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Household adoption of smog protective behavior: a comparison of two Chinese cities

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Abstract

This study compares residents of two Chinese cities – one with a high risk and one with a low risk of air pollution, in terms of their smog experience, reliance on smog information sources, risk perception, attribution of responsibility and intention for adoption of protective behavior regarding smog. The results indicate that the two cities differ considerably in their smog experience, somewhat less so in reliance on smog information sources and risk perception, and very little in protective behavior. Using multiple regression analyses the study revealed a basic chain of reaction in which demographic characteristics and location cause smog experience and smog information, smog experience and smog information cause risk perception, risk perception causes attribution of responsibility, and attribution of responsibility causes intention to adopt protective behavior. Theoretical and practical implications are discussed and recommendations for further research are suggested.

Keywords: smog, risk perception, attribution of responsibility, protective behavior

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Introduction

On 28 February 2015, the Chinese journalist Jing Chai produced an environmental documentary entitled "Under the Dome" about her own expense and uploaded it on the website of People's Daily Online (http://www.people.com.cn/). Three important issues related to smog were discussed in this documentary: compositions of city smog, sources of smog in China and what the Chinese residents can do during smog episodes. The documentary touched people and received more than one hundred million views online within 24 hours. As described in the video, the frequently occurring city smog, especially since 2011, makes the vision of a blue sky and white clouds an extravagant hope for China. A green paper on climate change published by the Chinese Academy of Social Sciences points out that smog has hit a historically record level, and at present China is experiencing the most serious air pollution since 1961 (Wang and Liu 2014).

The serious and frequent occurrence of smog can harm human health when individuals are exposed to pollution for a long time which forces them to seek refuge behind surgical masks (Wei et al., 2009). In a bid to tackle the serious air pollution, the Chinese government has undertaken many endeavors (Wei et al., 2012, 2014a). For example, on 22 October 2013 Beijing officials announced a raft of emergency measures, including mandatory factory closures and ban on cars entering the city on days when pollution levels are particularly high. In addition to governmental countermeasures aimed at curbing pollution, public institutions increasingly recognize the importance of raising awareness among individuals and encouraging behavioral responses to smog, including reduction in private car use.

Compared to other types of risks, particularly those associated with natural hazards, individual risk regarding smog is highly related to the way one is exposed to it (Prescott-Clarke 1982; Zeidner and Shechter 1988). Different people react differently when faced with city smog but to date there has been no research developing a clear profile of the households' risk responses to air pollution. The main focus of this study is to gain a better understanding of the influence the level of risk exposure to smog has on people's perception and behavioral responses. We analyze this within the settings of two Chinese cities with different levels of air pollution. One is Hefei – a high risk city because of frequent occurrence of smog, and the other is Chizhou – a low risk city with few occurrences of smog. The study explores whether the households in both cities differ in aspects of smog risk perception and intention to adopt protective behavior. Furthermore, we apply the Protective Action Decision Model (PADM) to predict people's behavioral responses to smog from a risk information perspective. Based on PADM, a basic protective action chain is proposed where demographic characteristics and location cause smog experience and smog information, these causing risk perception, which causes attribution of responsibility, and the latter causing protective behavior.

The article begins with a review of the theoretical framework and previous studies on people's behavioral responses in risk situations. Two hypotheses are then formulated. The subsequent section describes the study areas, sample and measures used in the analysis. This is followed by a presentation of the results from the study. A discussion of the findings with implications, limitations and recommendations for future research concludes the paper.

Literature Review

Although city smog in China is a relatively new phenomenon and people's reaction to it requires proper understanding, risk analysis associated with natural hazards and threats is an established area of research. Several bodies of literature are relevant to the analysis of household protective behavior against urban pollution. They relate to: how decisions are made when people perceive danger; the influence of demographic characteristics; the importance of previous experience; exposure to risk, including the role played by information; the role of risk perception and attribution of responsibility. A brief overview is presented below before we explain the hypotheses which form the basis of this study.

Making Decision about Protective Action

Protective actions are defined by Burton (1993) as those which intentionally or unintentionally aim to decrease the risk caused by extreme events derived from the natural or social environment. A model developed in the 1990s, namely the Protective Action Decision Model (PADM) by Lindell and Perry (1992, 2004), helps explain people's adoption of protective actions to threatening events. It was created based on analysis of responses to environmental hazards and disasters (Lindell and Perry 2012). The model can be used to account for people's decisions in response to imminent disasters (Lindell and Perry 1992) or long-term threat (Lindell and Perry 1992, 2004). It emphasizes that people's exposure to external risk information regarding hazards, including social and environmental cues, and their prior beliefs based on past personal experience interact to stimulate risk perception and behavioral responses (Lindell and Hwang 2008). In 2012, Lindell and Perry revised PADM from an information flow perspective. This revised model describes the decision-making process of people's protective behavior from exposure to environmental and social context to psychological processes, in turn to behavioral response (Lindell and Perry 2012). The emendatory PADM is better suited for explaining the psychological process during people's behavioral decision-making in risk situation. Research has shown that PADM can be applied to predict behavioral responses during earthquake, flood, hurricane and toxic chemical release (Lindell and Prater 2002; Lindell and Hwang 2008).

Demographic Attributes

According to PADM, demographic characteristics affect people's risk perception and behavioral responses to extreme events (Lindell and Perry 2012). In environmental risk research, characteristics such as age, sex, education, marital status and income, have typically been viewed as potential exploratory factors about perception and behavioral responses to risk (Gatersleben, Steg, and Vlek 2002; Skov et al. 1991). Previous studies indicate that gender plays a significant role in people's sensitivity to risk (Flynn, Slovic, and Mertz 1994; Slovic 1999). Women express higher levels of concerns about technologies posing risk of contamination (Davidson and Freudenburg 1996). Furthermore, they are more inclined to reduce outdoor activity and avoid car driving during smog episodes (Skov et al. 1991). People who are divorced and with low income have a tendency towards systematic overestimation of risk (Boholm 1998). Those with higher level of education are more likely to take action to mitigate the environmental risk of climate change (O'Connor, Bord, and Fisher 1999; O'Connor et al. 2002). Older respondents are apt to adopt behavioral responses to climate change by purchasing energy-efficient light bulbs and closing unused lights (Whitmarsh 2009).

