Who is Responsible for Particulate Matter in South Korea's Atmosphere? The Role of Social Media and Attribution of Responsibility on Risk Perception and Protective Behaviors

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This study analyzed national survey data from South Korean respondents to examine how social media use influences the attribution of responsibility to an out-group or in-group, risk perceptions, and protective behavioral intentions about particulate matter in South Korea's atmosphere. The findings indicate that social media use is positively associated with the attribution of responsibility to both an out-group and an in-group. The attribution of responsibility to an out-group affected risk perceptions, which were associated with protective behavioral intentions about air pollution.

Keywords: social media, particulate matter, attribution of responsibility, risk perception, protective behavioral intentions

Air pollution is a serious environmental problem in South Korea (Kim & Kim, 2019). According to data from the Organization for Economic Cooperation and Development's (OECD) Better Life Index in 2020, South Korea, along with the Czech Republic, Greece, Hungary, and Israel, had one of the highest levels of particulate matter 2.5 among the OECD countries. Particulate matter 2.5 refers to a mixture of solid particles and liquid droplets in the air smaller than 2.5 micrometers (Environmental Protection Agency [EPA], 2019).

Most fine particles in the atmosphere originate from chemical reactions involving hydrocarbons, sulfur dioxide, and nitrogen oxides, including pollutants emitted from industries and the combustion of fossil fuels (EPA, 2019). When inhaled, these particles can penetrate people's lungs and bloodstream, leading to various health issues, including respiratory and cardiovascular diseases and immune disorders (Nel, 2005). There is significant public concern about the health implications of particulate matter (Yang & Huang, 2018). A survey showed that South Koreans perceive air pollution resulting from particulate matter as a greater public risk than other societal problems, such as economic slowdown, aging, and conflicts with North Korea (Korea Institute for Health and Social Affairs, 2017).

When a public health problem arises, the public needs to receive relevant information to understand and respond effectively (Choi, Yoo, Noh, & Park, 2017). Traditional media, like newspapers and television, previously played a crucial role in informing the public about health and risk-related issues (You & Ju, 2015). Recently, an increasing number of people have begun to use social media, such as Facebook, Twitter, and

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Instagram, to obtain information about these issues (Choi et al., 2017). Some studies have suggested that using social media for health and risk information influences users' cognition and behaviors, such as risk perception and protective behaviors (e.g., Choi et al., 2017; Yoo, Choi, & Park, 2016).

The media play a large role in identifying or explaining who is responsible for a social issue (Entman, 1993; Jeong, Yum, & Hwang, 2018), such as particulate matter. When people are concerned about a public issue, discussions arise among citizens and the media, focusing on identifying those responsible (Chang, Kim, Shim, & Ma, 2016). There are two primary arguments among citizens and the media about who is responsible for the air pollution problem in South Korea. The first suggests that neighboring countries, such as China and Mongolia, are responsible for South Korea's air pollution because South Korea is downwind from China and Mongolia and, therefore, receives substantial transboundary air pollutants emitted from large industries and coal combustion occurring in these countries (Hu, 2017; Jeon et al., 2018). The other argument asserts that South Korea's air pollution problem stems from domestic emissions, including coal-powered plants, automobiles, construction, and industrial activities (Harris & Kang, 2017; Park, Lee, Lee, & Kim, 2019).

The media also influence how people attribute responsibility for social issues (Kim, Jang, & Noh, 2019). As key sources of information that help citizens understand these issues (Bolsen & Shapiro, 2018), they help people formulate the attribution of responsibility by identifying the causes of social problems (Iyengar, 1989). This study hypothesizes that social media use for news and information about particulate matter in South Korea can influence how people attribute responsibility for the country's air pollution problem—either to an external (foreign) or internal (domestic) cause—by shaping perceptions of who is responsible.

Attribution of responsibility (i.e., identifying the party responsible for a given problem) can influence people's perception of and responses to an issue (Chang et al., 2016). Environmental issues, such as particulate matter and climate change, are especially significant in this regard, as determining responsibility can subsequently affect people's risk perception and behavior (Chang et al., 2016). According to attribution theory (Weiner, 2006), how a person attributes responsibility can shape public perceptions and behavioral responses (Kim et al., 2019). For example, a study on food safety revealed that people's attribution of responsibility to the government positively influences their risk perceptions and preventive behaviors about food safety issues (Kim et al., 2019). Therefore, this study suggests that the public's attribution of responsibility for particulate matter is an important factor influencing their risk perception and protective behavior about air pollution.

