ISSN (P): 2790-9859 (E) 2790-9867
DOI:https://doi.org/10.37605/ijpbr.v6i1.2

Date of Submission:18-03-26
Date of Acceptance:26-04-26
Date of Publication: Jun,2026

Perceived Urban Air Pollution and Mental Health Among Adults in Pakistan: Health-Related Locus of Control as a Mediator and Outdoor Physical Activity as a Moderator

Khadija Syed[*], Syed Asad Shah[**], & Jabir Ansari[***]

Abstract

Those developing regions of the world where urbanization and industrialization have been the most rapid have produced population-dense areas with extremely high levels of ambient air pollution. Almost everywhere, poor air quality has been associated with several physical and mental health disorders. The only unexplainable part has been the psychological mechanism. The main objective of this study is to understand the psychosocial effects of urban air pollution on the Pakistani population. More specifically, this study aims to understand the effects of urban air pollution on the mental health of Pakistan's adult population, with health-related locus of control as the mediating factor and outdoor physical activity as the moderating factor. This study has been conducted across all major metropolitan areas of Pakistan, covering an urban population of approximately 104 million under the age of 60. Approximately 400 samples were collected in this cross-sectional study. Key findings of this study were derived from self-administered questionnaires. The locus of control was assessed using a questionnaire comprising the perception of air pollution, stress, and anxiety and depression scales, all of which were validated and adapted for this study. Active transportation and outdoor physical activity were assessed using a validated scale. For this study, the collected data were analyzed using descriptive analysis and regression analysis. The findings of the study revealed that urban air pollution and outdoor physical activity have a significant effect on the adult population of Pakistan.

Keywords: Perceived air pollution, Depression, Anxiety, Stress, Health locus of control,

[*]**M.phil. Psychology, Abdul Wali Khan University Mardan, syedkhadija316@gmail.com**

[**]**Lecturer, Institute of applied Technology, Myongian@gmail.com**

[***]**Mphil Psychology, Abdul Wali Khan University Mardan, kjabir909@gmail.com**

Introduction

Challenges pertaining to atmospheric quality within developing nations can be attributed to accelerating urbanization, industrialization, and the introduction of more advanced transportation (Obiageli et al., 2023; Rentschler & Leonova, 2023). Numerous challenges associated with urban atmospheric conditions may contribute to substantial environmental and public health concerns (Akomolafe et al., 2024; Rahaman et al., 2023). The detrimental effects of air pollution on the respiratory and circulatory systems have been well documented (Li et al., 2022); however, its ramifications for cognitive function and mental well-being have largely remained underexplored (Newbury et al., 2024). Numerous empirical studies have revealed that people living in areas with high levels of air pollution suffer a lower quality of life and higher levels of anxiety, depression, mental stress, and increased worries about living in a polluted environment and the overall stress it places on their quality of life (Siddik et al., 2026). There are many ways in which air pollution contributes to individuals' mental and emotional stress and is a concern in environmental and public health (Zhang et al., 2021; Petrowski et al., 2021).

Mental health issues related to pollution may begin to form in `clean' environments or at lower levels of pollution (Lyons et al., 2024). Use of poor-quality air and smoke pollution in large urban centers may contribute to serious lung problems (Bu-Olayan & Thomas, 2021; Piracha & Chaudhary, 2022). Another serious concern is that even in the absence of measurable pollution, people may experience high levels of environmental stress (Xian et al., 2024). Research in environmental psychology has shown that people in the presence of a stress-inducing environment may also develop mental health problems in the absence of a measurable environment (Fang et al., 2024; Müller et al., 2023). It is clear that living in an environment people perceive to be unsafe also negatively affects their mental and emotional health (Yang et al., 2025; Ferretti et al., 2024).

The phenomena in question may be partially understood via Environmental Stress Theory. According to this theory, exposure to specific environmental stressors (in this case, air pollution) may result in chronic physical and psychological stress (Zhang et al, 2021). Chronic exposure to environmental stressors may contribute to lower stress resilience and impaired stress coping ability

(Petrowski et al., 2021). Within urban environments, the chronic exposure to atmospheric pollutants may constitute a persistent stressor capable of exacerbating depressive symptoms, anxious ideation, and general psychological distress to even more pronounced levels (Cao et al., 2023),(Yang et al., 2023). Public health appears to be severely compromised by mental health conditions such as depression and anxiety, particularly as they are considered two of the most disabling conditions worldwide (Chodavadia et al., 2023). Both depression and anxiety may impair social and occupational functioning, including reduced productivity and increased absenteeism (Chodavadia et al., 2023). Depression often manifests as anhedonia, a persistently low effect, and an overall sense of hopelessness. The experience of anxiety is a heightened, almost constant, sense of apprehension regarding an imminent threat. Stress, in contrast, is the experience of being mentally and physically overwhelmed. Mental health is exacerbated in urban environments by environmental pollutants, which threaten physical health and safety (Pelgrims et al., 2021).

Empirical research suggests associations between environmental factors and mental health conditions; however, few studies investigate the psychological mechanisms that may underlie these associations. One hypothesized mechanism is health-related locus of control, defined as the perception of control over one's health (Botha & Dahmann, 2023). Individuals with a strong internal health locus of control attribute health outcomes to their own choices and behaviors (Janowski et al., 2013), whereas those with a strong external health locus of control attribute outcomes to external forces, such as environmental factors, chance, or influential others (Hinote, 2007). When individuals perceive environmental stressors, such as air pollution, as external and beyond personal control, they are more likely to develop an external health locus of control, which may diminish perceived control and increase feelings of helplessness. This process may exacerbate symptoms of anxiety, stress, and depression(Ganjoo et al., 2021). Thus, health-related locus of control represents a psychological mechanism that elucidates the negative impact of environmental stressors on emotional health.