Experience of Risk

As described in PADM, the perceived risk and behavioral responses are correlated with the recency, frequency and intensity of the individual's risk experience (Ge, Peacock, and Lindell 2011; Lindell and Hwang 2008). Such experience of casualties or damage caused by hazards can be own or that of relatives, friends, neighbors and peers (Lindell and Hwang 2008). Risk experience creates cognitive biases resulting in higher rate of concern and perception about the potential danger (Grothmann and Patt 2005). The link between people's protective behavior and risk experience has been confirmed in relation to natural hazards, such as flood, hurricane and earthquake (Lindell and Hwang 2008; Harries and Penning-Rowsell 2011; Ge, Peacock, and Lindell 2011; Lindell and Prater 2000). In the environmental risks literature, personal experience has also been shown to play an important role for perception but also in stimulating people to take actions (Whitmarsh 2008; Skov et al. 1991).

Personal experience of a natural hazard is to a certain extent different from that of air pollution where short- and long-term health effects (e.g. respiratory symptoms) are most important. According to the study by Skov et al. (1991), lung disease respondents tended to protect themselves from air pollution through avoiding outdoor activities more so than healthy people.

Whitmarsh (2008) found that people's experience of health effects from air pollution significantly impacts their risk perception and behavioral responses to climate change.

Risk Exposure

Risk exposure is another significant influencing factor on people's responses to potential and existing threats. In the 1980 study by Slovic, Fischhoff and Lichtenstein (1980), personal exposure acted as a predictor of and posed positive effects on risk perception. The positive relationship between personal exposure and perceived risk was also indicated by Marks and von Winterfeldt (1984) in which they described the not-in-my-backyard (NIMBY) phenomenon. Lindell and Prater (2000) reveal that residents in areas with high seismic hazard are more likely to adopt risk adjustments than those in places with lower earthquake probability. Botzen and van den Bergh (2012) indicate that residents living near a main river prefer to adopt mitigation measures against inundation.

There is however inconsistent relationship between exposure and perception of risk in previous environmental studies. Although positive correlation is to be expected, a negative relationship was identified in the study by Weber et al. (2001) which examined two communities – one with heavy metal contamination and the other without. The people in the heavy metal contaminated area perceived lower risk than those in the area without contamination. Similar conclusions were also reached by Grasmück and Scholz (2005). In the context of air pollution, personal exposure has consistently been confirmed to impact public awareness (Prescott-Clarke 1982; Zeidner and Shechter 1988) which might trigger protective actions.

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Information about Risk

Socially transmitted information about potential dangers is also an important explanatory variable for risk perception and behavioral responses (Brenkert-Smith et al. 2013; Basolo et al. 2008; Wei et al., 2014b). Information about risk plays a major role not only in the subjective recollection of previous personal experience, but also in influencing those without such direct exposure (Wachinger et al. 2013; Shaw, Kobayashi, and Kobayashi 2004; Wei, Zhao and Liang, 2009). Kasperson et al. (1988) talk about social amplification of risk (SAR) referring to the effects of the broader psychological, social, institutional and cultural processes affecting people's perception and behavioral responses. Information can amplify the perceived social effects of risk on human health (Kasperson et al. 2000).

Risk information has also been considered a vital predictor of responses to environmental hazards (Grothmann and Patt 2005; Lindell and Hwang 2008). For example, Grothmann and Patt (2005) found that the perceived risk regarding climate change is impacted and shaped by the information people hear in the media, from peers (such as friends, colleagues, and neighbors) or public agencies. Lindell and Hwang (2008) show that perception of chemical risk is significantly related to people's reliance on information sources including news media, peers, the Internet and authorities.

Risk Perception

In PADM, risk perception is a core factor of behavioral responses to environmental risk (Lindell and Perry 2012). Here risk perception refers to people's expectations of the adverse physical and social impacts caused by an environmental event (Lindell and Hwang 2008). The positive effects of risk perception on individuals' responses to warnings and adoption of protective behavior in threatening situations have been argued in many previous studies (Ruin, Gaillard, and Lutoff 2007; Hung, Shaw, and Kobayashi 2007). In the context of air pollution, individuals who believe it leads to real threats to their health prefer to take measures to deal with it and to protect themselves (Evans et al. 1988). Whitmarsh (2009) indicated that the insufficient behavioral responses to climate change amongst the UK public might be due to its lack of perceived threat from the issue. Based on the Protection Motivation Theory (Rogers 1983; Rogers and Prentice-Dunn 1997), Grothmann and Patt (2005) developed a process model of private proactive adaptation to climate change in which risk perception plays a vital role in motivating intentions.

Attribution of Responsibility

Attribution of responsibility is also an important predictor of people's behavioral responses as described in PADM (Lindell and Perry 2012). The perceived protection responsibility can be understood as people's perception of the obligations different stakeholders have to respond to and protect them from disasters (French and Raven 1959). Previous research evidence suggests that people prefer to attribute responsibility to government and business for addressing the air pollution issue (Freudenburg 1993). Qualitative studies also show that people's behavioral responses are impacted by attribution of responsibility in risk situations. In the case of climate change for example, the perception of responsibility for causing and mitigating it was confirmed to have significant effects on people's intentions about taking actions (Bibbings 2004; Darier and Schule 1999; Stoll-Kleemann, O'Riordan, and Jaeger 2001). Furthermore, research indicates that perception about individual protection responsibility leads to a higher level of hazard adjustment in the natural risk contexts, such as earthquakes, tornados and volcanoes (Lindell and Whitney 2000; Mullis, Duval, and Rogers 2003; Perry and Lindell 2008).

Perceptions about threat, protective action and stakeholder responsibility are psychologically the basis for people's decisions about behavioral response (Lindell and Perry 2012). Although PADM did not assume any particular relationships between these three core discernments, the correlation of risk perception with attribution of responsibility in threat situations was indicated by many previous studies. For instance, Weiner (2006) highlighted the importance of the perceived controllability of risk to predicting responsibility attributions. Sellstrom et al. (2000) reported a positive correlation between mothers' perceived risk of injury and attributing responsibility to the child. In a similar vein Rickard (2014) pointed that perceived controllability of park-related risk is significantly associated with attribution of responsibility.

The relationship between attribution of responsibility and behavioral response has not yet received a lot of academic attention in the context of air pollution and household responses. Thus, it is interesting to explore whether attribution of responsibility has significant effects on people's behavioral responses to smog.