This study explores how social media use influences people's attribution of responsibility, risk perceptions, and protective behavioral intentions about the particulate matter in South Korea. More specifically, this study examines the mediating role of the attribution of responsibility in the relationship between social media use, risk perceptions, and protective behavioral intentions by analyzing nationwide online survey data from South Koreans. Previous studies have examined the direct relationship between social media use and risk perception (e.g., Choi et al., 2017; Choi, 2021), as well as the role of emotions, such as fear and anger, in the association between social media use and risk perception (e.g., Oh, Lee, & Han, 2021; Zeballos Rivas et al., 2021). However, they have neglected the impact of cognitive factors, such as the attribution of responsibility, which can explain how social media use influences risk perception and

how risk perception is associated with protective behavior. As previous studies have assessed the direct association between media use and attribution of responsibility (e.g., Chang et al., 2016; Lee, Kim, Lee, & Chock, 2023) and between attribution of responsibility and risk perception (e.g., Cheng, Wei, & Ge, 2017; Rickard et al., 2017), the current study explores the potential serial link between social media use, attribution of responsibility, and risk perception. This study provides an understanding of the mechanism underlying the relationship between social media use and risk perception by investigating the role of the attribution of responsibility as a cognitive mediator. The study suggests practical and theoretical implications for public policy makers and health and risk communication practitioners about effective communication strategies in the social media era.

Literature Review

Attribution, Risk Perception, and Protective Behaviors

Attribution theory explains how individuals perceive the cause of and responsibility for a given outcome (Weiner, 2006). Attribution refers to "the perception or inference of cause" (Kelley & Michela, 1980, p. 458) and indicates one's judgment about who is responsible for a social problem by analyzing the cause and responsibility of its consequences. People often show different attributional patterns for social problems depending on an actor's group membership, such as in-groups and out-groups (Jang, 2013; Pettigrew, 1979). According to social identity theory (Tajfel & Turner, 1979), people tend to categorize themselves as an in-group and other individuals as an out-group, and group identification allows individuals to compare their in-groups with out-groups (Knobloch-Westerwick, Mothes, & Polavin, 2020). This theory explains that when individuals identify with a specific social group, they tend to perceive their own group members (i.e., in-group) more favorably and treat them better than other group members (i.e., out-group; Harwood, 2020). Hence, individuals make intergroup comparisons biased in favor of their in-group, exhibit discriminatory views toward the out-group, and adopt coping strategies such as internal or external causal attributions for group behavior (Ramasubramanian & Murphy, 2014). Based on social identity theory, individuals are inclined to attribute dispositional factors when observing negative outcomes for out-group members compared with the same consequences caused by in-group members. However, they tend to attribute positive outcomes for out-group members to situational factors more often than they do for the same outcomes for in-group members (Hewstone, 1990; Khan & Liu, 2008). For example, a study on poverty-related issues found that White Americans were likely to attribute poverty and its responsibility among White people (the in-group) to social factors, but the same issue among African Americans (the out-group) was attributed to individual factors, such as a lack of effort (Iyengar, 1989). An experimental study found that American participants who read information about China's (i.e., the out-group) excessive energy use were more likely to perceive that the out-group should take greater responsibility for their CO_2 emissions. Conversely, American participants who read information about excessive energy use in the United States (i.e., the in-group) were more likely to attribute climate change to natural rather than human causes (Jang, 2013). Thus, South Korean citizens may attribute the air pollution problem to the in-group or out-group. Some people may attribute this problem to neighboring countries, such as China (the out-group), whereas others may focus more on domestic causes (the in-group; Harris & Kang, 2017).

Attribution of responsibility can affect individuals' risk perceptions and behavioral changes. Attribution of responsibility refers to how people determine the causes of and allocate responsibility to a given social problem (Bhalla, O'Boyle, & Haun, 2019). For example, a survey research found that people tend to attribute responsibility to the government for natural disasters, such as smog, in China (Cheng et al., 2017). Attribution of responsibility is significantly associated with risk perception (e.g., Cheng et al., 2017). Risk perception refers to a person's subjective evaluation of the probability that negative consequences, such as disease or air pollution, will occur (Choi, Shin, Park, & Yoo, 2018). For example, in an environmental risk situation, people who attribute responsibility to an individual for the negative outcomes of a hurricane are more likely to perceive a greater risk of future storms and their aftermath (Rickard et al., 2017).

Furthermore, how people attribute responsibility can influence risk perception differently. For instance, in a survey study on food safety, people tended to perceive a higher risk when they believed that the government, rather than individual actors, was responsible for food safety problems (Kim et al., 2019). This tendency can be explained by perceived controllability (Chang et al., 2016), which indicates the extent to which individuals perceive that they can control the outcome of a given situation or issue (Rickard, Scherer, & Newman, 2011). A perceived lack of control can make individuals perceive greater risk because they see a social issue as being beyond their own control (Chang et al., 2016; Weinstein, 1980), whereas people may perceive lower risk when they believe they have control over a situation or issue.

