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Extending the Theory of Planned Behavior to understand residents' coping behaviors for reducing the health risks posed by haze pollution

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Abstract
Haze pollution threatens residents' health and has become an important public problem in China. With the gradual improvement of public environment consciousness, government failure in the environmental protection might stimulate individual coping behaviors. However, there is no implication about the mechanism differences within individual coping behaviors. This study aimed to understand Beijing residents' four coping behaviors against health risks of haze pollution including two behaviors of "inverted quarantine," i.e., wearing a mask when go outside (WM), purchasing air purifier (PAP), and two environmentally friendly behaviors, i.e., purchasing new energy vehicles (PNEV), making a real-time report of air pollution incidents to the government (MRR). We introduced risk perception and income into the theory of planned behavior, and used structural equation model to explore the formation mechanism of coping behaviors. The results showed that the positive effect of intention on behaviors of "inverted quarantine" is relatively higher than these environmentally friendly behaviors. Behavioral intentions are significantly affected by attitude ($\beta_{WM}=0.24$; $\beta_{PAP}=0.37$; $\beta_{PNEV}=0.45$; $\beta_{MRR}=0.16$), subjective norm ($\beta_{WM}=0.46$; $\beta_{PAP}=0.41$; $\beta_{PNEV}=0.31$; $\beta_{MRR}=0.62$) and risk perception ($\beta_{WM}=0.74$; $\beta_{PAP}=0.73$; $\beta_{PNEV}=1.07$; $\beta_{MRR}=0.74$) at 1% level. Furthermore, richer people showed higher level of coping behaviors than the poor, but showed similar or lower level of coping behavioral intentions. The conclusions would be helpful for policy makers to take effective measures to guide public behaviors and promote public participation in air pollution control.

Keywords Haze pollution · Risk perception · Theory of planned behavior · Coping behaviors · Beijing

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1 Introduction

Beijing is the capital city and one of the most important financial, cultural, and educational centers of China. Due to the frequent environmental accidents in Beijing in recent years, the Beijing government and the public paid more attention to the environmental problems. Many environmental governance policies had been adopted by the Chinese government. But environmental pollution did not get the effective control and was still worrisome (Johnson et al. 2017). In terms of air quality, the Beijing Municipal Bureau of Environmental Protection indicated that the average concentration of fine particles measuring less than 2.5 μm in diameter (PM2.5) in Beijing in 2019 reached 42 micrograms per cubic meter, which exceeded the thresholds in the Air Quality Guidelines published by the World Health Organization (WHO 2005). It indicated that air quality is still not optimistic in Beijing.

Compared with other air pollutants, e.g., sulfur dioxide, PM2.5 had attracted more attention from the government, researchers and the public due to higher health risks. The Chinese central government had incorporated PM2.5 into the new evaluation system of air quality (Ministry of ecology and environment of the People's Republic of China 2017). Numerous studies suggested that chronic exposure to PM2.5 contributes to the risk of developing cardiovascular and respiratory diseases and lung cancer (Weber et al. 2016; Weichenthal et al. 2014).

PM2.5 pollution threatened people's health and had become an important public problem in China. Both the government and Chinese residents deployed all available means to cope with the threat of air pollution. The government could issue regulations to limit emissions from polluting sectors, such as chemical plants, to reduce air pollution from the origin, which can ultimately benefit everyone (Li et al. 2019a; Sun et al. 2017). China has a strong central government with little separation of power and tends to be efficient at accomplishing the government's goals by collective arrangements. Therefore, environmental protection mainly relied on governmental actions in past years. However, the government might fail in the environmental protection, resulting in inefficiencies and even the further deterioration of the environment (Johnson et al. 2017). Some studies even showed that China's environmental pollution problems are partly caused by the low environmental standards set by the government (Tian et al. 2016). Failing collective arrangements in the environmental protection might stimulate individualized behaviors. In order to reduce the health risks, individual coping behaviors, i.e., individual response to the environmental and health risks, which helps to reduce the health risks, might prevail massively in situations where collective arrangements are deemed unsuccessful.

There was a wide literature on individual coping behaviors against the health risks. Szasz (2007) defined such individual behaviors "inverted quarantine," a strategy that private individuals can protect themselves against dangers and threats from the external environment. For example, individuals can invest to the environmental defensive strategies to reduce their exposure to current levels of outdoor pollution (Sun et al. 2017). "Inverted quarantine" was very effective in reducing individual health risks, but was useless to improve regional air quality. However, individual coping behaviors could not always be defined in terms of inverted quarantine. The individual always took a positive attitude toward environmentally friendly behaviors, e.g., green consumption, which should be regarded as an extension of lifestyle and social movements, rather than a quarantine (Johnson et al. 2017; Loures et al. 2015). In addition, the individual could supervise air pollutant emissions of related companies and government governance behaviors to take participate in air pollution control, e.g., disseminating real-time reports of air pollution incident to the

government (Li and Xia et al. 2018). These coping behaviors might contribute to improving regional air quality, but could not reduce the health risks in the short term (Fedorenko et al. 2016; Johnson et al. 2017; Li et al. 2019b).

In this paper, we aimed to understand about the individual coping behaviors against the health risks of haze pollution in China. Furthermore, we made efforts to analyze which factors would have impact on the coping behavioral intentions and behaviors because the analysis could provide references for managers and policymakers to develop appropriate strategies to guide public behaviors. There are many models for the prediction of human social behavior, e.g., Theory of Planned Behavior (TPB), Norm Activation Theory and Prospect Theory. TPB is grounded in self-interest and rational choice-based deliberation, and is one of the most frequently cited and influential models (Ajzen 2011). Individual would consider the cost of performing coping behaviors and the health risks, and decide whether to perform coping behaviors or not. Therefore, TPB is considered to be appropriate for the behavior studied and is chosen as the theoretical basis for this study. In addition, many researchers has extended TPB by introducing additional variables, e.g., moral norms (Botetzagias et al. 2015) and personal norms (Han et al. 2012), and found that the explained variation of the extended model has improved. However, related studies, that used TPB as the analytical framework to explore residents' coping behaviors to reduce the health risks of environmental pollution, are relatively scarce in China. Furthermore, we thought that the effect of individual cognitive variables and personal socioeconomic variables on the behaviors is not reflected in the original model of the TPB. Accordingly, our study constructed the theoretical model by introducing cognitive variable (risk perception) and personal socioeconomic variable (income) into the TPB model to examine the formation mechanism of coping behaviors against the health risks posed by PM2.5.