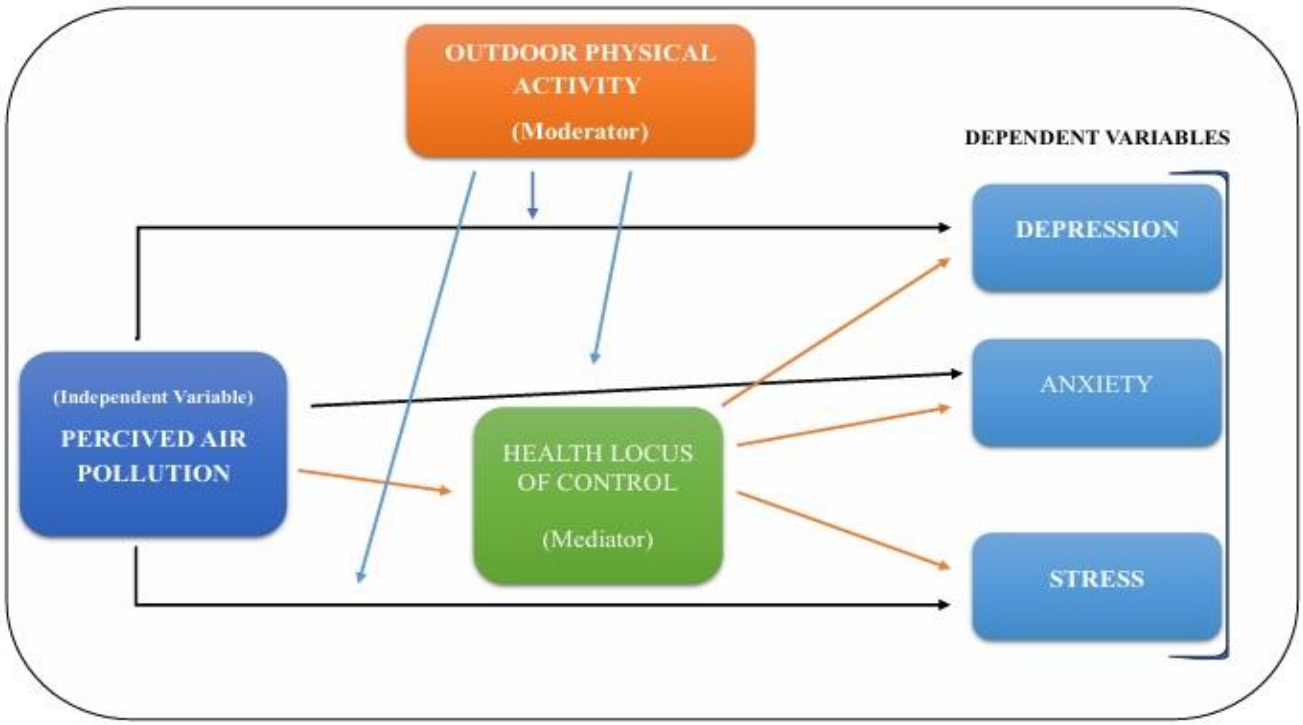
Coping resources at the behavioral level interface with cognitive resources in selecting responses to situational stressors. Engagement in physical activity has a positive association with mental health, psychological resilience, and a reduction in symptoms of depressed mood, anxiety, and stress. These protective effects may result from numerous physiological and psychological mechanisms. Although most of the psychological mechanisms are related to activity in general,

the therapeutic effect of exercising outdoors may be enhanced by exposure to a healing natural environment, the sun, and even the presence of company. The context of the situation plays an important role in how effective physical activity is as a coping resource. It is possible that physical activity helps lessen the psychological effects of certain environmental stressors and provides some "relief" from certain types of pollutant stressors (Chen et al., 2025).

In the developing world, the need to solidify these relationships is more critical, especially amid rapid urbanization. Over the last few decades, the growth of urban centers and industrialization, along with severe environmental degradation in Pakistan, has brought far-reaching changes (Dilawar et al., 2024). The severe environmental degradation has led to air pollution, smog, and increased particulate matter in the major cities of Peshawar, Islamabad, Lahore, and Karachi (Li et al., 2023). Although environmental challenges are abundant in Pakistan, most research investigates their effects on physical health. The effects on behavioral health, particularly the effects of pollution on behavior, have largely been neglected (Rafique et al., 2022). Within the limited framework of coping strategies and psychological mechanisms, the context of urbanization in Pakistan remains largely unexplored.

The identification of existing gaps has both theoretical and empirical implications. From a theoretical standpoint, the Environmental Experience Model, health belief models, and coping resources models together explain how environmental stimuli and stressors impact mental health. From the empirical standpoint, the thoughtful modification of the psychological and behavioral variables that can be changed brings methods (or strategies) to the design of interventions to lessen the impact of environmental stimuli and stressors on mental health for the affected communities (Xue et al., 2024). This explains why this study intends to understand the perception of urban air pollution in relation to depression, anxiety, and stress (in addition to the psychological distress) of the adult population of Pakistan. In addition, this study proposes the health-related locus of control as a mediating variable and outdoor physical activities as a moderating variable. This study thus combines environmental, cognitive, and behavioral approaches to understand perceived environmental situations and their impact on mental health in urban areas.

Conceptual Model



Hypothesis

H1: Perceived urban air pollution will be positively associated with depressive symptoms among adults.

H2: Perceived urban air pollution will be positively associated with anxiety symptoms among adults.

H3: Perceived urban air pollution will be positively associated with perceived stress among adults.

H4: Perceived urban air pollution will be positively associated with a more external health-related locus of control.

H5: Health-related locus of control will mediate the relationship between perceived urban air pollution and depressive symptoms.

H6: Health-related locus of control will mediate the relationship between perceived urban air pollution and anxiety symptoms.

H7: Health-related locus of control will mediate the relationship between perceived urban air pollution and perceived stress.

H8: Outdoor physical activity will moderate the relationship between perceived urban air pollution and depressive symptoms, such that the positive association between perceived air pollution and depression will be weaker among individuals with higher levels of outdoor physical activity.

H9: Outdoor physical activity will moderate the relationship between perceived urban air pollution and anxiety symptoms, such that the positive association between perceived air pollution and anxiety will be weaker among individuals with higher levels of outdoor physical activity.

H10: Outdoor physical activity will moderate the relationship between perceived urban air pollution and perceived stress, such that the positive association between perceived air pollution and stress will be weaker among individuals with higher levels of outdoor physical activity.