This study anticipates that South Koreans who perceive that neighboring countries, such as China, as opposed to South Korea, would be more responsible for the particulate matter issue are more likely to perceive a greater risk of the air pollution problem. This could be because the risk may be considered beyond their control and primarily influenced by external parties, such as neighboring countries (Chang et al., 2016). Therefore, this study hypothesizes that people who attribute greater responsibility to an out-group, such as neighboring countries, may perceive higher risks associated with particulate matter, whereas those who attribute greater responsibility to an in-group may perceive lower risks. We formulate the following hypotheses:

H1a: *The attribution of responsibility to an out-group is positively associated with risk perception about particulate matter in South Korea's atmosphere.*

H1b: *The attribution of responsibility to an in-group is negatively associated with risk perception about particulate matter in South Korea's atmosphere.*

In the fields of public health and environmental risk, attribution of responsibility can influence protective behaviors (e.g., Kim et al., 2019; Wei, Zhu, Marinova, & Wang, 2017). Protective behaviors are behavioral responses intended to decrease or eliminate risks from natural or social hazards (Burton, Kates, & White, 1993). For example, people engage in protective behaviors, such as vaccinations, condom use, and breast self-examinations, to maintain their health (Choi et al., 2018). Weiner (2006) explains that the attribution of responsibility can lead to a corresponding treatment motivation (Sun, Krakow, John, Liu, & Weaver, 2016). For example, a survey study found that the attribution of responsibility for smog was positively associated with engaging in protective behaviors, such as wearing masks outside and using air

purifiers indoors (Wei et al., 2017). When perceiving the attribution of responsibility for the particulate matter issue, individuals may be likely to act to avoid exposure to particulate matter in the atmosphere, such as by wearing masks, staying at home, and washing their hands. However, little is known about the relationship between the attribution of responsibility to an out-group or in-group and protective behaviors about the air pollution issue. Therefore, we formulate the following research question:

RQ1:   *How is the attribution of responsibility to an out-group or in-group associated with protective behavioral intentions about the particulate matter in South Korea's atmosphere?*

Social Media Use and Attribution of Responsibility

News media have played a large role in shaping the public perception of who is responsible for social problems (Chang et al., 2016). According to framing theory, news media outlets tend to report social problems by presenting the causes of the problems and identifying the responsible parties (Entman, 1993; Kim, Tanner, Foster, & Kim, 2015). Framing theory suggests how news media reports influence the audience's interpretation of given issues (Scheufele & Tewksbury, 2007) and presumes that clear differences in news media presentations, such as terminology or narrative structure, can produce distinct interpretations and perceptions of a given issue among people (Scheufele & Tewksbury, 2007). News media frames a social issue by identifying the actors of the causes and solutions to the problem, leading the audience to form an attribution of responsibility (Kim, Carvalho, & Davis, 2010). This framing effect on the attribution of responsibility indicates that news media use significantly shapes the public's perceptions of attribution of responsibility by indicating who is responsible for causing and fixing a given social problem (Chang et al., 2016; Iyengar, 1989). As previous studies have shown that Korean news media tend to frame and attribute the cause of particulate matter primarily to the influence of neighboring countries such as China and domestic sources in Korea (e.g., Park, Lee, & Jeong, 2025; Shapiro & Bolsen, 2019), news media use about the particulate matter is likely to positively affect the attribution of responsibility to both an out-group and in-group.

The recent rise of social media has led people to turn to these platforms to obtain news and information about social issues such as particulate matter (Choi et al., 2017). As traditional news media disseminate news and information through their own social media accounts, social media users obtain news and information from mainstream media outlets and ordinary users who post information and opinions about social problems. Thus, social media use can affect people's attribution of responsibility for a given social issue. As a social big data analysis revealed that attributions to neighboring countries' influence and domestic factors as causes of particulate matter in South Korea are prevalent in online media, including online news, blogs, and social network services (Song & Song, 2019), social media use is likely to be positively associated with the attribution of responsibility to an out-group and in-group. A recent study in the United States found that using social media for information influenced individuals to attribute greater responsibility to the federal government for the COVID-19 pandemic (Lee et al., 2023).

Moreover, as social media enables users to discuss and exchange opinions about news and information, individuals may encounter perspectives from out-groups and in-groups, similar to how incidental encounters with diverse news and information on social media can help users recognize and learn about

different viewpoints (Lin & Kim, 2023; Lu & Lee, 2019). For example, when exposed to news and information about the attribution of responsibility to an out-group for particulate matter, users can counter or refute the news and information about an in-group's responsibility for particulate matter, which is likely to increase exposure to viewpoints from both the out-group and the in-group. Therefore, this study anticipates that social media use for news and information about particulate matter in South Korea's atmosphere positively contributes to users' attribution of responsibility to both an out-group and an in-group.

H2a: Social media use is positively associated with the attribution of responsibility to an out-group about particulate matter in South Korea's atmosphere.

H2a: Social media use is positively associated with the attribution of responsibility to an in-group about particulate matter in South Korea's atmosphere.