The rest of the article is organized as follows: The remainder of this section reviews the related research, constructs the analysis framework and presents research hypotheses. This is followed by research methods. Then, we present the empirical results and discussions. Finally, the paper concludes with a discussion of the main findings, policy implications and limitations.

2 Research hypothesis

2.1 Theory of planned behavior and coping behaviors

The theory of planned behavior (TPB) originates in the fields of Psychology and Sociology, is an extension of the theory of reasoned action (TRA) (Ajzen and Fishbein 1980; Ajzen 1985), which is designed to explain human behavior and has been proven successful in explaining personal behavior in various areas. TPB is an attitude–intention–behavior model, which posits that individuals' behavioral intentions, which are assumed to capture the motivational factors that influence a particular behavior, are the immediate antecedents to behavior. The stronger the intention to engage a given behavior, the greater the likelihood that the individual will perform the behavior. Behavioral intention is a central component in the TPB, and is affected by three psychosocial factors, specifically, attitudes toward the behavior, subjective norms, and perceived behavioral control. Attitudes are generally viewed as person's overall evaluation on performing a certain behavior, i.e., individual's positive or negative feelings about engaging in a particular behavior. TPB predicts that the more favorable an individual evaluate a particular behavior, the more likely he or she will

intend to perform that behavior. The subjective norm refers to the social influence exerted by those important to the individual (family, friends, colleagues, etc.) on his or her behavioral decision making. The more an individual perceives that important others think he or she should carry out the behavior, the greater an individual' s level of motivation to conform to those referents and as a result, the intention to engage in the behavior should be greater. Perceived behavioral control is defined as individual's perception of the ease or difficulty of carrying out a certain behavior (Ajzen 1991). According to TPB, people who have greater perceived behavioral control, will have a stronger intention to perform the behavior in question (Oztekin et al. 2017; Shi et al. 2017). Among these three antecedents in TPB, PBC is a special one because it is assumed to directly impact both intentions to perform a particular behavior, as well as the actual performance of that behavior (Madden et al. 1992). TPB has been one of the most influential and widely cited models of individual behavior in social psychology (Armitage and Conner 2001), and has received good empirical support in applications in a variety of domains, such as technology (Gupta et al. 2015; Riemenschneider et al. 2011), consumer choices (Mirkarimi et al. 2016; Scalco et al. 2017; Yadav and Pathak 2016), and politics (Casper 2007). Based on the TPB, the following hypotheses were made:

H1.1 Attitude had significant influence on coping behavioral intentions.

H1.2 Subjective norm had significant influence on coping behavioral intentions.

H1.3 Perceived behavioral control had significant influence on coping behavioral intentions.

H1.4 Perceived behavioral control had significant influence on coping behaviors.

H1.5 Coping behavioral intention had significant effect on coping behaviors.

2.2 Risk perception and coping behaviors

Risk perception is the subjective judgement that people make about the characteristics and severity of risks, i.e., public attitudes and intuitive judgments of risks (Slovic 1992). Numerous studies had been devoted to explore the relationship between risk perception and protective behaviors (Bellrose and Pilisuk 1991; Burns and Slovic 2012; Cabrera and Leckie 2009; Ivers et al. 2009; Paalosalo-Harris and Skirton 2016) and found a positive association, e.g., Yang et al. (2014) found that both perception of risk duration and risk influence have significant positive effects residents' willingness to pay for CO2 mitigation. In the same vein, Oltra and Sala (2016) questioned 1202 residents and noticed that self-reported attention to air quality plays an important role in residents' self-protective behavior. Furthermore, Wang et al. (2019) revealed that risk perception of climate change is one of important predictors of residents' intention to submit an environmental complaint. Therefore, it is reasonable to say that people with higher risk perception might be more urgent to reduce the health risks and showed a higher level of individual coping behavioral intention than people with lower risk perception. The following hypothesis was made:

H2 Risk perception had significant influence on coping behavioral intentions.

2.3 Risk perception and the theory of planned behavior constructs

Considerable studies also explored the relationship between risk perception and the TPB constructs (Haque et al. 2012; Mullan et al. 2013). A significant correlation between risk perception and attitude (Carlton et al. 2016; Mou 2017), and perceived behavioral control (Deroche et al. 2012; Mullan et al. 2013) has been observed. People with higher risk perception would have stronger motivation to protect themselves and have more positive attitudes toward the coping behaviors (Lin et al. 2016; Ram et al. 2016), and always perceive the risk to be less controllable and show lower perceived behavioral control than people with lower risk perception (White et al. 2018). In addition, risk perception has also been observed to have a significant correlation with subjective norms (Kahlor 2007; Noh et al. 2016). Risk perception is easy to be influenced by the informal communication between families, friends, or colleagues (Zhu et al. 2014). In other words, if individual perceived a high risk, their families and friends would perceive a high risk. We can expect that individual would perceive high pressure to perform coping behaviors if their families and friends have a strong motivation to reduce the health risks. Therefore, people with higher risk perception would perceive a higher social norm than people with lower risk perception (Haque et al. 2012). Therefore, the following hypotheses resulted:

H3.1 Risk perception had significant influence on attitude.

H3.2 Risk perception had significant influence on the subjective norm.

H3.3 Risk perception had significant influence on perceived behavioral control.

2.4 The effect of income on coping behaviors and risk perception

Income is one of the most important personal socioeconomic characteristics that were used to explain the variance of behavior and behavioral intention in many studies (Liu et al. 2013; Oltra and Sala 2016; Oztekin et al. 2017). Considerable studies found that the rich have a higher level to invest to the environmental defensive strategies to reduce the damage caused by air pollution, e.g., purchasing air purifier (Sun et al. 2017; Zheng et al. 2014), and a higher willingness to pay for air quality improvement than the poor (Sun et al. 2014; Wang et al. 2016). Accordingly, did the richer show a significantly higher level of all types of coping behaviors than the poor?

In addition, income was also used to explain the difference of risk perception in many studies. However, the effect of income on risk perception remained contentious. Bickerstaff et al. (2001) found that middle-income people show a more intense concern on air quality than other groups. Brody et al. (2010) and Kim et al. (2012) found that the richer always shows a higher concern on air quality. Thus, the following hypotheses were presented:

H4.1 People with higher income would show a higher level of coping behaviors.