H11: Significant gender differences will exist in perceived urban air pollution, depression, anxiety, and stress among Pakistani adults.

H12: Significant differences will exist across Peshawar, Islamabad, Lahore, and Karachi in perceived urban air pollution, depression, anxiety, and stress among Pakistani adults.

Method

Research Design and Participants

An online quantitative cross-sectional survey was conducted on urban air pollution and psychological distress in the adult population of Pakistan. Participants comprised the four largest metropolitan cities in Pakistan: Peshawar, Islamabad, Lahore, and Karachi (urbanized areas experiencing rapid development and facing the growing challenge of air pollution).

Participants included 400 adults aged 18 to 60 years from all levels of education, employment, and socioeconomic groups. There was an even distribution of participants for both genders and cities of residence. Participation was voluntary and based on informed consent.

An online survey was used to collect data with an estimated collection time of 7 to 10 minutes. Prior to participation, participants were provided with an informed consent form outlining their

right to withdraw and guaranteeing confidentiality. The online survey was available only to participants who provided informed consent.

Perceived Urban Air Pollution

An amended version of the Perceived Environmental Pollution Scale was used to measure perceived urban air pollution. Previous studies in environmental health cite variations of the scale to measure perceived urban air pollution. The scale comprised eight questions regarding participants perceived air quality in their urban environments, including the presence of smog, bad smells, breathing discomfort, and the presence and severity of pollution. Higher scale scores indicated greater perceived urban air pollution (Pun et al., 2022; Zhang et al., 2021).

Health-Related Locus of Control

The Short Form of the Multidimensional Health Locus of Control Scale (MHLC) was administered to study participants to measure health-related locus of control. Wallston et al. (1987) indicated the MHLC evaluates individuals' perceptions of their health-related locus of control, where health outcomes could be a consequence of one's actions or a result of factors beyond their control, such as fate, the environment, or agents with power. In the present study, external health-related locus of control was emphasized by the use of the short-form version containing six items, where a higher score indicated a higher degree of external health control beliefs (Wallston et al., 1994).

Depression, Anxiety, and Stress

The DASS-21 or the Depression Anxiety Stress Scale -21, was used to measure psychological distress. This self-report tool is structured around 21 items that assess depression, anxiety, and stress. This tool is reported to have good reliability and validity. Using a 4-point Likert scale, participants reported their level of distress for each symptom as experienced over the past week. This tool is structured to report that the higher the score, the higher the distress (Lovibond & Lovibond, 1995).

Outdoor Physical Activity

The IPAQ-SF (International Physical Activity Questionnaire - Short Form) was used to measure outdoor physical activity levels among participants. The IPAQ-SF-SF quantitatively measures the duration of mild and vigorous forms of exercise and walking, in addition to measuring the amount of time spent on sedentary activities, over the preceding week. The IPAQ-SF-SF is based on the time spent on the reported activities, the score being the sum of all reported activities, and participants being ranked based on the total score. A higher score reflects a higher level of physical activity (Craig et al. 2003).

Results

Table 1: Demographic Data of the Participants (N = 400)

Variable	Category	n	%
Gender	Male	200	50.0
	Female	200	50.0
Age Group	18–30 years	138	34.5
	31–45 years	132	33.0
	46–60 years	130	32.5
City of Residence	Peshawar	100	25.0
	Islamabad	100	25.0
	Lahore	100	25.0
	Karachi	100	25.0
Marital Status	Single	208	52.0
	Married	180	45.0
	Divorced/Widowed	12	3.0

Variable	Category	n	%
Education Level	Intermediate	72	18.0
	Bachelor’s Degree	188	47.0
	Master’s Degree	110	27.5
	MPhil/PhD	30	7.5
Employment Status	Student	126	31.5
	Employed	178	44.5
	Self-employed	60	15.0
	Unemployed	36	9.0
Monthly Income (PKR)	< 50,000	118	29.5
	50,000–100,000	152	38.0
	100,000–200,000	92	23.0
	> 200,000	38	9.5
Smoking Status	Yes	96	24.0
	No	304	76.0
Chronic Health Condition	Yes	64	16.0
	No	336	84.0
Average Outdoor Time Daily	<1 hour	78	19.5
	1–3 hours	192	48.0
	3–5 hours	90	22.5

Variable	Category	n	%
	>5 hours	40	10.0

Table 1 details demographic data for the 400 adult participants cohort. Data shows that all participants were younger than 60. Gender data shows that male and female participants were equally represented, each comprising 50% of participants. The recruitment methods also balanced age representation. 34.5% of the participants were in the 18 – 30 age group, 33% were in the 31 – 45 age group, and the remaining 32.5% were in the 46 – 60 age group. For cross metropolitan comparability, participants were recruited in equal numbers from four metropolitan centers (Peshawar, Islamabad, Lahore, and Karachi) allocating 25% of the total study sample to each metropolitan center.

For the marital status of participants, 52% were single, 45% were married, and the remaining 3% were divorced and/or widowed. From the data on education, it can be concluded that 47% of the participants were educated to the level of bachelor's degree, 27.5% to the level of master's degree, 18% completed the intermediate level, and the remaining 7.5% were educated to the level of Master of Philosophy or doctorate. Employment data shows that 44.5% of participants were employed, 31.5% were students, 15% of participants were self-employed, and 9% were unemployed.

From the available data, it can be deduced that 38% of the participants reported a monthly income of between 50,000 and 100,000 PKR, and 29.5% of the participants reported a monthly income of less than 50,000 PKR. From the health-related data, it can be deduced that 24% of the participants were smokers, 16% of the participants reported a chronic health condition, and 48% of the participants reported that they spent between 1 and 3 hours outdoors. The remaining participants reported that they spent outdoors between 3 and 5 hours (22.5%), less than 1 hour (19.5%), and more than 5 hours (10%).