Hypotheses of the Study

The Protective Action Decision Model (PADM) has not yet been used to explain people's protective behavior in the specific context of air pollution. It should however also be applicable in this case because of the following reasons. First, the proposition of PADM is based on research about people's responses to environmental hazards and disasters which generally include air pollution. Second, according to PADM people present similar psychological processes of behavioral decision-making, namely from receiving information to risk perception and behavioral response, in different situations of danger (Lindell and Hwang 2008; Lindell and Perry 2012) and air pollution poses a threat to human life alike.

In this study we intend to address the role of risk associated factors in predicting people's perception and behavioral responses to air pollution. Based on previous research about people's risk perception and behavioral response to environmental risks, the following hypotheses informed by PADM can be formulated:

- Hypothesis 1: Compared to residents in a low risk city, those residing in a high risk city have significantly different levels of smog experience, air pollution information, risk perception, attribution of responsibility and intention of adopting protective behavior.
- Hypothesis 2: There is a causal chain composed of these variables in which (a) demographic characteristics and location cause smog experience, (b) smog experience and smog information cause risk perception, (c) risk perception causes attribution of responsibility, and (d) attribution of responsibility causes protective behavior.

They are explored in the sections below.

Method

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The study tests the above hypotheses in two Chinese cities in Anhui Province. It uses correlation analysis to investigate a proposed causal chain to explain households' protective behavior in response to urban smog. The study areas and ways of measuring the households' responses are explained in this section while the results from the analysis are presented in the section to follow.

Study Areas and Sample

The two cities used to analyze behavioral responses to smog have different levels of air pollution and they are Hefei and Chizhou in Anhui Province of China. Hefei is the provincial capital and is located in the midpoint of Anhui. In recent years, Hefei is playing an increasingly important role in the development of Anhui Province. China's rapid economic and social development has attracted a lot of attention. Hefei described as one of the top 20 emerging powerhouses in China (The Economist Intelligence Unit 2010) and the world's fastest growing metropolitan economy in 2012 (The Economist 2012), has been a large contributor to both economic prosperity and air pollution. Together with the fast growth in population which reached 8 million in 2014, the number of motor vehicle also increased to more than 1.2 million by the end of the same year. Automobile exhaust gases together with coal burning power stations contribute to the deteriorating city air quality and frequent smog episodes. By contrast, Chizhou located in the southwest of Anhui Province and bordered by the Yangtze River to the north, is a tourist city with good air quality. This city is similar to other places with advanced tourism industry in Southern China, such as Haikou, Zhoushan, Lhasa, Shenzhen, Zhuhai, Huizhou, Fuzhou, Xiamen, Kunming and Zhongshan, which were also had some of the best air quality in 2014 (Ministry of Environmental

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Protection of the People's Republic of China 2014). Hence Chizhou can be seen as exhibiings the typical features of Chinese cities with low level of air pollution. Hefei on the other hand, represents well the smog problems observed in China's large industrial cities.

Smog occurs frequently in Hefei, while such weather seldom takes place in Chizhou. Air quality is consistently worse in Hefei than in Chizhou (see Figure 1). All values of the monthly average PM10 index for Hefei were larger than those values for Chizhou in 2014 (see Figure 1). Moreover, in Hefei all values of the monthly average PM10 index between January and December 2014 were above the annual average concentration limit compared to only two exceeding this boundary in Chizhou.

<Figure 1 about here>

Formal surveys were conducted face to face in both cities. The larger proportion of surveys was allocated for Hefei, namely 700 respondents, than for Chizhou, namely 400 respondents, based on the population numbers. Although a convenient sampling method was used to select the participants, it was ensured the sample distribution was scattered as far as possible and the demographic variables were controlled in the analysis. From all collected questionnaires, 30.7% were not properly completed and the final sample composed of 486 respondents from Hefei and 276 from Chizhou.

A proper human research ethics protocol was followed during the survey. The respondents were thoroughly informed about the nature of the research, assured about the confidentiality of their replies and the academic purpose of the survey. Detailed explanation was also provided for each statement in the questionnaire to make sure respondents properly understood it. A small gift was presented to those who completed the survey questionnaire.

Based on the collected demographic information, analysis was carried out by age, gender, marital status, education and annual household income. The distributions of the two samples are as follows:

• the mean age of the respondents in Hefei was 26.0 years (SD=7.0) while it was 30.0 years (SD=10.1) for Chizhou;

• the percentage of female respondents was 44.0% for Hefei and 47.1% for Chizhou;

respectively. 29.8% and 42.8% of respondents were married in Hefei and Chizhou;

• the median education level was the same for the two samples, that is college graduate (which is four years of formal education after high school);

•. the median annual income was also the same for the two city samples, namely between $4,797 and $11,193 (¥30,000-¥70,000).

Measures

In addition to providing demographic characteristics, the respondents were required to complete a paper-based questionnaire with sequential questions assessing their risk perception, reliance on information sources, smog experience, attribution of responsibility and intention of adopting protective behavior. The way their responses were measured is described below.

Six statements or items were used to measure risk perception, namely: “Smog threatens personal physical health”; “Smog threatens personal psychological health”; “Smog threatens children's growth and development”; “Smog brings threats to personal or family life”; “Smog results in threats to work efficiency and performance" and "Smog causes threats to personal property". The respondents were asked to rate each statement on a 1 (not at all) to 5 (to a very large extent) scale. The Cronbach's alpha for the six risk perception items is 0.804, indicating an adequate internal consistency. Furthermore, smog experience was measured by asking respondents whether they or members of their household have experienced nasal, pharyngeal and respiratory discomfort symptoms during smog episodes.

The reliance on information sources was measured by asking the respondents to rate the extent to which they relied on each of the eight sources to obtain information about smog, namely: local television stations, provincial or national television stations, local newspapers, radio stations, local government news websites, national news websites (e.g. Sina.com, Sohu.com), peers (friends, relatives, neighbors and coworkers) and community information (e.g. ad columns or leaflets). Due to their strong intercorrelations, local television stations, provincial or national television stations, local newspapers, local news websites, national news websites and radio stations were combined into an official information sources scale with a reliability of Cronbach's alpha =0.855. The value of Cronbach's alpha indicated an adequate internal consistency. Peers and community information were combined into an unofficial information sources scale. These two items were highly correlated with r = 0.608.

