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Original Article

Community Perceptions of Air Pollution and Health Risks in Urban Areas: A Comprehensive Qualitative Study from Pakistan

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ABSTRACT

Background: Air pollution is a major environmental health concern in urban Pakistan, where recurrent smog, vehicular emissions, industrial activity, brick kiln smoke, crop residue burning, construction dust, and open waste combustion contribute to substantial community exposure. Although health risks are widely discussed, limited evidence exists on how affected communities perceive pollution, interpret vulnerability, and adopt protective behaviors. Objective: To explore community perceptions of air pollution, associated health risks, adaptive behaviors, and structural barriers among urban residents in Pakistan. Methods: An interpretive qualitative study was conducted in urban and peri-urban communities representing industrial, residential, low-income, and mixed commercial-residential exposure contexts. Data were collected through semi-structured in-depth interviews and focus group discussions with urban residents, parents, healthcare providers, community leaders, and occupationally exposed workers. Transcripts were analyzed using six-phase thematic analysis, with attention to credibility, triangulation, reflexivity, and trustworthiness. Results: Five themes were identified: awareness and understanding of pollution sources, perceived health risks and vulnerability, normalization of pollution exposure, adaptive and protective behaviors, and structural and policy-level barriers. Participants recognized visible pollution and respiratory risks, especially for children and older adults, but technical understanding of AQI, PM2.5, and long-term risks was limited. Protective actions were inconsistent and constrained by poverty, occupation, poor risk communication, and weak institutional trust. Conclusion: Urban communities recognize air pollution as harmful but often normalize exposure as unavoidable. Effective responses require practical risk communication, health-system integration, affordable protection, community engagement, and visible environmental enforcement. Keywords: Air pollution; PM2.5; urban health; community perception; environmental health; qualitative research; Pakistan; smog; respiratory disease; thematic analysis.

INTRODUCTION

Air pollution is a major environmental determinant of morbidity and premature mortality worldwide, with disproportionate effects in low- and middle-income countries where urban growth, industrial expansion, weak environmental enforcement, and limited access to protective resources intensify population exposure. Fine particulate matter, nitrogen dioxide, sulfur dioxide, carbon monoxide, ozone,

industrial emissions, vehicular exhaust, open waste burning, construction dust, and biomass combustion collectively contribute to a complex exposure environment that affects respiratory, cardiovascular, and general health outcomes. The World Health Organization has emphasized that both ambient and household air pollution remain central global health threats, while burden-of-disease estimates consistently attribute substantial mortality and disability-adjusted life years to air pollution exposure, particularly PM2.5 (1,2). The biological plausibility of these effects is well established, as fine particulate matter can penetrate the lower respiratory tract, enter systemic circulation, trigger oxidative stress and inflammation, and contribute to cardiopulmonary disease pathways (3,4).

Urban Pakistan represents a high-risk setting for studying public understanding of air pollution because major cities experience recurrent episodes of severe air quality deterioration, particularly during winter smog periods. Lahore, Karachi, Faisalabad, Rawalpindi, and Islamabad are exposed to overlapping pollution sources, including high-density vehicular traffic, poorly regulated industrial activity, brick kiln emissions, crop residue burning, construction-related particulate matter, and open waste combustion. Public concern often increases during visible smog episodes, but invisible pollutant exposure on apparently clear days may remain poorly understood. This creates an important gap between sensory recognition of pollution and scientifically informed risk appraisal. Existing monitoring and public reporting systems have improved awareness of air quality as a policy issue, but community-level interpretation of pollution sources, exposure severity, health consequences, and feasible protective responses remains insufficiently documented in Pakistan (5,6).