Table 2: Descriptive Statistics and Reliability of Study Variables (N = 400)

Variable	Mean	SD	Cronbach's α
Perceived Urban Air Pollution	3.41	0.78	.86

Variable	Mean	SD	Cronbach's α
Health-Related Locus of Control	3.68	0.74	.82
Depression	1.34	0.65	.88
Anxiety	1.41	0.69	.87
Stress	1.52	0.71	.89
Outdoor Physical Activity	2.67	0.83	.80

Descriptive statistics and internal consistency reliability estimates are provided for the research variables in Table 2. The results revealed an average score of 3.41 (SD = 0.78), implying that the research participants perceived the level of air pollution in their surroundings as being at a moderate level. An average score of 3.68 (SD = 0.74), suggests a moderate level of external health-related locus of control of the respondents. An average score of 1.34 (SD 0.65) for the depression subscale, 1.41 (SD 0.69) for the anxiety subscale, and 1.52 (SD 0.71) for the stress subscale indicates moderate emotional distress of the study population. Based on the study, it can be concluded that the participants experienced moderate emotional distress. Good internal consistency of the scales was indicated by Cronbach's alpha coefficient, with reliability estimates being between .80 and .89 (the recommended cut-off .70).

Table 3: Pearson Correlations Among Study Variables

Variable	1	2	3	4	5	6
1. Air pollution	—					
2. Health Locus of Control	.42**	—				
3. Depression	.36**	.39**	—			

Variable	1	2	3	4	5	6
4. Anxiety	.34**	.37**	.62**	—		
5. Stress	.38**	.41**	.58**	.64**	—	
6. Physical Activity	-.19*	-.16*	-.28**	-.25**	-.27**	—

Note. **p < .05, **p < .01.*

The Pearson correlation coefficients between the key study variables are shown in Table 3. Perceived air pollution in cities was also positively correlated with health-related locus of control ($r = .42$, $p < .01$), suggesting that persons who perceived higher air pollution levels were more likely to attribute their health to factors external to themselves. Perceived air pollution was also found to be significantly associated with depression ($r=.36$, $p <.01$), anxiety ($r=.34$, $p <.01$), and stress ($r=.38$, $p <.01$). These results suggest that those people who had a higher perception of urban pollution had a higher psychological distress level. Health-related locus of control was also found to be positively associated with depression (and its symptoms - $r = .39$, $p < .01$), anxiety (and its symptoms - $r = .37$, $p < .01$), and stress ($r = .41$, $p < .01$), suggesting that greater beliefs in external health control were associated with the development of greater levels of emotional distress. Outdoor physical activity was negatively associated with perceived air pollution and psychological distress. Specifically, physical activity was negatively related to depression ($r = - .28$, $p < .01$), anxiety ($r = -.25$, $p < .01$), and stress ($r = -.27$, $p < .01$), suggesting that people who engaged in higher levels of physical activity had a tendency to report lower levels of psychological distress.

Table 4: Gender Differences in Study Variables

Variable	Male M (SD)	Female M (SD)	t	p
Perceived Air Pollution	3.33 (.77)	3.49 (.79)	-2.08	.038
Health Locus of Control	3.61 (.72)	3.74 (.75)	-1.84	.067
Depression	1.28 (.63)	1.40 (.66)	-2.03	.043

Variable	Male M (SD)	Female M (SD)	t	p
Anxiety	1.34 (.67)	1.47 (.71)	-1.96	.050
Stress	1.45 (.69)	1.59 (.72)	-2.16	.031
Physical Activity	2.81 (.82)	2.53 (.83)	3.36	.001

The results of the gender-difference analysis of the study variables using an independent-samples t-test are shown in Table 4. Female participants had significantly higher levels of air pollution perception (M = 3.49, SD = .79) than male participants (M = 3.33, SD = .77), t(398) = -2.08, p = .038. Similarly, females were found to have significantly higher levels of depression, anxiety, and stress than males. In particular, females had a higher mean depression score (M = 1.40, SD = .66) than males (M = 1.28, SD = .63), t(398) = -2.03, p = .043. Comparable results were observed regarding the symptoms of anxiety and stress, which leads us to believe that the participants of this study were female and had higher levels of psychological distress in general. In contrast, levels of physical activity outdoors were reported to be significantly higher among male than female participants, M = 2.81, SD = .82; M = 2.53, SD = .83, t(398) = 3.36, p = .001. There was no statistically significant difference between genders regarding health-related locus of control, though females had slightly higher scores.

Table 5: City Differences in Study Variables

Variable	Peshawar M (SD)	Islamabad M (SD)	Lahore M (SD)	Karachi M (SD)	F	p
Air-pollution	3.56 (.75)	3.12 (.71)	3.68 (.80)	3.28 (.76)	9.41	.001
Health Locus of Control	3.72 (.73)	3.55 (.70)	3.77 (.76)	3.67 (.74)	2.11	.098
Depression	1.41 (.67)	1.20 (.61)	1.48 (.66)	1.29 (.64)	4.52	.004
Anxiety	1.47 (.71)	1.30 (.66)	1.55 (.69)	1.33 (.68)	3.88	.009

Variable	Peshawar M (SD)	Islamabad M (SD)	Lahore M (SD)	Karachi M (SD)	F	p
Stress	1.60 (.72)	1.36 (.65)	1.63 (.73)	1.47 (.69)	4.96	.002
Physical Activity	2.54 (.79)	2.83 (.84)	2.61 (.82)	2.69 (.86)	3.15	.025

The results of the one-way analyses of variance (ANOVAs) comparing the various cities are shown in Table 5. There were significant differences in perceived air pollution, $F(3, 396) = 9.41$, $p = .001$. It was found that perceived degree of pollution was found to be maximum among participants from Lahore ($M = 3.68$, $SD = .80$) followed by Peshawar ($M = 3.56$, $SD = .75$). The perceptions of pollution of the lower dust particles from Islamabad were comparatively ($M = 3.12$ and $SD = .71$). There were also significant findings of city differences in depression, anxiety and stress. Participants from Lahore and Peshawar were relatively psychologically more distressed in comparison to those from the other location, Islamabad. Additionally, there was a significant difference in physical activity, $F(3,396) = 3.15$, $p = .025$, with those from Islamabad reporting the highest average physical activity levels. No statistically significant differences across cities were found for health-related locus of control, and relatively similar health belief patterns were observed among the sampled urban populations.