Attribution of responsibility was measured by rating the nine stakeholders, namely "city environmental protection bureau", "provincial department of environmental protection", "regional environmental protection scientific research institutions", "chief leaders of the city government", "local industrial enterprises", "local building sites, restaurants, motor transport companies etc.", "friends, relatives, neighbors and coworkers", "the public" and "self", according to the extent to which they are to blame. Each of the nine items was measured on a five-point Likert-type scale. According to the nature of attribution and intercorrelations among the nine items, the first six were combined into a non-individual responsibility scale with a reliability of Cronbach's alpha =0.836. The last three items were combined into an individual responsibility scale with a reliability of Cronbach's alpha =0.870. The two values of Cronbach's alpha indicate acceptable internal consistency of both scales.

The intention of adopting protective behavior was measured by asking the respondents to report the extent to which they would adopt actions regarding smog. According to Skov et al. (1991), the actions in response to air pollution expected to be taken by people fall within two categories, namely actions aimed at decreasing the air pollution (e.g. decreasing automobile use) and actions aimed at protecting individuals from the health effects of air pollution (e.g. avoiding outdoor activities). Six protective actions related to smog from both categories were included in the survey, namely: moving to work or live in an area without smog; wearing a mask when outdoor; reducing outdoor activities; using air purifier indoors; paying attention to personal health; and reducing the use of private cars and resource consumption. All items were measured on five-point Likert-type scales. They formed an adoption intention of protective behavior scale with reliability of Cronbach's $\alpha = 0.693$.

Five demographic characteristics, namely age, gender, marital status, education and household annual income were also recorded. Respondent age was measured in years. Gender was described as a dichotomy (male = 0, female = 1) and so was marital status (married = 1, single, divorced or widowed = 0). Education was measured on a five-level scale, namely less than high school = 1, high school = 2, junior college = 3, university education = 4 and graduate school and further = 5. A category variable was used to measure annual household income, with 1 = less than $4,797 (¥30,000), 2 = $4,797–$11,193 (¥30,000–¥70,000), 3 = $11,193–$19,188 (¥70,001–¥120,000), 4 = $19188–$31980 (¥120,001–¥200,000), and 5 =more than $31980 (¥200,000).

Results

The two hypotheses are tested separately with the results showing some differences but also similarities between the two Chinese cities. This section describes the empirical results which is followed be a discussion of the findings.

Test of Hypothesis 1

As predicted by H1, respondents in the high risk city (Hefei) differ significantly from those in the low risk city (Chizhou) in their smog experience (see Table 1). The former are significantly more likely to experience nasal, pharyngeal and respiratory discomfort symptoms during smog episodes themselves or within their families. Also as predicted by H1 there are the differences between the cities in reliance on information sources. Respondents in the high risk city rate their reliance on official information sources for obtaining smog information significantly higher than those in the low risk city. Furthermore, Hefei also displays higher reliance on unofficial information sources than Chizhou.

Again, as predicted by H1 there are the differences between the cities in risk perception. There are however counter-intuitive. The respondents from the low risk city rate their smog risk perceptions significantly higher than do those from the high risk city. This includes threats to personal physical health, threats to work efficiency and performance and threats to personal property. The differences between the cities in perceived risk from threats to personal psychological health, threats to children's growth and development, and threats to personal or family life are not significant. Contrary to what was predicted by H1, there is no significant difference in attribution of responsibility, including related to individual and non-individual responsibility about protection and dealing with smog.

Finally, as predicted by H1, there are significant differences between the two cities in adoption intention for most protective actions. The low risk city has significantly higher levels of adoption intention on three of the six protective actions listed in the questionnaire, namely wearing a mask outdoors, using air purifier indoors, and reducing the use of private cars and resource consumption. Moreover, the respondents from the low risk city are significantly less likely than those in the high risk city to pay attention to personal health. There are non-significant differences in adoption intention for the remaining protective actions.

The dependent variable adoption intention of protective behavior was analyzed using a 2 (location: high risk city vs. low risk city) by 2 (risk perception: high vs. low) by 2 (attribution of responsibility: individual responsibility vs. non-individual responsibility) ANOVA (see Table 2). Location does not have a direct influence on adoption intention, as indicated by the failure to obtain a significant main effect ($F = 1.34$, $df = 1$, $p = 0.247$). In contrast, the main effect of risk perception on adoption intention is significant ($F = 6.17$, $df = 1$, $p = 0.013$). However, attribution of responsibility is not significantly related to adoption intention ($F = 1.77$, $df = 1$, $p = 0.184$).

Risk perception interacts significantly with attribution of responsibility (F = 6.74, df = 1, p = 0.010).

Moreover, location interacts significantly with both risk perception (F = 11.48, df = 1, p = 0.001) and attribution of responsibility (F = 3.05, df = 1, p = 0.081). More specifically, respondents with high risk perception in the high risk city have higher adoption intention than do their counterparts in the low risk city. The opposite result was confirmed by respondents with low risk perception in both cities (see Figure 2). Furthermore, respondents who attributed responsibility to individuals differed in adoption intention in both cities and the level of adoption intention was higher in the high risk than in the low risk city sample. The opposite results of respondents who attributed non-individual responsibility (to government sectors and industrial enterprises) in both cities were also indicated (see Figure 3).

Test of Hypothesis 2

Data related to the mean, standard deviation and bivariate correlations among all variables under study are presented in Table 3. Location correlates positively with smog experience and with reliance on information sources as well as education. It correlates negatively with risk perception, age and marital status. Demographic characteristics correlate significantly with all other variables. More specifically, age correlates positively with perception of individual responsibility and non-individual responsibility. Gender is positively related to reliance on official and unofficial information sources. Marital status correlates positively with smog experience and perception of individual responsibility. Education is negatively correlated with risk perception and protective behavior. Income correlates positively with smog experience and negatively with protective behavior.

As shown in Table 3, smog experience only correlates positively with perception of individual responsibility and non-individual responsibility. Reliance on official information sources is found to correlate positively with perception of individual responsibility and protective behavior. Reliance on unofficial information sources correlates positively with perception of individual responsibility and protective behavior, while it correlates negatively with perception of non-individual responsibility. Risk perception correlates positively with perception about individual responsibility and non-individual responsibility as well as protective behavior. Perceptions about individual responsibility and non-individual responsibility are confirmed to correlate positively with protective behavior.