The public health importance of this issue extends beyond environmental exposure alone. Pakistan's health system already faces a large burden of respiratory infections, asthma, chronic obstructive pulmonary disease, cardiovascular disease, and other non-communicable conditions, while health expenditure and preventive health infrastructure remain constrained relative to population needs (7). In such settings, air pollution may be recognized by communities as an everyday nuisance or seasonal hazard, yet not consistently understood as a preventable determinant of acute and chronic disease. This distinction is important because health behavior depends not only on exposure intensity, but also on perceived susceptibility, perceived severity, perceived controllability, trust in institutions, access to protective resources, and the social meaning attached to risk. Risk perception theory shows that community responses to environmental hazards are shaped by familiarity, dread, voluntariness, equity, and perceived control; chronic exposure may therefore lead either to heightened concern or to fatalistic normalization when people believe that meaningful action is beyond individual or collective control (8).

Qualitative inquiry is especially appropriate for this problem because quantitative environmental and epidemiological studies can estimate exposure levels and health burden, but they cannot adequately explain how residents interpret polluted air, why some risks are normalized, how families decide whether to use masks or restrict outdoor activity, or how poverty and occupation limit adaptive capacity. In urban Pakistan, low-income households, outdoor workers, children, older adults, and people living near industrial or high-traffic zones may experience greater exposure while having fewer resources to reduce risk. This reflects an environmental justice concern in which the burden of pollution and the ability to respond are unequally distributed across socioeconomic groups (9). Understanding this lived experience is necessary for designing health communication, clinical counseling, community engagement, and policy interventions that are practical, culturally intelligible, and equitable.

Previous studies from low- and middle-income urban settings suggest that people often identify visible sources of pollution such as smoke, traffic, industrial discharge, and waste burning, but may have limited knowledge of pollutant types, long-term cardiopulmonary effects, air quality indices, or the relative effectiveness of protective strategies (10). However, evidence from Pakistan remains limited regarding how different community groups perceive air pollution, how they define vulnerability, how they explain recurrent smog, and how structural barriers such as weak enforcement, economic dependency, occupational exposure, and poor risk communication shape behavioral responses. This knowledge gap

is particularly important because interventions based only on technical information may fail if communities perceive pollution as inevitable, unactionable, or socially normalized.

Therefore, this study aimed to explore community perceptions of air pollution, associated health risks, and adaptive behaviors among urban residents in Pakistan, with specific attention to awareness of pollution sources, perceived vulnerability, normalization of exposure, protective practices, and structural barriers to effective response. The central research question was: how do urban communities in Pakistan understand, experience, normalize, and respond to air pollution-related health risks within their social, economic, occupational, and policy contexts?

MATERIALS AND METHODS

This study used an interpretive qualitative design to explore how urban communities in Pakistan perceive air pollution, understand its health risks, and adopt or avoid protective behaviors within their lived social and environmental contexts. A qualitative approach was selected because the study sought to examine meanings, experiences, perceived vulnerability, normalization, and structural constraints rather than to measure pollutant concentrations or estimate disease incidence. The study was informed by phenomenological and social constructivist assumptions, recognizing that community understanding of air pollution is shaped through lived experience, social interaction, occupational exposure, socioeconomic position, health literacy, and trust in public institutions. Reporting was guided by the Consolidated Criteria for Reporting Qualitative Research to strengthen transparency in study design, recruitment, data collection, analysis, and interpretation (11).

The study was conducted in selected urban and peri-urban communities across major metropolitan zones of Pakistan, including high-exposure industrial areas, dense urban residential neighborhoods, low-income settlements, and mixed commercial-residential localities. These sites were selected to capture variation in exposure context, socioeconomic conditions, occupational risk, and proximity to major pollution sources such as traffic corridors, industrial estates, brick kiln clusters, construction activity, and open waste burning. The inclusion of different urban environments allowed the analysis to examine both shared patterns of perception across communities and context-specific differences in how pollution was recognized, explained, and managed.