Table 6: Mediation Analysis Health-Related Locus of Control as a Mediator between Perceived Air Pollution and Depression, Anxiety, and Stress

Outcome Variable	Path	B	SE	t	p	LLCI	ULCI
Depression	Air-pollution → HLOC (a)	.42	.04	10.50	.001	.34	.50
	HLOC → Depression (b)	.31	.05	6.20	.001	.21	.41
	Air-pollution → Depression (c')	.22	.06	3.67	.001	.10	.34
	Indirect Effect (a×b)	.13	.03	—	—	.08	.19

Outcome Variable	Path	B	SE	t	p	LLCI	ULCI
Anxiety	Air-pollution → HLOC (a)	.42	.04	10.50	.001	.34	.50
	HLOC → Anxiety (b)	.29	.05	5.80	.001	.19	.39
	Air-pollution → Anxiety (c')	.20	.06	3.33	.001	.09	.32
	Indirect Effect (a×b)	.12	.03	—	—	.07	.18
Stress	Air-pollution → HLOC (a)	.42	.04	10.50	.001	.34	.50
	HLOC → Stress (b)	.34	.05	6.80	.001	.24	.44
	Air-pollution → Stress (c')	.25	.06	4.16	.001	.13	.36
	Indirect Effect (a×b)	.14	.03	—	—	.09	.20

Note. *HLOC = Health-Related Locus of Control. Bootstrap sample = 5000.*

Table 6 presents the results of the mediation analysis examining whether health-related locus of control mediated the relationship between perceived urban air pollution and depression, anxiety, and stress. Perceived urban air pollution significantly mis predicted health-related locus of control ($B = .42$, $p < .001$), indicating that perceptions of increased environmental pollution predicted higher indices of external control of health. Health-related locus of control was also a significant predictor of depression ($B = .31$, $p < .001$), and also of anxiety ($B = .29$, $p < .001$) and stress ($B = .34$, $p < .001$). These results show that there were more levels of emotional difficulties reported by the people who have a belief system relating to being externally determined by their health outcomes. We found the indirect effects of perceived air pollution on depression, anxiety, and stress through health locus of control to be significant using bootstrap confidence intervals that did not include zero. These results show that the health-related locus of control partially mediated the relationship between the perceived urban air pollution and depression, anxiety, and stress.

Table 7: Moderation Analysis: Outdoor Physical Activity as a Moderator

Outcome Variable	Predictor	B	SE	t	P
Depression	Air-pollution	.29	.05	5.80	.001
	Physical Activity	-.21	.05	-4.20	.001
	Air-pollution × Physical Activity	-.15	.04	-3.75	.001
Anxiety	Air-pollution	.27	.05	5.40	.001
	Physical Activity	-.18	.05	-3.60	.001
	Air-pollution × Physical Activity	-.13	.04	-3.20	.002
Stress	Air-pollution	.31	.05	6.10	.001
	Physical Activity	-.20	.05	-4.00	.001
	Air-pollution × Physical Activity	-.16	.04	-3.90	.001

Table 7 presents the results of the moderation analysis of the relationships between outdoor physical activity and perceived air pollution in the city, and between outdoor physical activity and depression, anxiety, and stress. Perceived air pollution was a significant predictor for depression (beta (B) = .29, $p < .001$), anxiety (B = .27, $p < .001$), and stress (B = .31, $p < .001$). Outdoor physical activity was significantly related to negative associations with all 3 outcomes, showing that the people who engaged in more levels of physical activity reported lower levels of depression, anxiety, and stress. Importantly, the interaction between perceived air pollution and outdoor physical activity was evident across all three outcomes. The effects of the interaction were negative, suggesting that higher levels of outdoor physical activity reduced the impact of perceived air pollution on depression, anxiety, and stress. In other words, the more active people appeared to be less affected by negative psychological consequences from perceived environmental pollution. These results indicate that outdoor physical activity has a protective role as a buffer effect against the effect of perceived urban air pollution for the mood variables of depression, anxiety, and stress.

Discussion

This study examined urban air pollution and psychological distress among adults in Pakistan. It identified health-related locus of control as a mediating factor and outdoor physical activity as a moderating factor. As predicted, perceived urban air pollution increased depression, anxiety, and stress symptoms. It was also found that health-related locus of control mediated these relationships, and outdoor physical activity moderated the negative psychological effects of perceived pollution. This study provides an initial understanding of how elements and resources combine and interact within the urban environment and their impact on mental health.

Aligned with the rest of the literature, the findings of this study indicated that perceived urban air pollution has a positive impact on the prevalence of depression, anxiety, and stress (Xu et al., 2023). These findings also confirmed the assertion that pollution and urban development are major psychosocial stressors of our time (Mori et al., 2025; Xu et al., 2023) The physical impacts of air pollution on health are now firmly established (Rentschler & Leonova, 2023). However, these findings showed that, in addition to the real impacts of air pollution, the perception of urbanization can also be a primary psychosocial stressor. Perceived urban air pollution creates acute concerns for health and safety, and an overstressed anxiety about the future and the uncertainty it will bring. The transactional model of stress posits that the cognitive appraisal of the environment creates a stress-related state of concern (Dinesh et al., 2023). These findings support this theory because the environment influences mental health, stress, and illness via the interconnections of the biological and psychological impacts associated with perceived environmental safety.

The current study designates health-related locus of control as a significant mediating factor. Results show urban air pollution causes participants to adopt externally situated health locus of control, which is linked to increased depression, anxiety, and stress. Cognitively dangerous beliefs result from environmental concerns perceived as unconquerable. When such environmental concerns are insurmountable, how one perceives one's belief in agency is adversely affected. This is congruent with health psychology and control-related theories (Ahadzadeh et al., 2021). Many participants believed the environmental concerns of health control were beyond their control. When the outcome of health is perceived as externally controlled, environmental concerns about health control lead participants to believe they are health-vulnerable, thereby increasing their

emotional distress. This study is the first to research urban environmental pollution and the locus of health control.