Social Media, Risk Perception, and Protective Behaviors

Studies have shown that social media use is associated with risk perception and protective behaviors (e.g., Choi et al., 2017; Yoo et al., 2016). According to the theory of social amplification of risk (Renn, Burns, Kasperson, Kasperson, & Slovic, 1992), media coverage of risk issues tends to make them more prominent, thus increasing the public's perception of the associated risk. Moreover, people tend to share their risk perceptions in message formats through their personal networks, which are often transformed and amplified over time (Song, Song, Seo, Jin, & Kim, 2017). Social media helps amplify the public's perceptions of risk by encouraging the rapid and widespread dissemination of information and opinions (Yoo et al., 2016). During the Zika virus outbreak in the United States, social media coverage of the virus was positively associated with risk perceptions (Chan et al., 2018). Thus, about the particulate matter issue, social media use is likely to be associated with a higher level of risk perception.

H3:   Social media use is positively related to risk perception.

Moreover, social media use may lead to behavioral changes. People tend to learn how to behave in a given environment by observing the behaviors of those with whom they are socially connected (Goldstein, Cialdini, & Griskevicius, 2008). Social media promotes this learning process by spreading substantial behavioral information and visible evidence, such as photos and videos, via online social networks (Moreno, Kota, Schoohs, & Whitehill, 2013; Yoo, Paek, & Hove, 2020). For example, during the Middle East Respiratory Syndrome (MERS) outbreak in South Korea, a big data analysis revealed that people generated many mentions of protective behaviors, such as washing hands with soap and wearing protective masks, on social media (Song et al., 2017). A survey study found that social media use influences preventive action engagement in food safety issues (Mou & Lin, 2014). Therefore, this study hypothesizes that social media use affects people's protective behaviors about the particulate matter issue.

H4:   Social media use is positively related to protective behavioral intentions.

Moreover, this study proposes that risk perception impacts people's health behaviors. In the field of public health and health communication, greater risks can encourage people to engage in health-

protective behaviors to avoid associated hazards (Bish & Michie, 2010; Pask & Rawlins, 2016). The protective motivation theory suggests that when people perceive a risk, they tend to activate protective motivations to prevent potentially negative results (Choi et al., 2018; Rogers, 1975). Thus, when individuals perceive risks associated with the particulate matter issue, they are more likely to engage in protective behaviors, such as wearing masks and washing their hands.

H5:   Risk perception is positively related to protective behavioral intentions.

Finally, given the direct associations among these variables, this study examines the mediating path by which social media use is associated with protective behaviors through the attribution of responsibility to either an out-group or an in-group, as well as risk perceptions. That is, this study focuses on how the attribution of responsibility to an out-group or in-group mediates the influence of social media use on protective behaviors. This analysis provides a better understanding of attribution theory and its direct and indirect impacts on the relationships between social media use, risk perception, and protective behaviors. However, given the lack of empirical research suggesting specific directional hypotheses for the potential mediating role of the attribution of responsibility to an out-group or in-group, this study proposes the following research question:

RQ2:   Does the attribution of responsibility to an out-group or in-group mediate the relationships between social media use, risk perceptions, and protective behavioral intentions?

Based on our research questions and hypotheses, this study proposes a model to illustrate the potential interrelationships between social media use, attribution of responsibility, risk perception, and protective behavioral intentions in Figure 1.
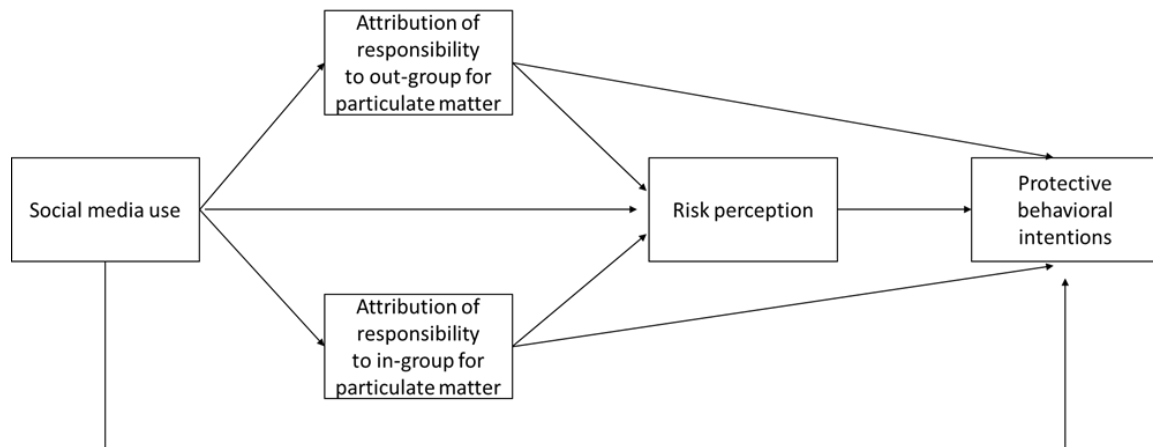

Figure 1. Proposed research model.

