

Cite this Article: Hassan, Z., Mushtaq, H., Rahim, A., Hussain, S. T. U., & Ahmed, S. (2026). Air Pollution Risk Perception and Protective Health Behaviors among Urban Residents in Pakistan: A Quantitative Cross-Sectional Study. *Journal of Regional Studies Review*, 5(3), 78-88. <https://doi.org/10.62843/jrsr/2026.v.iii.217>

RESEARCH ARTICLE

JOURNAL OF REGIONAL STUDIES REVIEW (JRSR)

Air Pollution Risk Perception and Protective Health Behaviors among Urban Residents in Pakistan: A Quantitative Cross-Sectional Study

Zeeshan Hassan ^a Hamza Mushtaq ^b Asar Rahim ^c Syed Tehzeen Ul Hussain ^d Subhan Ahmad ^e

Corresponding Author: Zeeshan Hassan; zeschanhasan12@gmail.com



Abstract: The current study explores the inter correlations between risk appraisal, coping beliefs, knowledge of smog, trust in information sources and protective health behavior. The study utilized survey data gathered from adult population of Lahore city in residential, commercial and industrial areas through convenience sampling during the peak smog season. Knowledge, information trust, threat severity, threat vulnerability, response-efficacy, self-efficacy, and protective behavior were measured by a structured questionnaire. The theoretical base for differences in people's reactions to an identical environmental threat is Protection Motivation Theory. Results indicate that perceived susceptibility, perceived severity, response efficacy, and control are factors that lead to self-protective behavior. Knowledge and trust also underpin the appraisal process which results in protective action. The study demonstrates that air-quality communication needs to be clear, credible, and “easy to do” and focus on the health risk, as well as practical actions that residents can take. Individual protection should be suggested as long-term measures for emission reduction and better urban air quality.

Keywords: Air Pollution, Risk Perception, Protective Health Behavior, PM2.5, Smog, Urban Residents, Protection Motivation Theory, Pakistan

Introduction

Air pollution is one of the greatest environmental-health problems of rapidly expanding cities. Particulate matter, nitrogen dioxide, sulfur dioxide, ozone, carbon monoxide, and other pollutants can impact respiratory and cardiovascular systems and can cause and aggravate disease. The World Health Organization (WHO) has drawn attention to the health effects of these low levels of exposure, and has established global guideline values for key air pollutants to safeguard human health (World Health Organization, 2021; Manisalidis et al., 2020; Hoffmann et al., 2021).

Lahore is a key study site for environmental exposure and protective behaviours, as smog is highly prevalent and present for several months during the winter season. Ground-level pollutant stratification is affected by the winter meteorological conditions, as is emission from road transport, industrial activity, brick kilns, fuel burning, construction, and area burning. Lahore has been dealing with severe air quality issues, including persistent particulate pollution and seasonal fluctuations in air pollutants (Khan et al., 2023; Raza et al., 2021; Ali & Rana, 2024).

The long-term solution will continue to be emission reduction. There are also day-to-day activities that residents can do which can reduce their exposure to pollution when concentrations are at their highest. This could involve using air quality information, reducing or avoiding outdoor activities, not exercising at a high

^a BS, Department of Public Health, University of The Punjab, Lahore, Punjab, Pakistan.

^b BS, Department of Public Health, University of The Punjab, Lahore, Punjab, Pakistan.

^c BS, Department of Public Health, University of The Punjab, Lahore, Punjab, Pakistan.

^d M.Phil. Scholar, Environmental Science, Department of College of Earth and Environmental Science (CEES), University of the Punjab, Lahore, Punjab, Pakistan.

^e BS, Department of Public Health, University of The Punjab, Lahore, Punjab, Pakistan.

level, choosing an alternative mode of transport, or using appropriate respiratory protection/advice. These measures will reduce exposure until the structural controls can be used, but can not be used as a solution to the pollution problem. As well as decreasing the quantity of emissions in the air, there has recently been evidence that there are means to decrease individual exposure that can be beneficial for short-term health protection (Shah et al., 2023; Ounsaneha et al., 2026).