H4.2 People with higher income would show a higher level of coping behavioral intentions.

H4.3 People with higher income would perceive higher health risks posed by haze pollution.

In summary, the theoretical model and hypotheses are presented in Fig. 1.

3 Methods

3.1 Questionnaire survey

The study design is shown in Fig. 2. The data for this study were compiled from responses to a questionnaire. The initial questionnaire was designed based on the summary of previous studies (Liu et al. 2017; Shi and Fan 2017; Shi and Wang 2017) and an interview with 20 respondents, and was piloted on residents in the area surrounding the Renmin University of China in June 2016 and was revised according to the feedback of 80 respondents on the understanding of the choice tasks and the duration of the survey. Subsequently, we commissioned a large network survey company to deliver the questionnaire randomly in its sample database in Beijing in July 2016. The respondents were restricted to living in Beijing for more than 2 years to ensure that respondents have a good understanding of the air pollution situation.

The questionnaire was organized into four sections. The first section introduced the situation of PM2.5 in Beijing and related knowledge of the health risks posed by PM2.5 to further ensure that respondents have basic knowledge about PM2.5.

The second section mainly investigated respondents' risk perception and began with respondents' opinions of air pollution in Beijing during the past 2 years. Public risk perception could be better described through individual judgment of risk characteristics. Based on psychometric paradigm, twelve risk characteristics from the studies of Slovic (1987) and Lazo (2000) were investigated using a five-point Likert scale. The details and summary statistics are presented in Table 1.

The third section explored respondents' four coping behaviors, i.e., wearing a mask when go outside (WM), purchasing air purifier (PAP), purchasing new energy vehicles

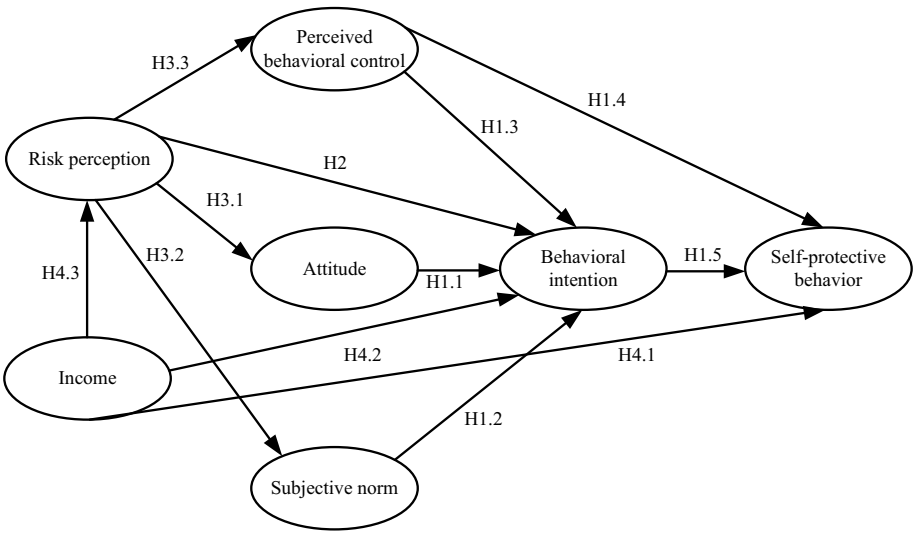

Fig. 1 Theoretical model and hypotheses

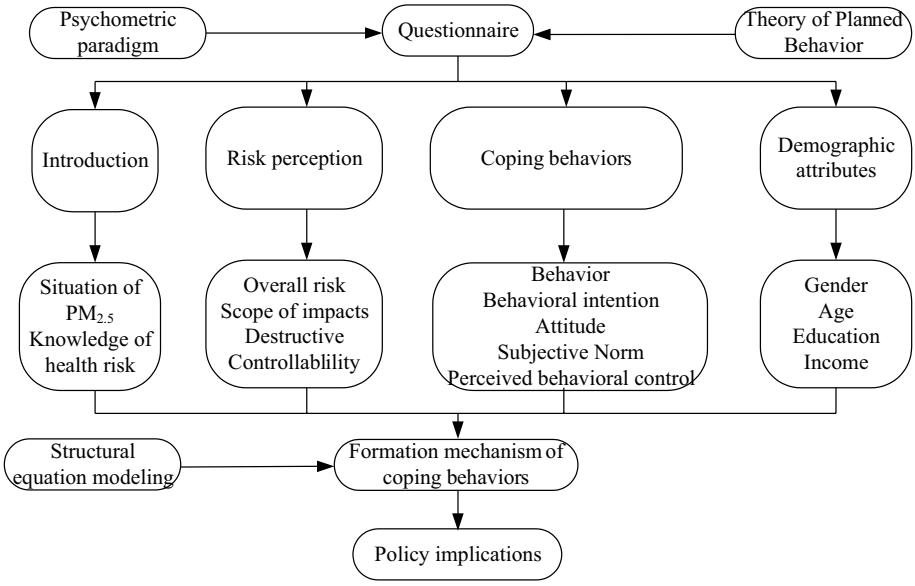

Fig. 2 Study design

(PNEV), making a real-time report of air pollution incidents to the government (MRR). WM and PAP are two typical behaviors of "inverted quarantine." But there are significant differences of the cost between WM and PAP. PNEV and MRR could not be identified as "inverted quarantine." The effect of WM, PAP and PNEV on reducing the health risks depended almost entirely on individual behavior. The effect of MRR did not only depend on residents' own behavior, but is more dependent on government actions. In summary, we chose these four coping behaviors because there are significant differences among four coping behaviors. According to the TPB, each behavior could be divided into five aspects: behavior, behavioral intention, attitude, subjective norm, and perceived behavioral control. The options of the behaviors of WM and MRR were set to range from 1 = never perform to 5 = perform almost every time. The options of the behaviors of PAP and PNEV ranged from 0 = didn't buy to 1 = have bought. There are some differences between "willingness" and "intentions." But there is significant positive correlation between "willingness" and "intentions." Therefore, we believed that it is also appropriate to rely on measures of "willingness" to assess "intentions," as used in many studies (Gao et al. 2017; Verma et al. 2018). Therefore, the four coping behavioral intentions were investigated by asking whether the respondents were willing to perform the behavior. The options ranged from 1 = very reluctant to perform to 5 = very willing to perform.