Method

Data

This study used data from a nationwide online panel survey of South Korean adults aged 19–69 years. A major Korean research firm conducted the survey. The data were collected in December 2018. The research company recruited more than 1.3 million panel members through a proportionate quota sampling method based on age, gender, and geographical region to represent national demographics. From the entire pool, 3,282 online panel members were randomly selected via a computer algorithm that used a random number table and invited them by e-mail to participate in the survey. Of these, 1,500 respondents agreed to participate, resulting in a survey completion rate of 45.7%. Appendix (Table A1) presents the respondents' demographic profiles.

Measures

Protective Behavioral Intentions

Protective behavioral intentions were measured using a 5-point scale (1 = *least likely* to 5 = *most likely*) in which the respondents were asked how likely they were to engage in the following protective behaviors when exposed to particulate matter in the atmosphere: (1) "I will stay at home when there is air pollution," (2) "I will check atmospheric information when I go out," (3) "I will try to reduce indoor air pollution, such as using ventilation when cooking," (4) "I will wear a mask when I go out," and (5) "I will wash my hands when I get back inside after having gone out." Responses to these five items were averaged to generate an index of protective behavioral intentions ($M = 4.04$, $SD = 0.59$, Cronbach's α = .82).

Social Media Use

Social media use was measured using a 5-point scale (1 = *never* to 5 = *very often*) by asking how often the respondents were exposed to news and information about particulate matter in the atmosphere on social media, such as Facebook, Twitter, and Instagram, during the past week ($M = 3.11$, $SD = 1.13$).

Attribution of Responsibility

Attribution of responsibility to an out-group for particulate matter was measured using a 5-point scale (1 = *strongly disagree* to 5 = *strongly agree*), asking how much the respondents agreed with the following statement: "I believe that particulate matter in South Korea's atmosphere comes mostly from neighboring counties, such as China" ($M = 3.86$, $SD = 0.93$). Attribution of responsibility to an in-group for particulate matter was measured using a 5-point scale (1 = *strongly disagree* to 5 = *strongly agree*), asking how much the respondents agreed with the following statement: "I believe that particulate matter in South Korea's atmosphere is being caused mostly within the country (i.e., South Korea)" ($M = 2.95$, $SD = 0.91$).

Risk Perception

Risk perception was assessed using four items based on a 5-point scale (1 = *strongly disagree* to 5 = *strongly agree*), asking how much the respondents agreed with the following statements: (1) "I think that the particulate matter in the atmosphere is dangerous to me," (2) "I think that the particulate matter in the atmosphere threatens my health," (3) "I think that the particulate matter in the atmosphere is dangerous to Koreans," and (4) "I think that the particulate matter in the atmosphere threatens Korean citizens' health." The responses were averaged to produce an index of risk perception (M = 4.20, SD = 0.66, Cronbach's α = .94). As previous studies have suggested that people tend to judge how seriously a risk issue affects themselves and others (Morton & Duck, 2001; Tyler & Cook, 1984), this study measured risk perception at both the personal and societal levels, which is consistent with prior research (e.g., Ibuka, Chapman, Meyers, Li, & Galvani, 2010; Oh, Paek, & Hove, 2015).

Control Variables

The control variables were age (M = 40.16, SD = 12.12), gender (48.8% female), education level (the highest degree of education attained, median: college degree), monthly household income (median monthly household income between KRW 4,000,000–5,000,000; approximately USD 4,000–5,000), place of residence (19.7% Seoul residents), and political ideology (1 = *very conservative*, 5 = *very liberal*, M = 3.18, SD = 0.71).

Analysis

The study's research questions and hypotheses were tested using the SPSS PROCESS macro (Model 80; Hayes, 2018). The PROCESS macro allows for the testing of direct effects using ordinary least squares regression, as well as the estimation of the significance of indirect effects with multiple mediators in the proposed model. A bias-corrected bootstrapping approach was employed with 5,000 bootstrap samples to produce more accurate confidence intervals (Hayes, 2018). Indirect effects were considered statistically significant if the confidence intervals did not contain zero (Hayes, 2018).