The main challenge for behaviors is: why is it that some people do not take steps to protect themselves and others? People can be conscious of the negative effects of smog, but not ready to take the steps that are suggested—because they feel it makes no sense, is not fun, is expensive, or because it is not part of their way of life. Here, the protection motivation theory can be applied, as it implies that threat appraisal and coping appraisal (Rogers, 1975; Maddux & Rogers, 1983) are independent. This concern aligns with the findings of the systematic evidence, which indicate that risk appraisal, self-efficacy, social norms, knowledge, and behavioural control all impact preventive behaviour regarding PM_{2.5} exposure (Bhatta et al., 2024; Ounsaneha et al., 2026).

An empirical study in Lahore revealed the association between Smog Knowledge, Information source trust, threat appraisal, coping appraisal, and protective health behaviour, as discussed in this article. This analysis is based on a published cross-sectional survey conducted in Lahore during the smog season at peak time (Imran et al., 2025).

Statement of the Problem

There is awareness about smog in Lahore, but awareness is not enough to take action to protect against smog. Residents may experience air pollution and may engage in outdoor activities without being attuned to air quality information and advice. Factors can impact behaviour, such as practical issues, intention, and trust of information sources. Knowing the factors is important in creating credible and effective health communication. Based on a literature review of smog in Pakistan and the study of behavior in Lahore, the need to explore translation of awareness to protective action was identified.

A health communication point of concern is in Lahore. Discussion of the severity of smog can lead to concern, but not action. On the other hand, if a message contains only information about what actions to take, but not the threat, it might not grab the attention of residents who don't feel threatened. So, when communicating, it's crucial to strike a balance between threat information and coping information. This study addresses this problem by taking a quantitative approach to both parties in the appraisal process.

Aim and Objectives

The purpose of the study is

- To explore the link between threat appraisal and coping health behaviors.
- To explore the threat-response-health protection action relationship.
- To assess how response efficacy and self-efficacy are related to protective behavior.
- To investigate the role of Smog Knowledge in threat appraisal and coping appraisal.
- To explore the effect of trust in information sources on threat and coping appraisal.
- To determine the importance of public-health communication during smog.

Research Questions

- What are the relationships between threat appraisal and protective health behavior to smog?
- How can threat vulnerability be related to health protective behavior?
- How are response efficacy, self-efficacy, and protective behavior related?
- What are the relationships among smog knowledge and threat/coping appraisal?
- What are the relationships between trust in information sources and threat and coping appraisal?
- What can be inferred for the communication of air quality in Lahore based on these relationships?

Literature Review

Air pollution leads to a range of health problems including respiratory disease, cardiovascular disease, exacerbation of asthma and premature deaths. Particulates are of specific concern as they can be inhaled

deep into the lungs. Both long-term and short-term air-quality management have been recommended by WHO, and key pollutants have been identified that are important for public health: these include PM_{2.5}, PM₁₀, ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide (World Health Organization, 2021). Particulate matter (PM) and major gaseous pollutants are still recognized as major drivers of morbidity and mortality (Manisalidis et al., 2020; Hoffmann et al., 2021; World Health Organization, 2021).

Fine particulate matter is especially relevant to urban air quality, due to its small aerodynamic diameter, which enables it to be inhaled to deep parts of the respiratory system. Thus, the concentration of particulate pollution (PM_{2.5} and PM₁₀) has been identified as an important parameter in the new WHO guidelines on air quality, which are significantly lower than those in previous guidelines. These are guidance values and not indicative of a threshold below which there is no risk. An air-quality index or concentration does not indicate the absence of all health risks for air-quality communication purposes (World Health Organization, 2021). This variety of PM_{2.5} and cardiopulmonary damage may be due to the small particle size of PM_{2.5}, which can penetrate deeply into the respiratory system and, for some constituents, the systemic circulation (World Health Organization, 2021; Manisalidis et al., 2020).

The health burden is also attributed to vulnerability. It can pose a more serious health threat to older individuals, children, individuals with preexisting respiratory and/or cardiovascular conditions, and individuals who are exposed to high levels of it outdoors during episodes of severe pollution. Vulnerability can therefore not be assumed to be a medical attribute. It is also dependent on social and occupational factors that affect the amount of polluted air inhaled by the individual and their willingness to limit it. The World Health Organization (WHO) guidance and reviews identify children and older adults as groups to be particularly protected, as well as those with underlying cardiopulmonary conditions, and other high-risk groups (World Health Organization, 2021; Shah et al., 2023).