The moderating role of outdoor physical activity helps identify factors that may shield individuals from the adverse effects of perceived pollution (Li et al., 2024). When it comes to perceived air pollution and the resulting psychological distress, the strength of the association decreases as physical activity increases, serving as a buffer (Li et al., 2024). This is supported by evidence that physical activity can help mitigate the negative effects of air pollution on mental health (Cao et al., 2023). Physical activity has been shown to mediate the relationship between environmental factors and mental health (Yang et al., 2025). Physical activity may reduce the strength of the association between air pollution and psychological distress (Li et al., 2024). The results of this study indicate that poor environmental conditions are not the primary focus of concern. Instead, the emotional rest from the stress of environmental concerns may be a coping strategy that draws on behavioral resources.

There were important variations in mental health data across populations and settings. Women exhibited greater symptoms of depression, anxiety, and stress, compared with men (Kakaei et al., 2023). Women's symptoms align with those commonly described in the literature (Kakaei et al., 2023). The differences may be attributable to a range of factors, including biological, social, and environmental stress (Kakaei et al., 2023). There were important differences in mental health across cities, with more mental health problems caused by air pollution in cities with lower economic development (Cao et al., 2023). The results highlight the importance of mental health in polluted, crowded cities, taking into account the specific context of urban settings. Environmental factors may have their primary impact on physical health, but they also affect mental health and the quality of everyday life, and how urban dwellers perceive it.

Including people's perceptions of their environments, their coping skills, and the resources they bring to bear on different situations also advances understanding of mental health and the role different environments play. The study provides a framework for thinking and for assessing cumulative and interacting factors. The results also suggest the importance of people's perceptions of urban conditions and their relationship to urban psychological health. Including both mediators and boundaries in how people perceive their environments as polluted and urban helps define the psychological situation of adults living in rapidly developed and urbanized environments.

Theoretical Implications

Within Environmental Stress Theory, this study positions the perception of air pollution as an ambient stressor contributing to the symptoms of depression, anxiety, and stress. From a Theory of Planned Behavior perspective, the findings suggest extending the health-related locus of control as a form of cognitive appraisal of environmental stress, which further sheds light on certain symptoms of mental health challenges. Thus, this study addresses a gap in the literature and explains that environmental perceptions will impact constructs of mental health challenges, both directly and indirectly via the locus of control in health.

Additionally, the effect of physical activity as a moderator contributes to the resources for coping available in environmental health. It appears the cumulative impacts of environmental distress may be negated by health-promoting behaviors. Thus, this study also contributes to the conceptualization of environmental distress, cognitive appraisal, and resources for coping as determinants of mental health.

Practical Implications

The findings have the potential to positively revise public health, mental health, and even planning policies. First, there is a psychological benefit to improved air quality, in addition to myriad physical health benefits. The reduction of urban pollution may be considered an environmental mental health intervention.

Regarding the second consideration, empowering people through health control measures may reduce the impact of the environment on people's health. Rather than focusing on the effects of coping, self-efficacy may offer an opportunity for health improvement in urban environments with high levels of pollution.

Third, health benefits and improvements in well-being may be gained from increased outdoor activity, especially in urban environments. Psychological well-being may be an additional benefit of good urban design.

Limitations and Future Directions

In this study, there are numerous limitations that warrant further examination. The first is the inability to assert causation for perceived air pollution, health-related locus of control, physical

activity, and psychological distress due to the cross-sectional design. To address this study's gaps, the following research will need to be longitudinal in design.

Second, the present research used only self-reported measures for all included variables, which is likely to have produced both common-method and social-desirability biases. Thus, in the following research, a broader range of assessment techniques should be employed, including more objective measures of the environment, such as the Air Quality Index (AQI) and GIS-based pollution mapping.

Third, only online recruitment of participants was employed, which may constrain the generalizability of the research. The following research should include additional participants, especially those from rural and semi-urban areas (if at all possible), and employ various sampling techniques.

Lastly, the psychological dimensions of environmental concern, risk perception, social identity, resilience, coping, and environmental identity may represent additional avenues for integrating the psychological dimensions of these conditions. The integration of such dimensions may help improve the understanding of the psychological effects of climate change on mental health.

Conclusion

The perceived existence of air pollution in the urban centers of Pakistan not only has detrimental effects on the mental health of the population by manifesting symptoms of anxiety, depression, and stress, but it also has far-reaching implications. There is a close association between the perceived locus of control and environmental health, and between the beneficial psychological coping mechanism of participation in outdoor activities and the mitigation of the adverse mental health impacts of urban air pollution.

REFERENCES

Ahadzadeh, A. S., Wu, S. L., Ong, F. S., & Deng, R. (2021). The Mediating Influence of the Unified Theory of Acceptance and Use of Technology on the Relationship Between Internal Health Locus of Control and Mobile Health Adoption: Cross-sectional Study. *Journal of Medical Internet Research*, *23*(12). https://doi.org/10.2196/28086

Akomolafe, O. O., Olorunsogo, T., Anyanwu, E. C., Osasona, F., Ogugua, J. O., & Daraojimba, O. H. (2024). AIR QUALITY AND PUBLIC HEALTH: A REVIEW OF URBAN POLLUTION SOURCES AND MITIGATION MEASURES. *Engineering Science & Technology Journal*, *5*(2), 259–271. https://doi.org/10.51594/estj.v5i2.751

Botha, F., & Dahmann, S. C. (2023). Locus of control, self-control, and health outcomes. *PubMed Central*, *25*, 101566–101566. https://doi.org/10.1016/j.ssmph.2023.101566

Bu-Olayan, A. H., & Thomas, B. V. (2021). Exposition of respiratory ailments from trace metal concentrations in incense. *Scientific Reports*, *11*(1), 10210–10210. https://doi.org/10.1038/s41598-021-89493-w

Cao, Z., Zhou, J., Li, M., Huang, J., & Dou, D. (2023). Urbanites' mental health is undermined by air pollution. *Nature Sustainability*, *6*(4), 470–478. https://doi.org/10.1038/s41893-022-01032-1

