measures of disaster prevention and reduction. These measures can assist high school students to correctly understand the threats posed by typhoon and raise the level of risk awareness of typhoon, which is beneficial for them to deal with typhoon threats.

Second, good guidance in the construction of high school students' environmental values are necessary. Great importance should be attached to typhoon prevention, including coordination and dealing with the relationships between population, resources, and the environment; the vigorous development of the ecological and the green economy; and the promotion of the sustainable development of social economy. Responsibility for the environment and society among high school students must be cultivated based on the concept of sustainable development, which leads to students' good behavior habits and lifestyles and the harmony among individuals, society, and the environment. Disaster education should be integrated into daily life, so that when high school students encounter typhoon, they can fully consider the environment and the situation they encounter to deal with typhoon according to the knowledge they have learned. Moreover, typhoon disaster prevention and reduction training should be actively performed. Schools should combine with social resources to provide students with access to off-campus typhoon knowledge to enrich disaster education and assist students to master practical skills. The school can organize students to go to the disaster area to truly understand the losses caused by the typhoon disaster and real environment after typhoon. The spot experience of disaster can make up for the deficiency of classroom teaching and improve the enthusiasm of students to learn disaster knowledge. In addition, the school can also organize teachers and students to go to the typhoon experience hall to carry out

on-site teaching, so that students can systematically learn typhoon knowledge and deepen their impression of typhoon environment.

In addition, strengthening the risk awareness of typhoon among high school students can improve the trust of the public in the disaster management ability of the government, enhance the confidence of high school students in dealing with other disasters, and assist the government to carry out effective disaster reduction actions. Besides, it is necessary to combine information communication technology to strengthen students' simulation experience. Students can play different roles in typhoon emergency action such as government officer, social rescuers, victims, which can help them truly feel the situation when disasters occur. In view of the existence of students in school, on the way to and from school, vacation and other states, the school needs to strengthen the practical training of different scenes in the simulation of disaster education. Typhoon simulation training can also relieve their tension and other psychological problems in time. The school can apply the information interaction platform to collect the data of the disaster drill, and summarize the experience of the previous drill.

6. Conclusions

This paper investigated the influence of environmental values on risk perception of typhoons among high school students. After a pilot study to finalize the questionnaire, the formal survey was conducted among high school students in Ningbo who were selected via stratified sampling. SEM was also employed to analyze the influence of various factors on the risk perception of typhoon among high school students, to verify the proposed theoretical model, and to test the hypotheses. The results reveal that environmental values have significantly positive impacts on the risk perception of typhoon, disaster threats have significantly positive impacts on the risk perception of typhoon, and the disaster management ability of the government has a significant positive impact on the risk perception of typhoon.

Several limitations exist in the current study. The variables measurement of this study developed from existing studies, which usually take general public as the research subject. Future efforts should be conducted to design more suitable measurements for high school students and analyze more socio-economic factors. In addition, this study merely focuses on high school students in Ningbo city, which does not cover the other cities affected by typhoons. In the future research, the scope of research objects can be expanded to make the research more comprehensive and more universal. In addition, this research focuses on high school students and overlook other vulnerable groups. Future studies can investigate the influence of environmental values on risk perception of typhoon for the elderly, the disabled, because they are also vulnerable.

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