Lahore Smog Context

High levels of local emissions and seasonal meteorological conditions make Lahore prone to recurrent smog. Khan et al. (2023) did a long-term monitoring study to explain the patterns of ambient air quality in Lahore. They pointed out the contribution of anthropogenic sources and vehicle emissions in the degradation of air quality in the city. Lahore is a suitable city to study environmental risk perception and decision-making for behavioral change in the context of a recurring smog season. Transport, industries, fuel combustion, construction, brick kilns, biomass burning, and meteorology might be contributing factors in the generation of smog based on a literature review of the smog problem in Pakistan and monitoring undertaken in Lahore (Raza et al., 2021; Khan et al., 2023).

This means that research in Lahore is where the worlds of environmental monitoring and health behavior converge. Pollution trends and possible pollution sources are described through monitoring studies, whereas the understanding of the residents and their response to pollution are given through behavior studies. The type of evidence required is whichever is required. In addition to monitoring evidence, recent Lahore studies have explored the spatial variation in smog risk perception and behavioural pathways towards protective responses (Ali & Rana, 2024; Imran et al., 2025).

Protective Health Behavior

Protective health behavior those behaviors that are performed to minimize exposure or harm when an environmental-health hazard exists. In the context of smog, these may involve reducing exposure outdoors, changing travel and activity habits, checking air-quality information, wearing a respiratory protection device and following public-health advice. However, it is not only information that influences the adoption of these actions; threat appraisal (seriousness of threat and susceptibility to threat) as well as coping appraisal (coping response self-efficacy, response efficacy) and self-efficacy in enacting the coping response (response self-efficacy, coping self-efficacy) are also important. Individual-level interventions to reduce exposure to air pollution (e.g., masks, respirators, air cleaning) and individual behavioral changes are often studied.

Therefore, to understand protective behavior, it cannot only be examined from the perspective of an individual. The ability to do actions is also influenced by social and physical environment. A delivery man, street vendor, a traffic official or a construction worker may have fewer options, but an office worker may be able to work remotely on a bad smog day. These restrictions should be recognized, and public-health guidance should not presume everyone in the community is capable of taking the same action.

Constraints also exist to behavioral adaptation. If residents are highly motivated, but pollution is everywhere within the Entire City, then they cannot clean up the pollution. In certain circumstances and environments, personal protective equipment can reduce exposure, but cannot clean the ambient air. Hence, structural and institutional responsibility for improved air quality is a prerequisite for behaviour-driven research and moral understanding. Hence the review of specific protective measures, exposure-reduction measures and population level pollution-control measures are suggested (Shah et al., 2023; Ounsaneha et al., 2026).

Knowledge and Trust

The information educates residents about the causes of smog, its effects and what residents can do about it. Trust is key to residents accepting and using information from government agencies, health professionals, researchers, media, and others. The present study conducted in Lahore has revealed that there is a positive relationship between cognitive appraisal processes, which contribute towards protective action, and knowledge and trust in smog. Additionally, evidence from systematic reviews suggests that psychosocial factors like knowledge, institutional trust, and self-efficacy are also pertinent for preventive action concerning PM2.5 exposure (Bhatta et al., 2024; Ounsaneha et al., 2026).

Trust is particularly pertinent when information is ambiguous, technical, or disputed. The data that are measured and the communication platforms, as well as the estimates provided by the sources, change over time, and so does the advice given in the air-pollution communication. When it comes to conveying accurate information, individuals don't always listen if they don't trust the messenger. But there are a number of measures that credible communicators can take to help pave the way for the acceptance and use of complex data. This renders trust not only a background, but a factor that constitutes the course from information to appraisal and from the appraisal to the behavior.

In sum, evidence indicates that the issue of protection against air pollution is multifaceted behavior. Bhatta et al. (2024) systematically reviewed the literature to evaluate the effectiveness of measures to prevent PM2.5. Risk appraisal, attitudes, behavioral control, social norms, education, self-efficacy, institutional trust, income, and knowledge were identified at all times. Risk appraisal, self-efficacy and social norms were also common predictors of adoption in a recent review of protective behaviors and interventions. It pointed out the necessity for localised interventions based on the local exposure and socio-economic context (Ounsaneha et al., 2026). The present study includes not only awareness as an explanation for people's non-engagement in healthy actions but also information-related variables and PMT appraisal variables, based on the findings.