The obtained correlation analysis results mostly verify the causal chain proposed in the article. Multiple linear regression analysis was conducted to confirm the causal chain and explore the roles of the variables in different stages of this sequence. As indicated in the first column of Table 4, smog experience is predicted significantly by location and marital status. respondents in the high risk city and who are married are more likely to experience health effects during smog episodes. Furthermore, as indicated in the second column of Table 4, people's reliance on official information sources is predicted significantly by location, gender and income: respondents in the high risk city, women and low income respondents rely more on official information sources to obtain information about smog. Further, the third column indicates that the reliance on unofficial information sources is predicted significantly by location, gender and education: respondents in the high risk city, women and those who are less-educated rely more on unofficial information sources to obtain information about smog.

As indicated in the fourth column of Table 4, risk perception is furthermore predicted significantly by reliance on official information sources, location and education. More specifically, respondents who rely more on official information sources, are in the low risk city and are less-educated have higher risk perception. The fifth column indicates that individual responsibility is predicted significantly by risk perception and also by location, age, smog experience and reliance on official and unofficial information sources: respondents with higher risk perception in the low risk city, older, with smog experience and who rely more on official and unofficial information sources, attribute more responsibility to individuals for protection and coping with smog. Moreover, as indicated in the sixth column, non-individual responsibility is predicted significantly by risk perception and also by age, education, smog experience and reliance on official and unofficial information sources. More specifically, respondents who have higher risk perception, are older, more educated, with smog experience, more reliant on official information sources and are less reliant on unofficial information sources, attribute more responsibility to government sectors and industrial enterprises for protection and dealing with smog.

Finally, protective behavior is predicted by perception of individual responsibility and risk perception, and it also is predicted by education, income and reliance on official information sources. In detail, respondents who attribute more responsibility to individuals for protection and dealing with smog, have higher risk perception, are less-educated, have low income and rely more on official information sources, have higher levels of adoption intentions of protective behavior related to smog.

In summary, the analysis of the empirical results supports the causal chain proposed in H2. Each of the hypothetical relationships in the chain is confirmed except for the link from smog experience to risk perception. In addition, additional relationships which were not assumed in the study are also revealed by the regression analyses. Hence, the variables in the casual chain only partially mediate the links.

Discussion and conclusions

The purpose of the study is to explore the differences in individual risk responses to smog in two cities with different levels of air pollution – Hefei with a high level and Chizhou with a low level of pollution. In order to identify key variables influencing behavioral responses to smog, a casual chain is constructed. The results provide support for the two hypotheses. With regard to H1, the respondents from the two cities are significantly different in their reliance on information sources, smog experience, risk perception and protective behavior. The respondents from the high risk city had higher levels of reliance on both official and unofficial information sources to obtain smog information and they were more likely to suffer from health effects caused by air pollution.

However, the respondents from the high risk city have significantly lower levels of risk perception. It seems that people who constantly face certain threats judge themselves as being at a lower risk. This finding is consistent with previous studies on heavy metal soil contamination (Weber et al. 2001; Grasmück and Scholz 2005). Three possible reasons may contribute to this phenomenon. First, respondents who seldom experience smog may be forming their perceptions based on information from various channels (e.g. mass media and Internet) which cover extreme air pollution accidents with pictures or warning commentaries. The media agenda may significantly affect public risk perception. Second, risk perception is an individual's subjective assessment of danger and is impacted by various factors. It may not be consistent with the objective external environment. Third, respondents in the low pollution city do not have sufficient risk cognition which may result in higher risk perception.

Significant interaction effects between location and risk perception, location and attribution of responsibility on protective behavior are also revealed in the results. The residents who have higher risk perception from the high risk city (Hefei) sample have higher adoption intention of protective behavior than those with high risk perception in the low risk city (Chizhou) sample. In contrast, those with low risk perception in Chizhou (the low risk city) have higher adoption intention than those with low risk perception in Hefei (the high risk city). Furthermore, the results reveal that respondents who attribute responsibility to individuals have higher adoption intention in high risk than in low risk conditions. In contrast, those who attribute responsibility to government sectors and industrial enterprises have higher adoption intention in low risk versus the high risk conditions.

Hypothesis H2 is also significantly supported by the survey. The results however are more complicated than for H1 with some unanticipated relationships. As expected, smog experience is predicted significantly by location indicating that respondents in the high risk city experience more health effects from air pollution because they were exposed to it more frequently. The results reveal that marital status (namely married respondents) is positively related to smog experience.

Also in accord with H2, reliance on information sources is significantly predicted by location and demographic characteristics. More specifically, respondents of the high risk city rely more on both official and unofficial information sources to obtain information about smog. As respondents from the high risk city experience smog more frequently, they need more information to guide their decision to take actions to protect themselves and respond to pollution. Also, women and respondents with a low income are more reliant on official information sources while women and low educated respondents are more reliant on unofficial information sources. The results further show that the social-economic status of the respondents is related to their reliance on information sources.

Significant effects of official information sources on risk perception are also confirmed. The study however failed to find significant impacts of smog experience on risk perception. Respondents relying more on official information sources have higher risk perception. It is also notable that location is negatively related to risk perception with respondents from the low risk city having higher risk perception. In addition, education is also found to be negatively related to risk perception. The finding that less-educated people show higher levels of risk perception is consistent with previous studies (e.g. Armas and Avram 2009).

Significant influence of risk perception on attribution of responsibility is strongly supported. The respondents' high perception of risk and threat contributes to the attribution of responsibility to stakeholders, including individuals, government sectors and industrial enterprises, to deal with and protect from smog. However, smog experience and smog information also have significant regression coefficients suggesting that these variables have effects on attribution of responsibility that are not mediated by risk perception. Moreover**,** location also has a negative effect on perception of individual responsibility indicating that the respondents from the low risk city have higher perception of individual responsibility. In addition, age is significantly related to both people's perception of individual responsibility and non-individual responsibility, while education is significantly related to only their perception of non-individual responsibility.

Finally, consistent with H2, intention to adopt protective behavior is impacted by perception of individual responsibility and risk perception. Also people's reliance on official information sources, education and income have significant effects. The results indicate that people's views about protection from and dealing with smog being individual responsibility lead to high levels of intention to adopt protective measures. The role of perception of individual responsibility in stimulating protective behavior is also indicated in previous studies (e.g. Lindell and Whitney 2000). Furthermore, respondents with higher risk perception are more likely to adopt protective behavior. The fact that risk perception plays a significant role in individuals' behavioral responses to risk is confirmed by many previous studies (e.g. Ruin, Gaillard, and Lutoff 2007; Hung, Shaw, and Kobayashi 2007). Risk perception is also the variable which explains the most variance in protective behavior in this study.