Attitude was investigated by a same question, i.e., rate the effect of behavior on reducing the health risks. The options ranged from 1 = very little to 5 = very big. The subjective norm of four behaviors was investigated by asking respondents' judgment about whether family, friends, or media agree the behavior should be carried out. There were huge differences among the measure variables of perceived behavioral control. Perceived behavioral control was investigated according the characteristics of each coping behavior. Perceived behavioral control of WM was investigated by two questions: whether respondents agree that it is trouble for wearing a mask every time and that the quality of masks is difficult to distinguish. Perceived behavioral control of PAP was

Table 1 Residents' perception of the health risks posed by $PM_{2.5}$

Variables	Description	Options (1 to 5)	Mean	SD	Factor 1	Factor 2	Factor 3
Familiarity	How much you know about the risks of $PM_{2.5}$	(Very little, Very much)	3.53	0.91	0.22	−0.20	**0.73**
Observable	How observable the effects of the risk posed by $PM_{2.5}$ are on human health	(Not at all observable, Very observable)	3.68	0.93	**0.55**	0.00	0.32
Anthropogenic	The health risk posed by $PM_{2.5}$ appear due to human activities	(Strongly disagree, Strongly agree)	4.22	0.86	**0.48**	−0.12	−0.34
Scope of impacts	In terms of size of the area affected, the scope of the effects from $PM_{2.5}$ on society	(Very little, Very big)	4.13	0.65	**0.76**	−0.17	0.06
Overall level of risk	How "risky", you think the risk probability of the health risk posed by $PM_{2.5}$	(Very little, Very big)	4.17	0.70	**0.81**	−0.04	0.15
Destructive	In terms of the extent of health damage, the severity from $PM_{2.5}$	(No serious, Very serious)	4.09	0.70	**0.77**	−0.09	0.00
Duration of effects	The process that $PM_{2.5}$ harm health is a long, continued process	(Strongly disagree, Strongly agree)	4.16	0.71	**0.73**	−0.15	0.09
Relevance to life	How relevant the risk is to your life in terms of the effects of the risk on human health	(No relevance, Closely related)	4.23	0.75	**0.72**	−0.03	0.18
Equitability	How equitable the health risk posed by $PM_{2.5}$ is for all Beijing residents	(Complete inequality, Completely equitable)	3.31	1.03	0.11	0.16	**0.62**
Controllability	How controllable the health risk posed by $PM_{2.5}$ is	(Completely uncontrollable. Completely controllable)	2.76	0.95	0.10	**0.59**	−0.16
Acceptability	How acceptable the risk is in terms of its effects on human health.	(Not at all acceptable, Completely acceptable)	2.56	1.05	−0.23	**0.78**	0.17
Adaptability	How well people can adapt to the risk	(Not at all adaptable, Very adaptable)	2.61	0.94	−0.26	**0.80**	0.1
Variance explained (%)					32.99	13.44	8.65

Factor 1, Factor 2 and Factor 3 show the factor loadings of three components extracted from the factor analysis

The bold font means that the factor loading is greater than 0.4

SD standard deviation

investigated by asking respondents that whether they agree that the cost of purchasing air purifier is too high and that the quality of air purifier is difficult to distinguish. Perceived behavioral control of PNEV was investigated by asking if respondents agree that the charging time of new energy car is too long and that travel distance is too short. Perceived behavioral control of MRR was investigated by four questions: whether they agree that the reporting channel is insufficient, that the reporting process is cumbersome and waste time, that they can't report because of the shortage of professional knowledge, and that information disclosure is at a low level. The options of all the above problems ranged from 1 = strongly disagree to 5 = strongly agree.

The final section was devoted to standard demographic questions on gender, age, education, and personal annual gross income.

3.2 Measures

AMOS 21 was used to analyze the theoretical model. First, many scholars had indicated that risk perception could be divided into different dimensionalities. For example, Slovic (1987) identified two most important dimensions: The first one was dread risk that had a high score in the perceived lack of control, dread, catastrophic potential, fatal consequences, and the inequitable distribution of risks and benefits; the second one was unknown risk that was defined at its high end by hazards judged to be unobservable, unknown, new, and delayed in the manifestation of harm. Lazo et al. (2000) elicited perceptions of 31 risk characteristics and identified four dimensions: "impacts on species and impacts on humans," "avoidability/controllability," "acceptability" and "understandability." Therefore, the latent variable, risk perception, was constructed by the exploratory factor analysis in this paper. We used a two-stage measurement model to measure risk perception according to the result of factor analysis. Factor analysis could be effective for reducing the dimensionality of risk perception, because significant correlations was seen among risk characteristics, e.g., the correlation coefficient between "scope of impacts" and "overall risk" was 0.60 and significance at 5% level. Therefore, the factor analysis with varimax rotation was used to explore the underlying structure of risk characteristics. Three factors with eigenvalues greater than one were retained. The rotation factor loadings are shown in the last three columns in Table 1. Factor 1 comprised 7 scales, "scope of impacts," "overall risk," "destructive," "duration of effects," "anthropogenic," "observable" and "relevance to life," explained 32.99% of the sample variance and could be classified into the factor labeled "impacts on species and impacts on humans" in Lazo's finding. Factor 2 comprised "acceptability," "controllability" and "adaptability," could be classified into "acceptability." Factor 3 comprised "familiarity" and "equitability" and could be classified into "understandability."

Secondly, confirmatory factor analysis was used to examine the proposed theoretical constructs. Each measurement model was estimated and improved based on the criteria that factor loading should be significant and higher than 0.5. The results showed that the risk characteristics of "Anthropogenic," "Equitability," "Controllability" and "Observable" were not meet the criteria and were dropped in the measurement model of risk perception. The measure variable of "quality" was dropped in the measurement model of perceived behavioral control of WM. Other measure variables were preserved in the respective measurement models. Furthermore, the factor loading coefficient of "acceptability" on risk perception was negative, and all other factor loading coefficients were positive.

3.3 Data reliability

Data reliability was tested by Cronbach's α, composite reliability (CR) and the average variance extracted value (AVE). The results showed that the data have a relatively good reliability (Cronbach's $\alpha > 0.63$, CR > 0.77, AVE > 0.52). However, the perceived control in the model of MRR revealed low reliability and validity (CR = 0.74; AVE = 0.41). It is desirable to have higher reliability coefficients, however, many studies have also shown a low reliability, for example, López-Mosquera et al. (2014) reported a relatively low reliability of perceived behavioral control (AVE = 0.36). Finally, the results showed that AVE was greater than the square of the correlation coefficient in the model, which indicated that discriminant validity was good.