Theoretical Framework

Protection Motivation Theory (PMT) as suggested by Rogers (1975) and self-efficacy as suggested by Maddux and Rogers (1983) were used in this study. PMT has two types of appraisals: threat appraisal and coping appraisal. Threat appraisal involves both the severity of the hazard as well as susceptibility to the hazard. Coping appraisal is the consideration of how the person can either limit damage or how self-efficacious he or she is in taking the recommended action. This theory could also be applicable when it comes to smog, as people might know that it is bad but not think that it will make a difference or feel that it will be difficult to do. Besides, PMT has been applied to recent studies on environmental behaviors, and its threat and coping appraisals have been suggested as predictors of pro-environmental/protective action (Shafiei & Maleksaeidi, 2020).

The appraisal of threat can be broken down into two analytically separable components. Severity – If this hazard does affect me, what are the serious consequences? The second is one's vulnerability: What is the risk it will happen to me? One individual could rate one dimension higher and one lower. For instance, people might realize the environment has a high concentration of smog pollution and that this pollution can impact health. However, they might not feel the risk to themselves due to being young, healthy, not going outside, or believing they are safe inside. This dimensional division allows us to more accurately describe the motivational drivers.

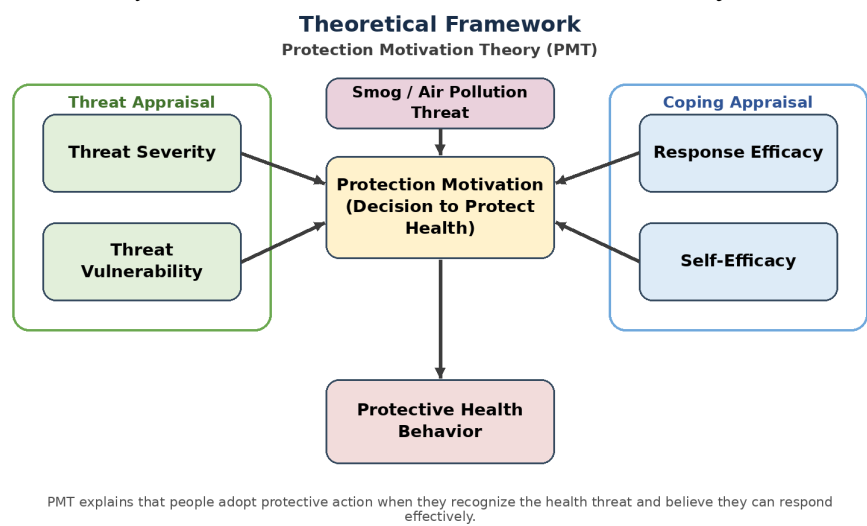
There are again two separate questions about coping appraisal. Response efficacy: Does the recommended response decrease exposure and/or harm? Self-efficacy: What about the person's ability to do the action? These dimensions in particular are linked to the air pollution problem, and it is a change which has to be made regularly, not once; otherwise it is not a change. Access and behavioural control evaluate the use of this knowledge through interventions such as modifying work schedule, limiting physical activity, wearing respiratory protection, and/or modifying work pattern in the outdoor environment.

The Lahore model added the knowledge and trust elements to the theoretical model, thereby enhancing it. In the realm of appraisal, knowledge is information, which trust can affect the acceptance of. These variables are not mutually exclusive of the basic PMT constructs, but can provide explanations concerning how residents make threat and coping judgments. This framework is well suited for environmental-health communication, since the quality of information becomes a part of the mental process leading to action.