The statistical significance of reliance on official information sources indicates that its effects on protective behavior are not completely mediated by risk perception and attribution of responsibility. In fact, reliance on official information sources has a higher correlation with protective behavior (r=0.196) than with perception of individual responsibility (r=0.221) and risk perception (r=0.046), which would result in the mediating effects. Among the demographic characteristics, the leading factor is education, followed by income. Less-educated respondents are more likely to take protective behavior because they have higher smog risk perception as indicated by the regression results. The negative effect of income is somewhat surprising because most of the protective behavior included in the article involves little or no cost except moving for work or living to an area without smog. In contrast to previous studies which found a positive effect of income (e.g. Zaalberg et al. 2009) the opposite result here is rather difficult to explain. One possibility is that previous studies focused mainly on natural hazards such as floods and earthquakes that are different in nature from smog. The results indicate that the effects of income on protective behavior are distinct in different risk situations and this needs further explorations in future research.

It is important to acknowledge that this study has its limitations. First, the samples were drawn from Hefei and Chizhou in China, hence the generalization of the results is constrained. There are also questions that arise from the measurement of the perceived personal risk. In this study, risk perception was measured by threats to people's health and property caused by smog. There are still other components of risk perception that were not measured – for example, people's perceptions of hazard likelihood, outrage factors and institutional trust (Weyman, Pidgeon, and Walls 2006). Future research could endeavor to widen the meaning of risk perception. In addition, mediating effects are also revealed by additional unpredicted relationships that were not the focus of the study. Further studies of the mediating effects can be undertaken in the future.

Notwithstanding these limitations, this study does have theoretical implications. First, it explored the role of risk exposure in people's risk response to smog which has not gained a lot of scholarly attention. The results confirmed that the way one is exposed to smog has significant effects on smog experience, reliance on information sources, risk perception and protective behavior. Second, the study applied PADM to explain people's behavioral responses to smog from a risk information perspective. This model provides a way to understand people's risk responses to smog from a new perspective. Although PADM is used for the first time in air pollution context, similar psychological processes of people's decision-making are present in different risk situations making its application appropriate. The results of the study extend the applied range of PADM from natural hazards to environmental risks, such as air pollution.

The study's findings also have practical implications. Firstly, the results imply that the respondents in both cities generally have relatively low intention to adopt protective behavior. Paying attention to personal health is the most popular action in both cities with Hefei and Chizhou respondents rating it respectively as 3.87 and 3.68 on a five-point scale. On average, the respondents believed that through caring for personal health, they would be better able to protect themselves and their families from the smog's consequences. Although households were being advised by local government during smog episodes to wear a mask outside and reduce outdoor activities, the respondents had relatively low intention to adopt such a behavior in the near future. Their intention to adopt other protective behavior was also low. People's perception about protective behavior, including hazard related attributes and resource related attributes, contributes to the different popularities of protective behavior (Terpstra and Linedell 2013). More understanding about which protective actions are effective and the expected effects of these actions is needed if local government wants to encourage the adoption of protective behavior among individuals. Measures facilitating households to adopt protective behavior are also necessary. For instance, local government can cooperate with manufacturers to distribute masks free of charge to local residents. Further subsidies can encourage people to purchase hybrid or electric vehicles.

The study also found that compared to the respondents from the low risk city, those in the high risk city have lower risk perception. It appears that the frequent occurrence of smog reduces people's perceived threat and danger from air pollution. Hence, more efforts should be made, particularly by the government, to communicate the negative impacts of smog to people at the outset of the incidents in order to increase their risk perception. More effective communication about individual responsibility in protection and dealing with smog will need to stimulate people's protective actions. In practical terms, increasing awareness about responsibility and guiding changes in individual behavior are vital measures. A particular effort should be made by government to encourage people to choose more environmentally friendly means of transportation, including the use of public transport.

The significant effects of risk perception indicate that communicating information regarding smog is likely to be effective in stimulating protective behavior with sources of smog information also playing a significant role in predicting protective behavior. As the study found that official information sources impact positively protective behavior, local government should be releasing information about the risk of smog, responsibility and protective behavior through means, such as national television stations and national news websites. This will encourage people to adopt protective behavior in response to smog.

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With air pollution being a significant problem is China, the focus of economic development and environmental protection should be to reduce and even eliminate the causes for city smog. While this remains part of the bigger picture of industrialization, economic progress and quality of life, the findings of this study allow to understand the immediate responses to smog and how Chinese people can be better protected.