4 Results

As network survey could not be submitted if there are nonresponse items, there was no questionnaire with nonresponse items in the final samples. We identified the invalid questionnaire based on the time spent on answering the questionnaire. It might indicate that respondents could not think about the questions or might be influenced by other factors if time spent is too short and too long. According to the result of the preliminary survey, the questionnaires were usually answered between 300 and 1000 s. Therefore, we kept the questionnaires that were answered from 300 to 1000 s. Finally, 920 questionnaires were recycled and 878 questionnaires were screened as effective.

4.1 Social-economic characteristics

The respondents' social-economic characteristics are presented in Table 2. According to the Beijing Statistical Yearbook 2017, the mean of gender, age and education of Beijing residents was equal to 0.50, 3.09, 1.78, respectively. Per capita disposable income was about 52530 CNY/a ($7621/a) in 2016. By comparison, we can see that the survey sample had the characteristics of lower age, higher educational level, and higher income level than the population, which means the survey sample was not perfect as a representation of Beijing residents. The network survey might face the risk of partial bias, but we could exclude the deviation caused by the subjective guidance of the investigator to control the randomness of the sample, compared with the traditional face-to-face survey method (Windle et al. 2011). In addition, many residents were not keen to participate in environmental governance. Our study was more concerned about those who were willing to participate in environmental management. People who were active online were always active in real life. It was another reason that we adapted the network survey.

4.2 Risk perception

Respondents' perception of air pollution situation during the past 2 years was investigated. The result indicated that most respondents (86%) agreed that air pollution was still a serious problem. However, the perception of air quality did not equate to the perception of the health risks posed by air pollution. In addition, there might be huge differences in

Table 2 The respondents' demographic characteristics ($N = 878$)

Variable	Definition	Frequency	Proportion (%)	Mean	SD
Gender	Male = 0	456	51.9	0.48	0.5
	Female = 1	422	48.1		
Age	Below 18 = 1	31	3.5	2.64	0.67
	18–29 = 2	319	36.3		
	30–49 = 3	470	53.5		
	50–69 = 4	55	6.3		
	Above 70 = 5	4	0.5		
Education	Junior high school or below = 1	0	0.0	2.86	0.35
	High school or junior college = 2	126	14.4		
	Bachelor degree or above = 3	752	85.6		
Personal gross income (unit: 1000 CNY/a)	Below 20 = 1	114	13.0	2.88	1.06
	20 to 50 = 2	162	18.4		
	50 to 120 = 3	359	40.9		
	120 to 240 = 4	200	22.8		
	Above 240 = 5	43	4.9		

residents' judgment of different risk characteristics. Respondents gave the highest rating for the risk characteristic of "relevance to life" (mean: 4.23). 38.6% and 48.6% agreed that the health risks were related and closely related to their life, respectively. Respondents gave similar judgment on "scope of impacts," "overall risk," "destructive," "duration of effects," and "anthropogenic." The average value of these risk characteristics was higher than 4. In addition, the average value of "acceptability" was close to the mean of "controllability" and "adaptability," lower than 3. Above results indicated that Beijing residents' perception of the health risks of PM2.5 was at a high level. However, the result of "familiarity" showed that residents did not have a good knowledge of the health risks of PM2.5. Air pollution received considerable attention and became the subject of massive media coverage in recent years (Fedorenko et al. 2016). However, previously residents did not have strong environmental awareness and mastered little environmental knowledge (Fedorenko et al. 2016). Therefore, residents showed relatively high level of risk perception and relatively low degree of understanding.

4.3 Behavior

From Table 3, we can see that four coping behavioral intentions were at a relatively high level. The intention of MRR was the highest (mean: 3.87). The intention of PAP was closed to MRR. 69% and 65.3% indicated that they are intended to perform the behavior of MRR and PAP, respectively. The intention of PNEV was lowest (mean: 3.44). Only 52.1% indicated that they were willing to purchase new energy vehicles. Furthermore, there was a remarkable inconsistency between behavior and behavioral intention. Compared with behavioral intentions, the level of implementation of four coping behaviors was much lower. The situation of PAP (mean: 0.53) and WM (mean: 3.10) was relatively good. Of the respondents, 52.6% had purchased an air purifier, and 39.8% and 5.8% indicated that

Table 3 Descriptive statistics of the TPB constructs of the four coping behaviors

Variables	Mean	SD	Variables	Mean	SD
Wearing a mask when go outside (*WM*)			*Purchasing air purifier* (*PAP*)		
Behavior	3.10	1.06	Behavior	0.53	0.50
Behavioral intention	3.68	1.07	Behavioral intention	3.82	1.04
Attitude			Attitude		
Effect	3.19	1.05	Effect	3.43	0.97
Subjective norm			Subjective norm		
Family	3.87	0.92	Family	3.80	0.93
Friends	3.82	0.90	Friends	3.74	0.90
Media	3.82	0.90	Media	3.70	0.95
Perceived behavioral control			Perceived behavioral control		
Trouble	2.94	1.21	Cost	3.67	1.01
Quality	3.80	1.00	Quality	3.89	0.95
Purchasing of new energy vehicles (*PNEV*)			*Making a real-time report* (*MRR*)		
Behavior	0.13	0.34	Behavior	2.07	1.22
Behavioral intention	3.44	1.07	Behavioral intention	3.87	0.93
Attitude			Attitude		
Effect	3.40	1.02	Effect	3.51	1.13
Subjective Norm			Subjective Norm		
Family	3.40	1.03	Family	3.58	0.94
Friends	3.34	1.04	Friends	3.58	0.99
Media	3.63	1.02	Media	3.82	0.90
Perceived behavioral control			*Perceived behavioral control*		
Charging time	3.91	0.93	Channel	3.94	0.89
Travel distance	3.96	0.90	Reporting process	3.50	1.10
			Professional knowledge	3.38	1.05
			Information disclosure	3.91	0.95

SD standard deviation

they wear a mask with a high frequency or every time, respectively. The situation of PNEV (mean: 0.13) and MRR (mean: 2.07) was quite bad. Only 13.5% indicated that they had purchased new energy vehicles. 48.8% and 14% indicated that they never performed the behavior of MRR or only occasionally, respectively. Only 14.0% and 2.6% indicated that they performed the behavior of MRR with a high frequency or every time.