Table 1
Protection Motivation Theory Constructs Used in the Study

PMT component	Study construct	Meaning in the smog context	Expected behavioral role
Threat appraisal	Threat severity	Judgment that smog can cause serious health consequences	Greater seriousness is expected to strengthen protective motivation
Threat appraisal	Threat vulnerability	Judgment that the individual may personally experience smog-related harm	Greater vulnerability is expected to strengthen protective motivation
Coping appraisal	Response efficacy	Belief that recommended actions can reduce exposure or harm	Stronger efficacy is expected to support protective action
Coping appraisal	Self-efficacy	Confidence in one's ability to carry out the recommended actions	Greater confidence is expected to support protective action

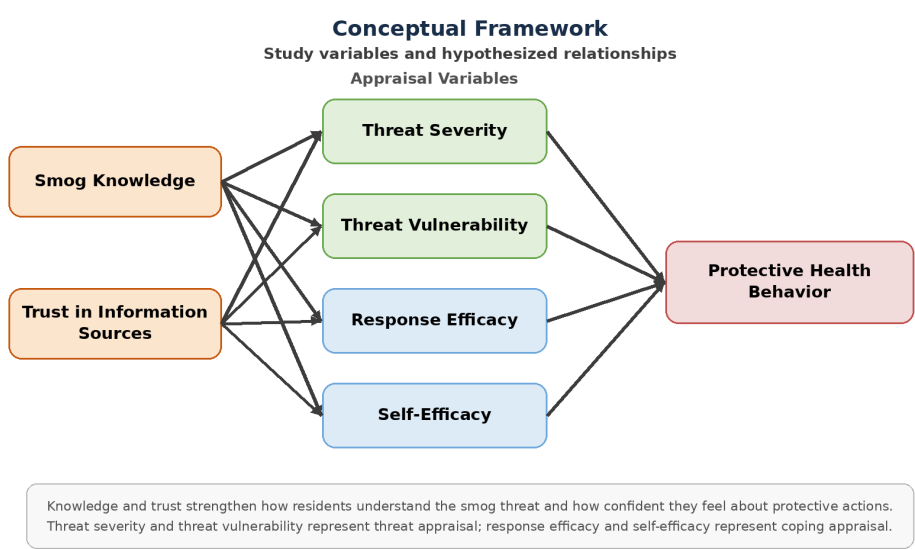
Figure 1
Theoretical framework based on Protection Motivation Theory



Conceptual Framework

The conceptual framework introduces the PMT using the variables measured in the Lahore survey. Smog knowledge and trust in information sources are considered factors of threat appraisal and coping appraisal. Threat severity and threat vulnerability are the threat-appraisal pathway. This coping-appraisal pathway is called response efficacy and self-efficacy. The response variable is protective health actions in the context of smog. The framework is conceptual and directional, but the cross-sectional design prevents causal interpretation. The arrows in the diagram represent theory-driven relationships that were statistically examined and do not indicate that one variable preceded the other in time. This matters because those who already engage in protective behaviors may also have higher efficacy beliefs. A longitudinal study would be needed to establish temporal ordering more definitively. This limitation is noteworthy given recent literature reviews of air-pollution behavior studies that recommend further longitudinal and intervention studies to better understand the temporal relationship (Bhatta et al., 2024; Ounsaneha et al., 2026).

Figure 2
Conceptual Framework of the Study



Methodology

Study Design and Setting

The study was quantitative and cross-sectional. The study was conducted on the adult population of Lahore in the winter smog season. The fieldwork involved areas within the accessible municipal areas such as residential neighbourhoods, commercial streets and industrial outskirts. This design was appropriate for the study of the statistical relationship between knowledge, trust, appraisals, and protective behaviour in the case of severe air pollution.

Sampling and Participants

The sampling method was convenience sampling. The survey teams received feedback from the people of various areas of Lahore through offline and online survey modes. Participants were adult city dwellers who could understand and complete the questionnaire. The returned questionnaires were checked before analysis for incomplete responses, missing information, and straight-lining.

After screening, 913 valid questionnaires were included in the final analysis. This sample size provides sufficient observations for structural modeling of the constructs reported in this study, which include multiple variables. However, sample size does not eliminate sampling bias. The demographic profile from the source study shows a significant number of educated adults, which should be considered when analyzing results related to knowledge, information use, and access to air quality advice.