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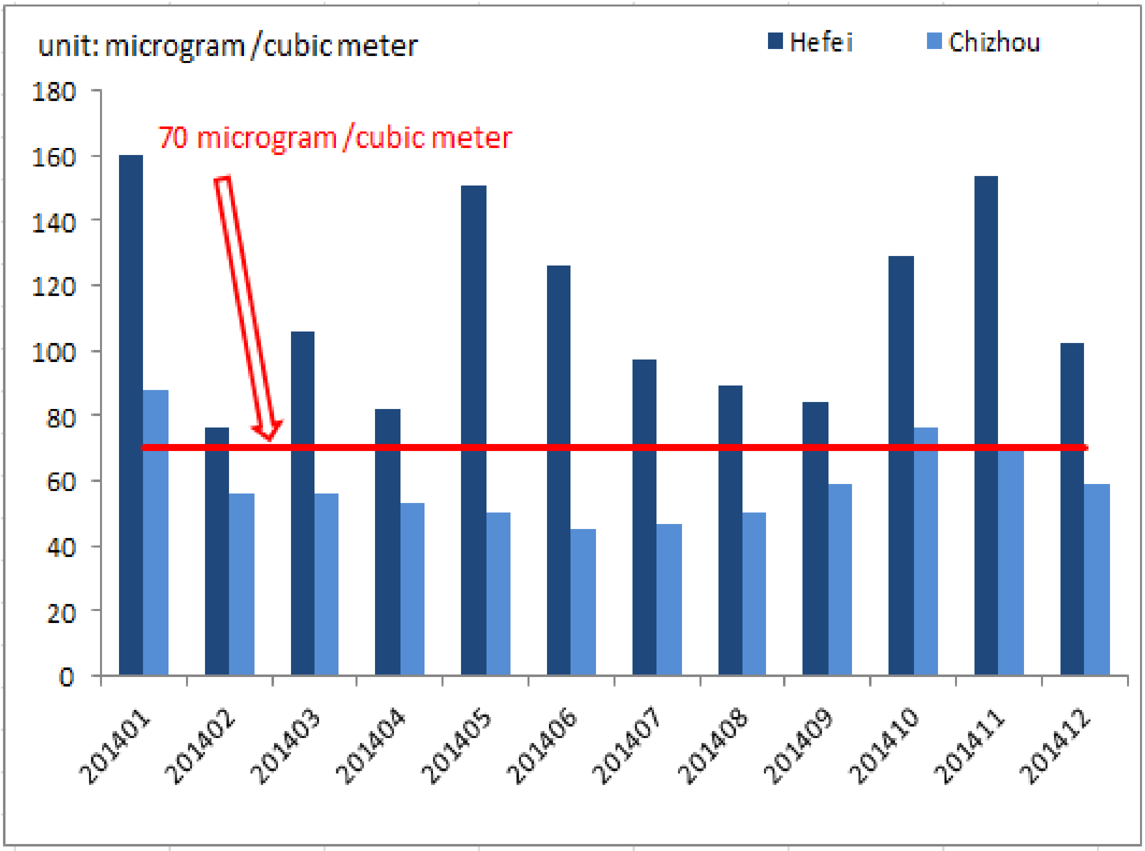

Figure 1. PM10 indexes for Chizhou and Hefei in 2014

Source of data: Environmental Protection of Anhui (http://www.aepb.gov.cn/pages/Home.html)

Note: The average concentration PM10 index limit is 70 micrograms/cubic metre.

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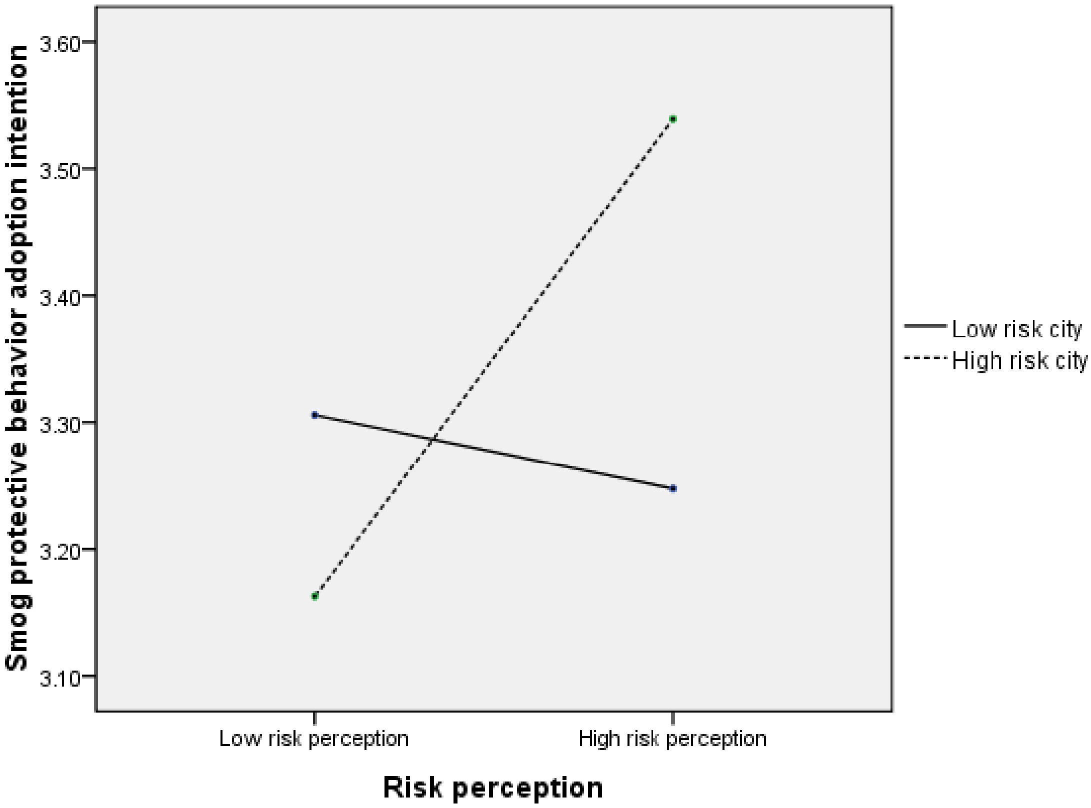

Figure 2. Intention of adopting smog protective behavior as a function of risk perception and location

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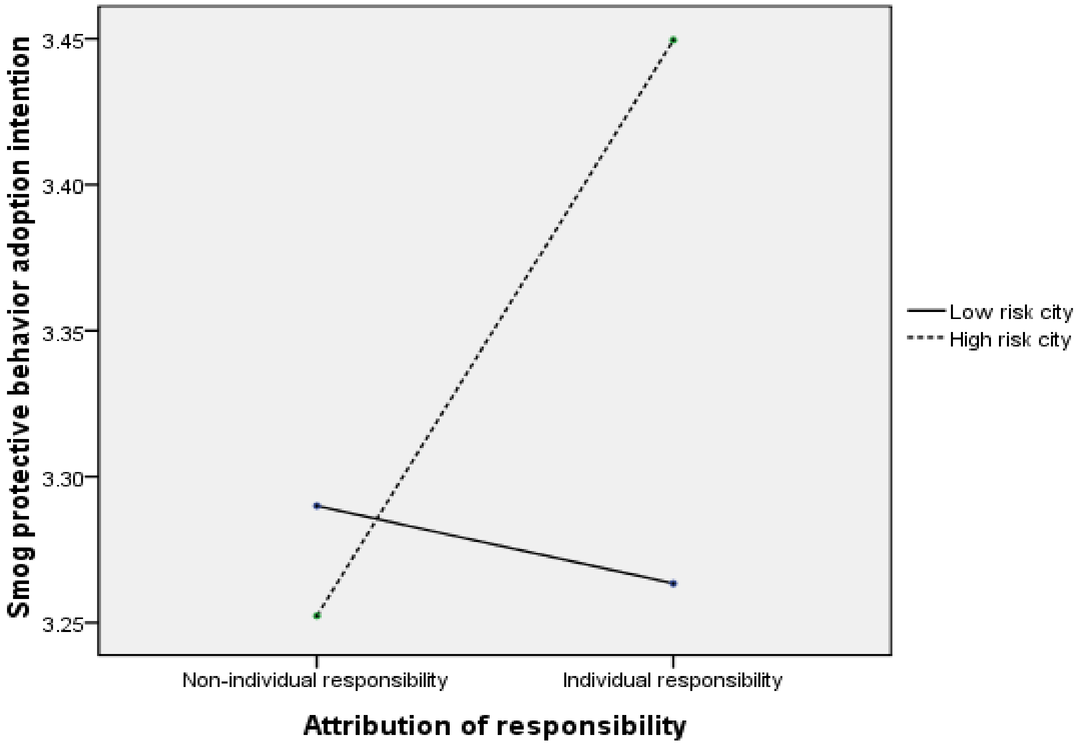