Respondents were most positive about the effect of MRR on reducing the health risk (mean: 3.51), and were relatively pessimistic about the effect of WM (mean: 3.19). The proportion of respondents who agreed that RMM, PNEV, PAP and WM was effective in reducing the health risks was 54.9%, 47.5%, 50.0% and 41.2%, respectively. Residents might want to improve regional air quality rather than only reduce exposure to air pollution. As a result, resident had more positive attitude toward behaviors, which had positive effect on improving regional air quality. In terms of subjective norm, WM and PAP were at a relatively high level and generally higher than PNEV and MRR. It showed that there was a favorable atmosphere for WM and PAP. In addition, perceived pressures from media of PNEV and MRR were much higher than pressures from family and friends. There had been a lot of publicity, however, did not form powerful environment for PNEV and MRR. Furthermore, in terms of perceived

behavioral control of WM, residents' main concern was the quality of masks. 70.9% agreed that the quality is difficult to distinguish. 61.6% agreed that the cost of air filter was high and 71.4% agreed that the quality was difficult to distinguish. 70.7% agreed that the charging time of new energy car was too long and 74.0% agreed that travel distance was too short. There was huge difference among four measurement of perceived behavioral control of MRR. The proportion of residents, who agreed that the reporting channel was insufficient and that information disclosure was at a low level, was relatively high, 72.8% and 73.3%, respectively.

4.4 Hypothesis testing

Maximum likelihood was used to estimate the structural equation model due to its robustness (Kline 2010). Upon completing the fit improvement process of the measurement models based on modification indices, the theoretical structural equation model was estimated. The results of four behavioral models are presented in Table 4 and Fig. 3. All the four models indicated a satisfactory level of goodness of fit as RMSEA, CFI and GFI were at good fit (RMSEA <0.08, CFI >0.90, GFI >0.90). The model explained 35%, 36%, 13% and 15% of the variance in behavior, explained 38%, 46%, 44% and 34% of the variance in behavioral intention in the model of WM, PAP, PNEV and MRR, respectively.

The results showed that the effect of behavioral intention on the behavior was significantly positive at the 1% level in all the four models, which led us to accept H1.5. Income also showed significant positive impact on the behaviors in the four models ($p<0.01$), confirming H4.1. The effect of perceived behavioral control on behavior was not significant in the model of WM ($\beta=0.03$, $p=0.32$), PAP ($\beta=-0.03$, $p=0.29$) and MRR ($\beta=-0.02$, $p=0.48$), rejecting H1.4. But it was significant at the 10% level in the model of PNEV ($\beta=-0.06$, $p=0.07$).

In addition, the effect of attitude, subjective norm and risk perception on behavioral intention was positively significant at the 1% level in four models as expected, conforming H1.1, H1.2 and H2. The influence of perceived behavioral control on the coping behavioral intentions was significant in the model of WM ($\beta=-0.13$, $p<0.01$), but was not significant in the other models, rejecting H13. Income showed negatively significant effect on the intention of WM ($\beta=-0.15$, $p<0.01$) and the intention of MRR ($\beta=-0.09$, $p=0.01$), did not show significant effect on the intention of PAP ($\beta=0.01$, $p=0.71$) and PNEV ($\beta=-0.02$, $p=0.53$), partially confirming H4.2.

Furthermore, all the influence coefficients of risk perception on attitude and subjective norm were positively significant at the 1% level in the four models, confirming H3.1 and H3.2. Although the influence of risk perception on perceived behavioral control was significant in the four models, confirming H3.3, the influence was negative in the model of WM ($\beta=-0.10$, $p=0.04$) and was positive in the other models. Finally, income showed significant positive impact on risk perception in the four models as expected ($p<0.01$), confirming H4.3.

5 Discussion

5.1 Coping behaviors

In this paper, we investigated respondents' four coping behaviors, i.e., wearing a mask when go outside (WM), purchasing air purifier (PAP), purchasing of new energy vehicles (PNEV), making a real-time report of air pollution incidents to the government (MRR). The survey results indicate that respondents showed a high level of intention of these

Table 4 Results of the structural model of the four coping behaviors based on the expanded theory of planned behavior model

Paths	WM			PAP			PNEV			MRR		
	UE	C.R.	SE	UE	C.R.	SE	UE	C.R.	SE	UE	C.R.	SE
H1.1	0.24	7.36	0.24***	0.37	10.53	0.35***	0.45	12.91	0.43***	0.16	5.66	0.19***
H1.2	0.46	6.14	0.30***	0.41	5.83	0.28***	0.31	4.85	0.18***	0.62	8.92	0.38***
H1.3	−0.12	−4.60	−0.13***	−0.03	−0.62	−0.02	−0.04	−1.01	−0.03	−0.03	−0.69	−0.02
H1.4	0.03	1.00	0.03	−0.03	−1.06	−0.03	−0.03	−1.81	−0.06*	−0.04	−0.71	−0.02
H1.5	0.58	20.58	0.58***	0.21	15.69	0.44***	0.09	8.23	0.27***	0.31	7.53	0.24***
H2	0.74	3.99	0.24***	0.73	4.10	0.24***	1.07	4.27	0.23***	0.74	3.66	0.23***
H3.1	0.51	3.41	0.17***	0.54	3.55	0.19***	1.25	5.29	0.29***	0.74	3.06	0.20***
H3.2	1.13	8.51	0.57***	1.13	8.00	0.55***	1.06	5.78	0.39***	0.74	6.09	0.37***
H3.3	−0.34	−2.11	−0.10**	0.49	4.05	0.29***	0.91	4.55	0.26***	0.41	3.09	0.16***
H4.1	0.13	4.51	0.13***	0.16	12.38	0.35***	0.07	6.24	0.20***	0.34	9.49	0.38***
H4.2	−0.15	−4.64	−0.15***	0.03	0.37	0.01	−0.02	−0.63	−0.02	−0.08	−2.47	−0.09***
H4.3	0.10	6.50	0.29***	0.11	7.71	0.34***	0.09	7.04	0.41***	0.10	7.68	0.40***
RMSEA	0.07			0.06			0.06			0.06		
GFI	0.94			0.94			0.94			0.93		
CFI	0.92			0.94			0.94			0.92		