Chen, Y., You, Y., He, J., Zhang, Q., Zhang, Y., & Ma, W. (2025). Physical activity modifies the association between ambient air pollution and comorbid depression and disability in activities of daily living. *Scientific Reports*, *15*(1), 41418–41418. https://doi.org/10.1038/s41598-025-25347-z

Chodavadia, P., Teo, I., Poremski, D., Fung, D., & Finkelstein, E. (2023). Prevalence and economic burden of depression and anxiety symptoms among Singaporean adults: results from a 2022 web panel. *BMC Psychiatry*, *23*(1), 104–104. https://doi.org/10.1186/s12888-023-04581-7

Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J. F., & Oja, P. (2003). International Physical Activity Questionnaire: 12-country reliability and validity. *Medicine & Science in Sports & Exercise, 35*(8), 1381–1395. https://doi.org/10.1249/01.MSS.0000078924.61453.FB

Dilawar, A., Chen, B., Haq, Z. ul, Ali, S., Sajjad, M. M., Junjun, F., Gemechu, T. M., Guo, M., Dilawar, H., Zhang, H., Zheng, Z., & Lodhi, E. (2024). Evaluating the potential footprints of land use and land cover and climate dynamics on atmospheric pollution in

Pakistan. *Frontiers in Environmental Science*, *11*. https://doi.org/10.3389/fenvs.2023.1272155

Dinesh, T. K., Shetty, A., Shetty, A., TS, S., Pai, R. Y., Shetty, A. D., & Shetty, A. D. (2023). Embracing complexity: Exploring the silent struggle of life insurance agents. *Cogent Business & Management*, *10*(3). https://doi.org/10.1080/23311975.2023.2279346

Fang, Z., Lin, Y., Chen, C., Jian, J., & Dong, L. (2024). Mental health in China: exploring the impacts of built environment, work environment, and subjective perception. *Frontiers in Psychology*, *15*, 1352609–1352609. https://doi.org/10.3389/fpsyg.2024.1352609

Ferretti, F., Gualtieri, G., Masti, A., & Uvelli, A. (2024). Urban safety and psychological distress during the pandemic: the results of a longitudinal study. *Frontiers in Psychology*, *15*, 1343585–1343585. https://doi.org/10.3389/fpsyg.2024.1343585

Ganjoo, M., Farhadi, A., Baghbani, R., Daneshi, S., & Nemati, R. (2021). Association between health locus of control and perceived stress in college student during the COVID-19 outbreak: a cross-sectional study in Iran. *BMC Psychiatry*, *21*(1), 529–529. https://doi.org/10.1186/s12888-021-03543-1

Hinote, B. P. (2007). Health Locus of Control. In *The Blackwell Encyclopedia of Sociology*. https://doi.org/10.1002/9781405165518.wbeosh009

Huang, H., & Wang, Q. (2024). Within digital collaborative teams, how can leaders promote productive knowledge sharing among members with diverse settings? *Digital Economy and Sustainable Development*, *2*(1). https://doi.org/10.1007/s44265-023-00027-w

Janowski, K., Kurpas, D., Kusz, J., Mroczek, B., & Jedynak, T. (2013). Health-Related Behavior, Profile of Health Locus of Control and Acceptance of Illness in Patients Suffering from Chronic Somatic Diseases. *PLoS ONE*, *8*(5). https://doi.org/10.1371/journal.pone.0063920

Kakaei, H., Maleki, F., Biderafsh, A., Valizadeh, Ř., Mansournia, M. A., Pakzad, I., & Pakzad, R. (2023). High prevalence of mental disorders: a population-based cross-sectional study in the city of Ilam, Iran. *Frontiers in Psychiatry*, *14*, 1166692–1166692. https://doi.org/10.3389/fpsyt.2023.1166692

Li, S., Liu, Y., Li, R., Wan, X., Ou, J., Tao, F., & Wan, Y. (2024). Association between green space and multiple ambient air pollutants with depressive and anxiety symptoms among Chinese adolescents: The role of physical activity. *Environment International*, *189*, 108796–108796. https://doi.org/10.1016/j.envint.2024.108796

Li, T., Yu, Y., Sun, Z., & Duan, J. (2022). A comprehensive understanding of ambient particulate matter and its components on the adverse health effects based from epidemiological and laboratory evidence. *Particle and Fibre Toxicology*, *19*(1), 67–67. https://doi.org/10.1186/s12989-022-00507-5

Li, Y., Khan, M., Khurshid, A., Gulistan, M., Rehman, A. U., Ali, M., Abdulla, S., & Farooque, A. A. (2023). Designing pentapartitioned neutrosophic cubic set aggregation operator-based air pollution decision-making model. *Complex & Intelligent Systems*, *9*(5), 4765–4782. https://doi.org/10.1007/s40747-023-00971-2

Liu, R., Menhas, R., & Saqib, Z. A. (2024). Does physical activity influence health behavior, mental health, and psychological resilience under the moderating role of quality of life? *Frontiers in Psychology*, *15*, 1349880–1349880. https://doi.org/10.3389/fpsyg.2024.1349880

Lovibond, S. H., & Lovibond, P. F. (1995). *Manual for the Depression Anxiety Stress Scales* (2nd ed.). Psychology Foundation of Australia.

Lyons, S., Nolan, A., Carthy, P., Griffin, M., & O'Connell, B. (2024). Long-term exposure to PM2.5 air pollution and mental health: a retrospective cohort study in Ireland. *Environmental Health*, *23*(1), 54–54. https://doi.org/10.1186/s12940-024-01093-z

Mori, E., Lorenzo, T. D., Viviano, A., Jakovljević, T., Marra, E., Moura, B. B., Garosi, C., Manzini, J., Ancillotto, L., Hoshika, Y., & Paoletti, E. (2025). Under Pressure: Environmental Stressors in Urban Ecosystems and Their Ecological and Social Consequences on Biodiversity and Human Well-Being. *Stresses*, *5*(4), 66–66. https://doi.org/10.3390/stresses5040066

Müller, H., Rehn-Groenendijk, J., & Wasmer, A. (2023). Small-scale urban design interventions: A framework for deploying cities as resource for mental health and mental health

literacy. *Frontiers in Psychology*, *14*, 1112209–1112209. https://doi.org/10.3389/fpsyg.2023.1112209