Figure 3. Intention of adopting smog protective behavior as a function of attribution of responsibility and location

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Table 1. Comparison between the two cities in reliance on information sources, smog experience, risk perception, attribution of responsibility and protective behavior

	High risk city: Hefei	Low risk city: Chizhou	t
Reliance on information sources			
1. Reliance on official information sources	3.43	3.10	4.98***
2. Reliance on unofficial information sources	2.88	2.33	7.16***
Smog experience			
Own/family health effects	0.68	0.44	6.70***
Risk perception	3.74	3.92	-3.60***
1. Threats to personal physical health	4.41	4.66	-4.47***
2. Threats to personal psychological health	3.55	3.67	-1.58
3. Threats to children's growth	4.44	4.53	-1.44
4. Threats to personal or family life	3.73	3.83	-1.52
5. Threats to work efficiency and performance	3.43	3.71	-3.62***
6. Threats to personal property	2.88	3.13	-3.22***
Attribution of responsibility			
1. Individual responsibility	3.16	3.17	-0.11
2. Non-individual responsibility	4.29	4.28	0.26
Protective behavior	3.23	3.29	-1.17
1. Moving to an area without smog for working or life	3.00	2.89	1.45
2. Wearing a mask outside	3.31	3.49	-2.16**
3. Reducing outdoor activities	2.84	2.71	1.49
4. Using air purifier indoors	2.99	3.42	-5.78***
5. Paying attention to personal health	3.87	3.68	2.35**
6. Reducing the use of private cars and saving resources	3.40	3.57	-2.04**

Note: p levels are indicated as follows: *$p<0.1$; **$p<0.05$; ***$p<0.01$.

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Table 2. ANOVA summary table for intention of adopting protective behavior with location, risk perception, attribution of responsibility as independent variables

Source	df	F	p
Location	1	1.34	0.247
Risk perception	1	6.17	0.013
Attribution of responsibility	1	1.77	0.184
Location * Risk perception	1	11.48	0.001
Location * Attribution of responsibility	1	3.05	0.081
Risk perception * Attribution of responsibility	1	6.74	0.010
Location * Risk perception* Attribution of responsibility	1	0.12	0.727

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Table 3. Intercorrelations among variables

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
1.Location	0.64	0.48												
2.Age	27.95	8.51	-0.215**											
3.Gender	0.45	0.50	-0.030	-0.176**										
4.Marital status	0.35	0.48	-0.131**	0.659**	-0.154**									
5.Education	3.86	0.90	0.145**	-0.244**	0.010	-0.204**								
6.Income	2.41	1.05	0.022	0.166**	-0.036	0.294**	0.119**							
7.Smog experience	0.60	0.49	0.236**	0.035	0.016	0.080*	0.067	0.090*						
8.Official information sources	3.31	0.92	0.174**	0.003	0.182**	0.004	-0.047	-0.056	0.007					
9.Unofficial information sources	2.68	1.05	0.251**	-0.062	0.085*	-0.022	-0.025	0.011	0.032	0.529**				
10.Risk perception	0.46	0.50	-0.146**	0.037	-0.014	0.064	-0.114**	-0.016	-0.026	0.046	-0.007			
11.Individual responsibility	3.17	0.94	-0.004	0.099**	0.008	0.076*	0.008	0.036	0.108**	0.221**	0.193**	0.102**		
12.Non-individual responsibility	4.29	0.63	0.009	0.126**	-0.068	0.068	0.033	0.007	0.086*	0.043	-0.125**	0.178**	0.292**	
13.Protective behavior	3.26	0.68	-0.042	0.067	0.021	0.026	-0.226**	-0.100**	0.016	0.196**	0.114**	0.241**	0.186**	0.089*

Note: The number of cases per correlation is N = 762. *. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

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Table 4. Regression analysis results

Independent variables	Smog experience[a]	Smog information[b]		Risk perception[a]	Attribution of responsibility[b]		Protective behavior[b]
		Official information sources	Unofficial information sources		Individual responsibility	Non-individual responsibility	
Location	1.085***	0.206***	0.262***	-0.654***	-0.067*	0.060	-0.020
Age	0.011	0.061	-0.024	-0.016	0.096**	0.151***	0.033
Gender	0.204	0.202***	0.094***	-0.138	-0.019	-0.054	-0.007
Marital status	0.421*	0.032	0.025	0.283	-0.006	-0.036	-0.045
Education	0.131	-0.050	-0.067*	-0.210**	0.052	0.073**	-0.190***
Income	0.103	-0.067*	0.014	-0.014	0.016	-0.013	-0.067*
Smog experience				0.059	0.114***	0.077**	0.030
Official information sources				0.185*	0.167***	0.142***	0.140***
Unofficial information sources				-0.027	0.127***	-0.201***	0.021
Risk perception					0.091**	0.185***	0.195***
Individual responsibility							0.127***
Non-individual responsibility							0.017
Adjusted R^2	0.10	0.07	0.07	0.05	0.08	0.08	0.14

Dependent variables: all columns except "Independent variables".

Note: The number of cases analyzed is N = 762.
p levels are indicated as follows: *p<0.1; **p<0.05; ***p<0.01.
a The Nagelkerke R^2 and coefficients of binary logistic regression were reported.
b The standardized coefficients of multiple linear regression were reported.