UE unstandardized estimates; *SE* standardized estimates

*, **, ***Significance at 10%, 5% and 1% level, respectively

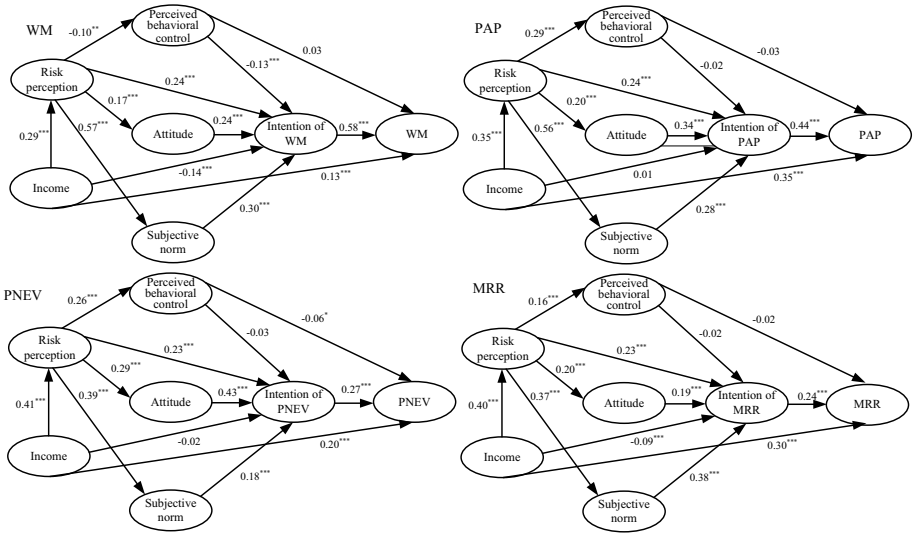

Fig. 3 The standardized estimates of four behavior models

coping behaviors on one hand, but a low level of implementation of coping behaviors on the other hand. The result had a certain discrepancy with other studies. For example Johnson et al. (2017) investigated self-protecting measures taken by Beijing individuals and found that more than 60% have used air purifiers at home and 34% have worn facemasks. The difference was most likely due to the sample difference. The sample in Johnson's study represented people with middle and high incomes. People with higher income might show higher level of coping behaviors (Sun et al. 2017).

5.2 Theory of the planned behavior

We tried to explore the formation mechanism of these coping behaviors by introducing risk perception and income into the theory of planned behavior (TPB), and analyzed the difference of the formation mechanism among different coping behaviors. Firstly, we focused on the variables that had a direct influence on behavior in the TPB, including behavioral intention and perceived behavioral control. It was widely known that behavioral intention had a strong positive effect on behavior (Ajzen 1991; Oztekin et al. 2017). Our study was consistent with these previous findings. However, there was considerable discrepancy among the influence coefficients on behavioral intention to the behavior in the four models. The influence coefficient in the model of WM ($\beta = 0.58$) and PAP ($\beta = 0.44$) was much higher than the powers in the models of PNEV ($\beta = 0.27$) and MRR ($\beta = 0.24$). The effect of WM and WAP on reducing health risks was significant and could appear in the short term. The effects of PNEV and MRR had positive externalities to improve regional air quality, however, was very slow to appear. Therefore, the intention showed bigger impact on behavior in the model of WM and PAP.

Uncertainty existed in the direct effect of perceived behavioral control on behavior. The effect was significant in some studies (Shi et al. 2017), while was not significant in some studies (Li et al. 2018). The result in this research showed that the effect was not significant in the model of WM, PAP and MRR. Most residents might be eager to reduce the health

risks due to excessive attention and worry at present. Therefore, people might perform the coping behaviors without regard to difficult circumstances. For example, perceived behavioral control did not show significant direct impact on the coping behaviors.

Secondly, we focused on the influence of the original constructs of the TPB on behavioral intention. Attitude was found to be a strong influence factor of behavioral intention in many studies (Shi and Fan 2017; Shi and Wang 2017), as shown in our study. The effect of attitude on behavioral intention was positively significant in this paper. It indicated that people with a stronger positive attitude toward the effect of the behavior on reducing the health risks would have a stronger intention. Furthermore, the influence coefficient was relatively higher in the model of PNEV ($\beta = 0.43$) and relatively lower in the model of MRR ($\beta = 0.19$). It indicated that the effect of attitude on intention might be stronger if the effect of these behaviors, which contributed to improve air quality, on reducing risks was more dependent on residents' own behavior. And the influence coefficient in the model of PAP ($\beta = 0.34$) was higher than in the model of WM ($\beta = 0.24$). If the effect of behaviors of "inverted quarantine" on reducing risks was bigger, the effect of attitude on intention might be stronger.

The influence of the subjective norm on intention was not completely confirmed. Some studies showed significant influence (Han 2015), while others was not able to confirm (López-Mosquera et al. 2014; Park et al. 2014). Our study indicated that subjective norm had significant positive effect on behavioral intention. If people felt stronger pressure to perform the behavior from family, friends or the media, their behavioral intention would be stronger. Nor had the effect of perceived behavioral control on behavioral intention been demonstrated. Some authors had cited perceived behavioral control as one of the determinants of behavioral intention (Shi and Fan 2017; Shi and Wang 2017), while others had found no significant link (López-Mosquera et al. 2014; Oztekin et al. 2017). In general, the effect of perceived behavioral control on the coping behavioral intentions was not significant in this paper. It might be caused by that residents might ignore perceived difficulty to perform the coping behaviors, with an exigent mind to reduce the health risks.

5.3 The role of risk perception

Regarding the impact of risk perception on the TPB components, the results showed that risk perception had significant positive impact on the behavioral intentions in the four models. It suggested that people who perceived a higher risk would have a higher behavioral intention, as noted previously by Sun et al. (2016). If people perceived a higher risk, they might be more eager to reduce the risk, therefore, showed higher coping behavioral intentions. In addition, all the influence coefficients of risk perception on attitude and subjective norm were positively significant. It suggested that people with a higher risk perception had more positive attitude and perceive stronger pressure from family, friend and media, as expected. People with higher risk perception might pay more attention to relevant information and might have more positive attitude toward the coping behaviors. People with higher risk perception might affect their family and friends, which in turn could put pressure on themselves to perform the coping behavior (Zhu et al. 2014). However, regarding the impact of risk perception on perceived behavioral control, we did not reach a unified conclusion. Although the influence was significant in the four models, the influence was negative in the model of WM and was positive in the other models. The difference might be mainly caused by the implementation costs of the coping behaviors. People with higher risk perception might get more information, therefore, perceived lower difficulties to perform WM because of low implementation costs, significant

and rapid effect on reducing risks, and amplified the difficulties of performing other three behaviors because of high implementation cost, or slow effect on reducing risks (Sun et al. 2017).