Table 2

Screening Stage	n
Questionnaires collected	1,143
Excluded: straight-line responding	109
Excluded: missing data	83
Excluded: incomplete submission	38
Total excluded	230
Final valid responses	913

Table 3

Study Design and Sampling Profile

Element	Description
Research design	Quantitative cross-sectional survey
Study location	Lahore, Punjab, Pakistan
Sampling method	Convenience sampling
Population	Adult urban residents of Lahore
Coverage	Residential, commercial, and industrial locations across 15 accessible municipal zones
Survey mode	Offline and online
Fieldwork period	1 November 2023 to 20 February 2024
Instrument	Structured 42-item self-administered questionnaire
Pretest	Questionnaire pretested with 50 participants across three Lahore zones
Analysis software	SPSS and AMOS
Main analysis	Confirmatory factor analysis and structural equation modelling

Table 4

Sociodemographic Characteristics of the Analyzed Participants (N = 913)

Characteristic	Category	n	%
Gender	Male	400	43.8
	Female	513	56.2
Age	20-30 years	378	41.4
	30-40 years	199	21.1
	40-50 years	182	19.9
	Above 50 years	154	16.9
Education	Secondary	84	9.3
	Intermediate	115	12.6
	Graduate	447	49.0
	Postgraduate	267	29.2

Measurement

The questionnaire included 42 items measuring trust in information sources, smog knowledge, threat appraisal, coping appraisal, and protective behavior. Multi-item scales were used to measure all constructs that were adapted from existing research and used 5-point Likert response formats. Pretesting of the instrument was carried out prior to the fieldwork, and later the measurement model was analyzed using confirmatory factor analysis.

Table 5
Study Variables and Measurement Structure

Variable	Role in the model	Measurement description
Trust in information sources	Explanatory factor	Assessed confidence in sources providing smog-related information
Smog knowledge	Explanatory factor	Covered knowledge of smog causes, effects, and protective measures
Threat severity	Threat appraisal	Assessed seriousness of health consequences associated with smog
Threat vulnerability	Threat appraisal	Assessed personal susceptibility to smog-related health harm
Response efficacy	Coping appraisal	Assessed confidence that recommended measures can reduce risk
Self-efficacy	Coping appraisal	Assessed confidence in carrying out protective measures
Protective behavior	Outcome	Included actions such as mask use, limiting outdoor exposure, using public transport, and checking air quality

Data Analysis

Data were analyzed descriptively using SPSS. AMOS was used for confirmatory factor analysis and structural equation modeling. We used multiple fit indices to evaluate model adequacy rather than a single fit index. Before interpreting structural relationships, we assessed reliability and convergent validity. We measured the level of threat as the seriousness respondents assigned to the health effects of smog. Threat vulnerability was the extent to which respondents felt personally vulnerable or at risk for those consequences. Together, these constructs make up the threat appraisal aspect of PMT.

The analysis covers the scope of the study. This method enables a more complete theoretical and public health interpretation of the findings while retaining the authenticity of the empirical record.

Results

Sample Profile and Data Screening

Causes of Smog according to the participants

Participants identified some sources of smog in Lahore. Participants most often reported emissions from industrial activities, followed by emissions from vehicles. They also identified coal-fired power generation, domestic biomass combustion, meteorological conditions, straw stacking, and brick kiln emissions.

Table 6
Simulated Descriptive Statistics and Reliability

Reported cause	Frequency	Percentage	Reported cause
Industrial gas emission	384	42.1	Industrial gas emission
Vehicle emission	251	27.5	Vehicle emission
Coal-fired power plant emission	94	10.3	Coal-fired power plant emission
Household biomass burning	72	7.9	Household biomass burning
Meteorological reasons	61	6.7	Meteorological reasons
Straw burning	21	2.3	Straw burning
Brick kilns	13	1.4	Brick kilns
Other	17	1.9	Other
Total	913	100	Total

Measurement Model

The Tucker-Lewis Index fell below the widely used cut-off of 0.90, while the other major indices indicated sufficient overall fit.

Don't forget about the lower TLI. Fit indices may vary due to model complexity, sample size, and number of parameters estimated. The overall model fit is fair - the model was acceptable on several indices, although not every indicator met the desired level. This transparency is also critical for enhancing the interpretation credibility because it should not give the impression that the model is statistically perfect.