Results

Path Model: Direct Effects

Figure 2 depicts the direct relationships among social media use, attribution of responsibility to an out-group, attribution of responsibility to an in-group, risk perception, and protective behavioral intentions after accounting for age, gender, education, income, place of residence, and political ideology. In support of H2a and H2b, this study found that social media use is positively associated with the attribution of responsibility to an out-group (b = .08, SE = .02, p < .001) and the attribution of responsibility to an in-group (b = .09, SE = .02, p < .001). Our analysis revealed that the attribution of responsibility to an out-group is positively related to risk perception (b = .22, SE = .02, p < .001), supporting H1a. However, no significant direct relationship existed between the attribution of responsibility to an in-group and risk perception. Thus, H1b was not supported. About RQ1, the results indicated that the attribution of

responsibility to an out-group is positively associated with protective behavioral intentions (b = .04, SE = .02, p < .01). Conversely, the attribution of responsibility to an in-group was not significantly associated with protective behavioral intentions. Supporting H3, this study found that social media use is positively associated with risk perception (b = .04, SE = .01, p < .01). H4, claiming that social media use positively relates to protective behavioral intentions, was supported (b = .05, SE = .01, p < .001). Finally, the study found that risk perception is positively associated with protective behavioral intentions (b = .38, SE = .02, p < .001), supporting H5.
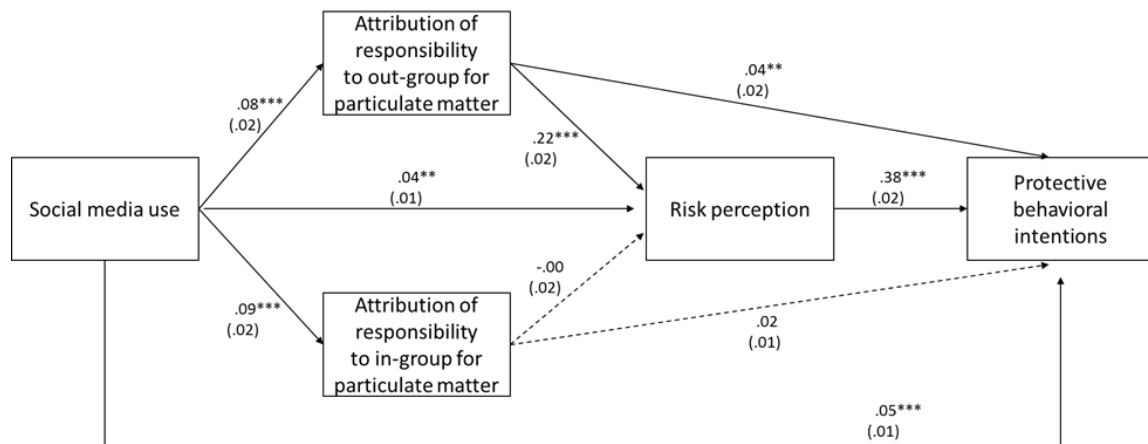

Figure 2. Mediation model and path coefficients.
Note. Unstandardized regression coefficients and corresponding standard errors are reported. Solid black lines indicate statistically significant relationships, while dotted lines represent nonsignificant relationships.
**p < .01, ***p < .001.

Mediation Model: Indirect Effects

In response to RQ2, this study investigated the indirect effect mechanism by which social media use is associated with protective behavioral intentions through the attribution of responsibility to an out-group and in-group and risk perception. Table 1 presents the results of the indirect effects of the five mediating paths. This study found a significant indirect effect between social media use and protective behavioral intentions via the attribution of responsibility to an out-group (b = .004, SE = .002, 95% CI = 0.001 to 0.007). Social media use was also significantly, but indirectly, associated with protective behavioral intentions via the attribution of responsibility to an out-group and risk perception (b = .007, SE = .002, 95% CI = 0.003 to 0.011). However, the attribution of responsibility to an in-group did not mediate the relationship between social media use and protective behavioral intentions. Finally, this study found that social media use has statistically significant indirect effects on protective behavioral intentions via risk perception (b = .015, SE = .005, 95% CI = 0.005 to 0.026).

Table 1. Indirect Pathway of Social Media Use on Protective Behavioral Intentions through Attributions of Responsibility to Out-Group and In-Group for Particulate Matter and Risk Perception.

Indirect Path	Estimate	*SE*	CI
Social media use → M1 → Protective behavioral intentions	0.004*	0.002	0.001 to 0.007
Social media use → M1 → Risk perception → Protective behavioral intentions	0.007*	0.002	0.003 to 0.011
Social media use → M2 → Protective behavioral intentions	0.001	0.002	-0.001 to 0.004
Social media use → M2 → Risk perception → Protective behavioral intentions	-0.000	0.001	-0.002 to 0.001
Social media use → Risk perception → Protective behavioral intentions	0.015*	0.005	0.005 to 0.026

Note. M1 = Attribution of responsibility to out-group for particulate matter, M2 = Attribution of responsibility to in-group for particulate matter. Unstandardized regression coefficients and corresponding standard errors are reported. CIs are bias-corrected 95% confidence intervals for the indirect effects (Bootstrap N = 5,000). * indicates a significant effect.