5.4 The role of income

Income was regarded as an important factor of individual behaviors. Most research showed that income had positive effect on willingness to pay for air quality improvement (Akhtar et al. 2017; Sun et al. 2016) or self-protection investment to reduce air pollution exposure (Sun et al. 2017). Our study had uncovered similar results. Income showed significant positive impact on the behaviors in the four models. But the interesting point was the effect of income on behavioral intentions, which was entirely different from the effect of income on behaviors. Income showed significant negative effect on the intention of WM and MRR), did not show significant effect on the intention of PAP and PNEV. It might be caused by that people with different income level wanted to reduce the health risks. As a result, there was no significant difference in the intentions of PAP and PNEV. And it was difficult for the low-income to make up the health damage of air pollution (Sun et al. 2017). Therefore, the low-income might search for low cost methods or depend on governmental actions, and showed a higher intention of WM and MRR. However, due to income restrictions, time and energy constraints, the low-income showed lower level of the coping behaviors. Finally, income showed significant positive impact on risk perception as expected. The rich might have more time and resources on environmental problems and perceived higher health risks.

5.5 Limitations

This study also had some limitations that should be further considered. First, few studies have paid attention to the relationship between risk perception and the theory of planned behavior constructs. Our study showed that risk perception had a significant influence on attitude, subjective norms, and perceived behavioral control. However, it is necessary to further examine the influence at the theoretical and practical level. Second, this research had been conducted only in Beijing, China and only focused on the health risk posed by PM2.5. The theoretical model should be tested in other environmental contexts and regions to ensure the robustness of the results. Similarly, the limitation of the sample—younger and richer—was another limitation of our study. It would be interesting to obtain a more representative population sample by extending it to include old and poor residents. In addition, given the Chinese residents' aversion to completing the questionnaire, we reduced the length of the questionnaire to ensure a high degree of response and accuracy. As a result, some measuring variables need to be investigated further in the future. For example, perceptions of 31 risk characteristics were elicited in Lazo's (2000) study. While only twelve characteristics of the health risk posed by PM2.5 were investigated in this study.

6 Conclusions and managerial implications

6.1 Conclusions

This study investigated Beijing residents' four coping behaviors against the health risks of PM2.5 pollution, wearing a mask when go out, purchasing air purifier, purchasing new

energy vehicles and making a real-time report of air pollution incidents to the government, and introduced risk perception and income into the theory of the planned behaviors to explore the formation mechanism of coping behaviors. The results showed that the actual participation rate of coping behavior against the health risks of PM2.5 pollution was still fairly low, especially for purchasing new energy vehicles and making a real-time report of air pollution incidents to the government. Only 13.5% of respondents indicated that they had purchased new energy vehicles and 48.8% indicated that they never made real-time reports of air pollution incidents to the government. The analyses of four behavior models showed that behavioral intentions, which were the immediate antecedents to coping behaviors, were significantly affected by attitudes ($\beta_{WM}=0.24$, $p<0.01$; $\beta_{PA}p=0.37$, $p<0.01$; $\beta_{PNEV}=0.45$, $p<0.01$; $\beta_{MRR}=0.16$, $p<0.01$), subjective norm ($\beta_{WM}=0.46$, $p<0.01$; $\beta_{PA}p=0.41$, $p<0.01$; $\beta_{PNEV}=0.31$, $p<0.01$; $\beta_{MRR}=0.62$, $p<0.01$;) and risk perception ($\beta_{WM}=0.74$, $p<0.01$; $\beta_{PA}p=0.73$, $p<0.01$; $\beta_{PNEV}=1.07$, $p<0.01$; $\beta_{MRR}=0.74$, $p<0.01$). The effect of perceived behavior control on the coping behavioral intention of wearing masks (WM) was significantly negative ($\beta=-0.13$, $p<0.01$), but was not significant in the other models. In addition, risk perception showed significant effect on attitude ($\beta_{WM}=0.51$, $p<0.01$; $\beta_{PA}p=0.54$, $p<0.01$; $\beta_{PNEV}=1.25$, $p<0.01$; $\beta_{MRR}=0.74$, $p<0.01$;), subjective norm ($\beta_{WM}=1.13$, $p<0.01$; $\beta_{PA}p=1.13$, $p<0.01$; $\beta_{PNEV}=1.06$, $p<0.01$; $\beta_{MRR}=0.74$, $p<0.01$) and perceived behavioral control ($\beta_{WM}=-0.34$, $p<0.01$; $\beta_{PA}p=0.49$, $p<0.01$; $\beta_{PNEV}=0.91$, $p<0.01$; $\beta_{MRR}=0.41$, $p<0.01$). Richer people showed higher level of coping behaviors than the poor ($\beta_{WM}=0.13$, $p<0.01$; $\beta_{PA}p=0.16$, $p<0.01$; $\beta_{PNEV}=0.07$, $p<0.01$; $\beta_{MRR}=0.34$, $p<0.01$), but showed similar or lower level of coping behavioral intentions ($\beta_{WM}=-0.15$, $p<0.01$; $\beta_{PA}p=0.03$, $p>0.1$; $\beta_{PNEV}=-0.02$, $p>0.1$; $\beta_{MRR}=-0.08$, $p<0.01$).

6.2 Managerial implications

This study provides evidence of the internal formation processes of coping behaviors for reducing the health risks posed by haze pollution, especially the influence of residents' sociodemographic profiles and the psychosocial characteristics on the coping behaviors. From the point of management practice, the results had significant implications for policymakers and managers to guide public behaviors and further promote public participation in air pollution control. Based on the TPB, positive attitude and great social stress would help to increase the intention of citizen's coping behavior. Therefore, it is necessary to publicize the positive role of coping behavior in air pollution control, especially for these behaviors which can contribute to improving regional air quality such as making a real-time report of air pollution incidents to the government and to further raise public awareness of environmental protection. Furthermore, we found risk perception have a significant impact on attitude, subjective norm and perceived behavioral control. Increasing the health risks perceived by the residents contribute to raising public participation intention of coping behaviors through risk management. However, people who perceive too high health risks might cause some irrational behaviors. Risk management needs to be carefully considered.

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