Table 7
Measurement-model Fit Indices

Fit index	Reported value	Common guideline	Interpretation
CFI	0.961	≥ 0.90	Meets guideline
NFI	0.971	≥ 0.90	Meets guideline
RMSEA	0.063	≤ 0.08	Meets guideline
CMIN/DF	4.67	≤ 5.00	Meets guideline
TLI	0.822	≥ 0.90	Below preferred threshold

Table 8
Construct-level Reliability and Convergent Validity Results

Construct	Items	Loading range	AVE	Composite reliability	Cronbach alpha
Threat severity	5	.80-.89	0.61	0.94	0.750
Threat vulnerability	5	.82-.91	0.54	0.95	0.897
Self-efficacy	6	.71-.79	0.60	0.87	0.883
Response efficacy	8	.73-.89	0.67	0.94	0.945
Smog knowledge	8	.82-.89	0.75	0.95	0.953
Trust in information sources	5	.69-.80	0.52	0.84	0.781
Protective behavior	4	.74-.84	0.62	0.86	0.793

Note. The published Table 4 reports one trust item loading at 0.69; the remaining reported loadings are 0.70 or higher.

Table 9
Discriminant Validity Matrix (Square Root of AVE on the Diagonal)

Construct	TS	KN	IS	SE	RE	TV	PB
TS	0.753						
KN	0.405	0.866					
IS	0.209	0.338	0.725				
SE	0.405	0.417	0.270	0.774			
RE	0.502	0.455	0.237	0.612	0.821		
TV	0.486	0.447	0.269	0.486	0.623	0.807	
PB	0.170	0.164	0.119	0.174	0.078	0.558	0.803

Abbreviations: TS = threat severity, KN = smog knowledge, IS = trust in information sources, SE = self-efficacy, RE = response efficacy, TV = threat vulnerability, PB = protective behavior.

Structural Relationships

The results showed statistically significant positive relationships between all four PMT appraisal constructs and protective behavior, as indicated by the structural model. Self-efficacy was directly and most strongly and significantly associated with protective behavior, followed by response efficacy, threat severity, and threat vulnerability. The model explained 54% of the variance in protective behavior.

Table10
Explained Variance (R-squared) in Endogenous Constructs

Endogenous construct	R-squared
Threat severity	0.16
Threat vulnerability	0.19
Self-efficacy	0.24
Response efficacy	0.21
Protective behavior	0.54

A causal sequence. Convenience sampling, however, restricted population-level inferences, and the English-language questionnaire may have overrepresented educated respondents. There may also be a recall-and/or social-desirability bias affecting self-reported behavior. Future studies should be conducted in Urdu and regional languages, where possible, with probability-based sample types, longitudinal designs, and objective air-quality measurements.

But there are some precautions in interpreting the results. The sampling method used was convenience sampling, as the probability of selection for the entire adult population of Lahore was unknown. The sample should therefore not be taken as a measure of the prevalence across the city with as much certainty as a probability survey. Also, the education level of the participants may have been over-represented, which may result in higher information levels than among the urban population.

Conclusion

Lahore evidence also reveals that threat appraisal is related to protective health behaviour during smog along with coping appraisal. Factors that contribute to mobilization are perceived threat to health, feeling vulnerable, believing the measures can reduce harm, and self-efficacy. Knowledge and trust influence these judgments. Effective communication should then include credible risk information and instructions that can be easily followed by residents in practical ways. In the interim, however, pollution control is crucial. More stringent emission reduction, monitoring and regulation, transport planning, cleaner technology, and ongoing public-health coordination are required for long-term improvements. This finding is consistent with the study published in Lahore and recent systematic evidence about the psychosocial determinants of PM2.5 protective actions (Imran et al., 2025; Bhatta et al., 2024; Ounsaneha et al., 2026).

The results show support for a policy-level linkage between individual protection and structural pollution control. In high-exposure events, residents can reduce their exposure but not emissions through their activities. Cleaner transport, better industrial control, better fuel and energy systems, together with strong monitoring and enforcement, and waste management and urban planning, are all durable solutions. One part of this larger policy response can be most ethical and helpful as behavioral guidance.