Discussion

This study examined the indirect relationship mechanisms by which social media use is related to protective behavioral intentions through the attribution of responsibility and risk perception about particulate matter in South Korea's atmosphere. Specifically, this study found that social media use is positively associated with the attribution of responsibility to an out-group and an in-group. Consistent with previous research that found a significant relationship between social media use and the attribution of responsibility (e.g., Kim et al., 2019), this result suggests that social media plays a substantial role in shaping people's attribution of responsibility by informing them about who is responsible for South Korea's particulate matter problem. As social media provide a public space where people express their opinions on public issues (e.g., Jang & Hart, 2015), exposure to discussions about particulate matter among social media users could affect the attribution of responsibility about the issue. Specifically, as the descriptive statistics in the analysis showed a difference between the attribution of responsibility to an out-group (M = 3.86) and an in-group (M = 2.95), social media users would most likely express their opinions more about an out-group attribution than an in-group attribution. Because social media algorithms present information tailored to individual preferences, users are more inclined to consume information that aligns with their existing views or discuss it with others who share similar opinions (Lee et al., 2023). This tendency would strengthen their perception of who is responsible for the issue of particulate matter.

Second, this study indicated that social media use is positively associated with risk perception and protective behavioral intentions. These findings are consistent with those of previous studies that demonstrated positive relationships between social media use and risk perception and between social media use and protective behaviors (e.g., Choi et al., 2017; Mou & Lin, 2014). As social media has become a widespread and useful channel for disseminating risk information during public health crises (Yoo et al., 2016), social media use might help people shape risk and learn how to respond to the air pollution problem.

Third, consistent with the results of previous studies (Choi et al., 2018; Yoo et al., 2020), this study found that risk perception is positively related to protective behavioral intentions. Supporting the protection motivation theory (Rogers, 1975), the finding suggests that individuals who perceive a higher level of risk about particulate matter in South Korea's atmosphere are more likely to engage in protective behaviors aimed at preventing or avoiding the negative outcomes associated with air pollution.

Fourth, this study revealed that the attribution of responsibility to an out-group for particulate matter in South Korea's atmosphere is positively associated with people's risk perceptions and protective behavioral intentions. This finding may be explained by the concept of involuntariness as a characteristic of dread risk (Slovic, 1987), which indicates the degree to which an individual is willingly or unwillingly exposed to a particular risk. Similar to climate change, exposure to particulate matter in South Korea's atmosphere poses an involuntary risk that people do not willingly choose. In particular, involuntary exposure caused by external factors can heighten risk perception (Cori, Bianchi, Cadum, & Anthonj, 2020; Slovic, 1987). Because out-group members (e.g., neighboring countries) are often perceived as a source of involuntary risk, people who attribute the issue of particulate matter to an out-group are more likely to perceive a higher level of risk.

Fifth, this study showed that the attribution of responsibility to an in-group is not statistically related to risk perceptions or protective behavioral intentions. This result could be partially explained because those who attributed responsibility to an in-group, as an internal factor, tended to perceive an outcome as under their control (Lewis & Sznitman, 2017), and thus view the adoption of protective behaviors as unnecessary. Because people generally internally attribute positive results to themselves (Cheng et al., 2017), risk perception as a negative outcome was not closely associated with the attribution of responsibility to an in-group as an internal factor. These findings highlight that the way individuals attribute responsibility (to in-group or internal factors versus out-group or external factors) plays a significant role in determining their subsequent risk perceptions and protective behavioral intentions.

Finally, this study identified the mediating paths by which social media use is associated with protective behavioral intentions via the attribution of responsibility to an out-group and risk perception. Attribution of responsibility to an out-group had a direct relationship with protective behavioral intentions and mediated the association between social media use and risk perception and protective behavioral intentions. This finding indicates that social media, as a major source of information on environmental issues, is effective in helping people learn and shape their perceptions of who is responsible for the problem, subsequently affecting risk perception and protective behavioral intentions. Thus, it is essential to continuously monitor and analyze how the issue of particulate matter is discussed on social media and whether public discourse influences the attribution of responsibility, risk perception, and protective behavior about this environmental issue.

Limitations and Suggestions for Future Research

This study has some limitations. First, this study relied on cross-sectional data to test the relationships between the variables. Owing to the nature of the cross-sectional data, the study's findings should be interpreted with caution. Our findings cannot establish a temporal order by stating that social

media use always precedes or causes protective behavioral intentions. Nevertheless, the proposed research questions and hypotheses were based on strong inferences derived from previous studies. Future research needs to use longitudinal data to develop stronger causal arguments.

Second, because this study's data were based on self-reported measures from a single source at a single point in time, a common method bias may have occurred. This study checked for common method bias using Harman's single-factor test and found that no single factor explained more than 50.0% of the total variance (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). This indicates that common method bias is unlikely to threaten the validity of the findings.