Newbury, J. B., Heron, J., Kirkbride, J. B., Fisher, H. L., Bakolis, I., Boyd, A., Thomas, R., & Zammit, S. (2024). Air and Noise Pollution Exposure in Early Life and Mental Health From Adolescence to Young Adulthood. *JAMA Network Open*, *7*(5). https://doi.org/10.1001/jamanetworkopen.2024.12169

Obiageli, J. U., Ugwu, E. B. I., & Eucharia, C. O. (2023). Identification of the spatial patterns of air pollution and its sources in Ogui New Layout, South-East of Nigeria, using remote sensing and GIS technology. *Scientific Research and Essays*, *18*(4), 56–64. https://doi.org/10.5897/sre2023.6775

Pelgrims, I., Devleesschauwer, B., Guyot, M., Keune, H., Nawrot, T. S., Remmen, R., Saenen, N. D., Trabelsi, S., Thomas, I., Aerts, R., & Clercq, E. M. D. (2021). Association between urban environment and mental health in Brussels, Belgium. *BMC Public Health*, *21*(1), 635–635. https://doi.org/10.1186/s12889-021-10557-7

Petrowski, K., Bührer, S., Strauß, B., Decker, O., & Brähler, E. (2021). Examining air pollution (PM10), mental health and well-being in a representative German sample. *Scientific Reports*, *11*(1), 18436–18436. https://doi.org/10.1038/s41598-021-93773-w

Piracha, A., & Chaudhary, M. T. A. (2022). Urban Air Pollution, Urban Heat Island and Human Health: A Review of the Literature. *Sustainability*, *14*(15), 9234–9234. https://doi.org/10.3390/su14159234

Pun, V. C., Manjourides, J., & Suh, H. (2022). Association of ambient air pollution with depressive and anxiety symptoms in adults. *Environmental Health Perspectives, 130*(3), 037005. https://doi.org/10.1289/EHP9014

Rafique, M. Z., Sun, J., Larik, A. R., & Li, Y. (2022). Assessment of Willingness to Pay for Pollution Prevention, Health and Happiness: A Case Study of Punjab, Pakistan. *Frontiers in Public Health*, *10*, 825387–825387. https://doi.org/10.3389/fpubh.2022.825387

Rahaman, M. A., Kalam, A., & Al-Mamun, Md. (2023). Unplanned urbanization and health risks of Dhaka City in Bangladesh: uncovering the associations between urban environment and

public health. *Frontiers in Public Health*, *11*, 1269362–1269362. https://doi.org/10.3389/fpubh.2023.1269362

Rentschler, J., & Leonova, N. (2023). Global air pollution exposure and poverty. *Nature Communications*, *14*(1), 4432–4432. https://doi.org/10.1038/s41467-023-39797-4

Siddik, M. A. B., Mahmud, A., Ali, A., FERDOS, J., Mahdee, M. T. A., & Guo, H. (2026). Impact of air pollution on mental health in bangladesh: a comparison between Dhaka and Rajshahi. *Scientific Reports*, *16*(1), 6723–6723. https://doi.org/10.1038/s41598-026-36158-1

Wallston, K. A., Wallston, B. S., & DeVellis, R. (1994). Development of the Multidimensional Health Locus of Control (MHLC) scales. In K. A. Wallston & B. S. Wallston (Eds.), *Health locus of control scales manual* (pp. 1–14). Vanderbilt University.

Xian, Z., Nakaya, T., Liu, K., Bing, Z., Zhang, J., Zhang, J., Lin, Y., & Zhang, J. (2024). The effects of neighbourhood green spaces on mental health of disadvantaged groups: a systematic review. *Humanities and Social Sciences Communications*, *11*(1). https://doi.org/10.1057/s41599-024-02970-1

Xu, J., Liu, N., Polemiti, E., Garcia-Mondragon, L., Tang, J., Liu, X., Lett, T. A., Yu, L., Nöthen, M. M., Feng, J., Yu, C., Marquand, A. F., Schumann, G., Walter, H., Heinz, A., Ralser, M., Twardziok, S., Vaidya, N., Serin, E., … Ogoh, G. (2023). Effects of urban living environments on mental health in adults. *Nature Medicine*, *29*(6), 1456–1467. https://doi.org/10.1038/s41591-023-02365-w

Xue, S., Massazza, A., Akhter-Khan, S. C., Wray, B., Husain, M. I., & Lawrance, E. (2024). Mental health and psychosocial interventions in the context of climate change: a scoping review. *Npj Mental Health Research*, *3*(1), 10–10. https://doi.org/10.1038/s44184-024-00054-1

Yang, T., Cai, H., Song, J., Li, N., & Liu, H. (2025). Research on the network structure and gender/age differences of psychological safety among urban residents: network analysis based on a large sample. *BMC Psychology*, *13*(1), 80–80. https://doi.org/10.1186/s40359-025-02401-z

Yang, T., Wang, J., Huang, J., Kelly, F. J., & Li, G. (2023). Long-term Exposure to Multiple Ambient Air Pollutants and Association With Incident Depression and Anxiety. *JAMA Psychiatry*, *80*(4), 305–305. https://doi.org/10.1001/jamapsychiatry.2022.4812

Yang, Z., Kwan, M., Liu, D., & Huang, J. (2025). How objective and subjective greenspace, combined with air and noise pollution, impacts mental health through the mediation of physical activity. *Urban Forestry & Urban Greening*, *105*, 128683–128683. https://doi.org/10.1016/j.ufug.2025.128683

Zhang, W., Peng, S., Fu, J., Xu, K., Wang, H., Jin, Y., Yang, T., & Cottrell, R. R. (2021). Urban Air Pollution and Mental Stress: A Nationwide Study of University Students in China. *Frontiers in Public Health*, *9*, 685431–685431. https://doi.org/10.3389/fpubh.2021.685431

Zhang, X., Chen, X., & Zhang, X. (2021). The impact of exposure to air pollution on cognitive performance. *Proceedings of the National Academy of Sciences, 118*(3), e2014350118. https://doi.org/10.1073/pnas.2014350118