References

- Ali, A., & Rana, I. A. (2024). Assessing smog risk perception in Lahore metropolitan: A survey-based analysis. *Urban Climate*, 56, Article 102080. <https://doi.org/10.1016/j.uclim.2024.102080>
- Bahrami, Z., Sato, S., Yang, Z., Maiti, M., Kanawat, P., Umemura, T., Onishi, K., Terasaki, H., Nakayama, T., Matsumi, Y., & Ueda, K. (2024). The perception of air pollution and its health risk: A scoping review of measures and methods. *Global Health Action*, 17(1), Article 2370100. <https://doi.org/10.1080/16549716.2024.2370100>
- Bhatta, J., Laosee, O., & Rattanapan, C. (2024). Factors related to preventive measures towards PM2.5 exposure: A systematic review. *Global Transitions*, 6, 212–220. <https://doi.org/10.1016/j.glt.2024.10.002>
- Cori, L., Donzelli, G., Gorini, F., Bianchi, F., & Curzio, O. (2020). Risk perception of air pollution: A systematic review focused on particulate matter exposure. *International Journal of Environmental Research and Public Health*, 17(17), Article 6424. <https://doi.org/10.3390/ijerph17176424>
- Hoffmann, B., Boogaard, H., de Nazelle, A., Andersen, Z. J., Abramson, M., Brauer, M., Brunekreef, B., Forastiere, F., Huang, W., Kan, H., Kaufman, J. D., Katsouyanni, K., Krzyzanowski, M., Kuenzli, N., Laden, F., Nieuwenhuijsen, M., Mustapha, A., Powell, P., Rice, M., et al. (2021). WHO Air Quality Guidelines 2021—Aiming for healthier air for all. *International Journal of Public Health*, 66, Article 1604465. <https://doi.org/10.3389/ijph.2021.1604465>
- Imran, M., Tallat, A., & Özçatalbaş, O. (2025). Trust, knowledge, and risk appraisal as predictors of protective behavior during smog crisis in Lahore. *Discover Sustainability*, 6, Article 1336. <https://doi.org/10.1007/s43621-025-02052-5>
- Khan, W. A., Sharif, F., Khokhar, M. F., Shahzad, L., Ehsan, N., & Jahanzaib, M. (2023). Monitoring of ambient air quality patterns and assessment of air pollutants' correlation and effects on ambient air quality of Lahore, Pakistan. *Atmosphere*, 14(8), Article 1257. <https://doi.org/10.3390/atmos14081257>
- Maddux, J. E., & Rogers, R. W. (1983). Protection motivation and self-efficacy: A revised theory of fear appeals and attitude change. *Journal of Experimental Social Psychology*, 19(5), 469–479. [https://doi.org/10.1016/0022-1031\(83\)90023-9](https://doi.org/10.1016/0022-1031(83)90023-9)
- Manisalidis, I., Stavropoulou, E., Stavropoulos, A., & Bezirtzoglou, E. (2020). Environmental and health impacts of air pollution: A review. *Frontiers in Public Health*, 8, Article 14. <https://doi.org/10.3389/fpubh.2020.00014>
- Ounsaneha, W., Bhatta, J., & Rattanapan, C. (2026). Factors related to protective behaviors and interventions targeting PM2.5 exposure reduction: A systematic review. *Green Technologies and Sustainability*, 4(1), Article 100256. <https://doi.org/10.1016/j.grets.2025.100256>
- Raza, W., Saeed, S., Saulat, H., Gul, H., Sarfraz, M., Sonne, C., Sohn, Z. H., Brown, R. J. C., & Kim, K.-H. (2021). A review on the deteriorating situation of smog and its preventive measures in Pakistan. *Journal of Cleaner Production*, 279, Article 123676. <https://doi.org/10.1016/j.jclepro.2020.123676>
- Rogers, R. W. (1975). A protection motivation theory of fear appeals and attitude change. *The Journal of Psychology*, 91(1), 93–114. <https://doi.org/10.1080/00223980.1975.9915803>
- Shafiei, A., & Maleksaeidi, H. (2020). Pro-environmental behavior of university students: Application of protection motivation theory. *Global Ecology and Conservation*, 22, Article e00908. <https://doi.org/10.1016/j.gecco.2020.e00908>
- Shah, S., Kim, E., Kim, K.-N., & Ha, E. (2023). Can individual protective measures safeguard cardiopulmonary health from air pollution? A systematic review and meta-analysis. *Environmental Research*, 229, Article 115708. <https://doi.org/10.1016/j.envres.2023.115708>
- World Health Organization. (2021). *WHO global air quality guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. World Health Organization. <https://www.who.int/publications/i/item/9789240034228>