Third, social media use and attribution of responsibility were measured using a single-item scale, which may have raised concerns about reliability and validity. However, because our items were straightforward and explicit, the participants could easily reflect on their opinions retrospectively. Nevertheless, using several measurement items could have enhanced the reliability and validity (Diamantopoulos, Sarstedt, Fuchs, Wilczynski, & Kaiser, 2012), thus yielding stronger relationships among the variables. Because of the limitations of a single-item measurement, we should acknowledge that the present study is exploratory and that the results need to be regarded as preliminary. Future research should use more sophisticated measures for each variable to reduce measurement errors and overcome reliability and validity issues.

Fourth, this study did not consider the difference between larger metropolises and smaller cities in terms of air quality on individuals' protective behavioral intentions. However, because many regions of South Korea are influenced by particulate matter (Kim, 2019), the difference between metropolises and small cities would not be significant in terms of the respondents' behavioral intentions. Nevertheless, future research should use a hybrid method that combines air quality data from each city type with respondents' survey data.

Fifth, the measurement items for risk perception used in this study did not measure the multidimensional characteristics of risk perception. Some scholars suggest that risk perception has cognitive and affective dimensions, such as emotions (e.g., worry or fear), susceptibility (e.g., how vulnerable one is to a negative impact or how likely it is), exposure (e.g., how likely it is or how often it occurs), and severity (e.g., how severe or dangerous it is) (e.g., Ferrer, Klein, Persoskie, Avishai-Yitshak, & Sheeran, 2016; Walpole & Wilson, 2021). Future research needs to include multidimensional measurement items for risk perception.

Finally, future research needs to explore the issue of particulate matter in South Korea from a political perspective. Our study focused only on the environment and public health. However, some scholars argue that the air pollution problem in South Korea has become politicized and connected to foreign affairs (e.g., Kim & Ku, 2022; Song, 2023). For example, the Pew Research Center (2022) showed that 80% of South Korean respondents have unfavorable views of China. It would be interesting to examine whether and how South Koreans' negative views of China affect their attribution of responsibility for particulate matter in the atmosphere.

Conclusion

This study has some significant theoretical and practical implications. First, in terms of theoretical implications, the issue of particulate matter in South Korea offers a unique opportunity to investigate citizens' attribution of responsibility and how the attribution of responsibility affects their risk perceptions and protective behavioral intentions. Particulate matter in the atmosphere has been an important topic of concern for the past 10 years and has produced controversial public discourse in South Korea. Thus, the perception of who is responsible for particulate matter is an essential element in communicating environmental and risk issues in South Korea (Chang et al., 2016). Second, this study proposes a research model that explains how social media is associated with risk perceptions and protective behavioral intentions through the attribution of responsibility. While previous studies have examined the direct relationship between the attribution of responsibility and risk perception (e.g., Chang et al., 2016; Rickard et al., 2017) or policy support (e.g., Jang, 2013; Jeong et al., 2018), this study further suggests an indirect path—the way people attribute responsibility plays an important role in shaping their risk perceptions, which is associated with engaging in protective behavioral intentions. Using the particulate matter issue, this study proposes a systematic research model that links the attribution of responsibility, risk perceptions, and protective behavioral intentions.

In terms of practical implications, journalists and news content producers should be cautious when reporting on the responsibility for the particulate matter issue. This study found that the attribution of responsibility in a particular way (e.g., in-group or out-group) can affect people's subsequent risk perception and protective behaviors differently. Thus, journalists and news producers should precisely and unbiasedly describe who is responsible for the air pollution issue. Second, understanding the public's perceptions of the attribution of responsibility and risks to this issue is important for various interest groups, such as governments, corporations, and nonprofit organizations, because they influence the direction and nature of environmental policies and regulations (Chang et al., 2016; Jang, 2013). These stakeholders need to understand that social media can be an important tool for informing the public about the risks and responsibilities of the air pollution problem. It is also necessary for environmental public policymakers and health or environmental communication practitioners to consider social media's formative role in risk perception and protective behaviors when designing effective public outreach campaigns.

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Appendix

Table A1. Demographic Statistics of the Participants.

	Participants (N = 1,500)
Age (years)	
19–24	132 (8.8)
25–34	387 (25.8)
35–44	402 (26.8)
45–54	414 (27.6)
55 or more	165 (11.0)
Gender	
Male	768 (51.2)
Female	732 (48.8)
Education	
High school or less	325 (21.7)
College degree	1,029 (68.6)
Graduate degree	146 (9.7)
Income (KRW)	
Less than 2,000,000 (USD 2,000)	132 (8.8)
2,000,001–4,000,000 (USD 2,001 – USD 4,000)	481 (32.0)
4,000,001–6,000,000 (USD 4,001 – USD 6,000)	546 (36.4)
6,000,001–10,000,000 (USD 6,001 – USD 10,000)	270 (18.0)
10,000,001 or more (USD 10,001)	71 (4.7)

Note. Frequency and percentage in parentheses.