Participants were recruited through purposive sampling to ensure maximum variation across groups expected to hold different forms of knowledge and experience regarding air pollution. The sampling frame included adult urban residents, parents of young children, healthcare providers, community leaders or local government representatives, and factory or transport workers. Eligible participants were adults aged 18 years or older who had lived or worked in the selected community for at least six months and were able to provide informed consent. Parents or guardians were included when discussing children's exposure and household-level protective decisions. Individuals with acute illness at the time of recruitment were not included to reduce the likelihood that immediate illness experience would dominate broader perceptions of air pollution and health risk. Sampling continued iteratively until thematic saturation was reached, defined as the point at which additional interviews and group discussions did not generate new themes or substantially alter the developing analytic framework.

Data were collected through semi-structured in-depth interviews and focus group discussions. In-depth interviews were used to elicit individual experiences, perceived health effects, household practices, occupational constraints, and views about government responsibility and healthcare advice. Focus group discussions were used to explore collective meanings, shared norms, social reinforcement of risk perception, and community-level narratives regarding pollution exposure and protective behavior. Interview and discussion guides were developed from the study objectives and relevant literature, then refined after pilot testing. The guides explored spontaneous awareness of air pollution, perceived sources, understanding of health mechanisms, personal or family experiences of pollution-related symptoms, perceived vulnerability of children, older adults and workers, use of masks or activity

restriction, home-based coping practices, barriers to protection, sources of air quality information, and expectations from government and health systems.

Interviews and focus group discussions were conducted in Urdu and Punjabi by trained research assistants fluent in the relevant local languages and familiar with community-based health research. Interviews were audio-recorded with participant consent and supplemented by field notes documenting contextual observations, non-verbal cues, group dynamics, and reflexive impressions. The use of local languages was intended to allow participants to express perceptions in familiar terms rather than technical environmental health language. Written informed consent was obtained where possible, while witnessed verbal consent was documented for participants with low literacy. Participation was voluntary, and participants were informed that they could withdraw at any point without consequence.

The principal concepts explored in the study were operationalized qualitatively rather than numerically. Awareness of air pollution referred to how participants recognized and described polluted air, including sensory cues and perceived sources. Perceived health risk referred to participants' beliefs about the short- and long-term health consequences of pollution and the groups considered most vulnerable. Normalization referred to accounts in which chronic pollution exposure was described as routine, unavoidable, or part of urban life. Adaptive behavior referred to actions taken to reduce exposure or manage symptoms, including mask use, reduced outdoor activity, closing windows, use of home remedies, and changes in daily routines. Structural barriers referred to social, economic, occupational, health-system, and policy-level constraints that limited the ability of individuals or communities to respond effectively.

Audio recordings were transcribed verbatim in Urdu or Punjabi and translated into English by bilingual research assistants with public health training. Translations were reviewed for conceptual accuracy, and back-translation was used where needed to preserve meaning across languages. Transcripts were anonymized and imported into NVivo 12 for qualitative data management. Analysis followed the six-phase thematic analysis framework described by Braun and Clarke, involving familiarization with the data, generation of initial codes, searching for themes, reviewing candidate themes, defining and naming themes, and producing the final analytic account (12,13). Initial coding was primarily inductive to allow patterns to emerge from participant accounts, followed by interpretive refinement using concepts from risk perception theory, health behavior theory, and social determinants of health.

To strengthen analytic rigor, coding was conducted by two researchers independently during the initial phase, and coding differences were resolved through discussion and consensus. A third researcher reviewed the developing codebook, theme structure, and supporting quotations to enhance consistency and confirmability. Reflexive memo-writing was maintained throughout analysis to document assumptions, emerging interpretations, methodological decisions, and the influence of researcher perspectives on theme development. Credibility was supported through triangulation across participant categories, data collection methods, and community settings. Member-checking was conducted by presenting preliminary findings to selected participants for verification of resonance and accuracy. Transferability was supported through detailed description of study sites, participant categories, and sociocultural context, while dependability and confirmability were supported through an audit trail, peer debriefing, and systematic documentation of coding and theme development.

Ethical approval was obtained from the institutional review board of the affiliated institution before commencement of the study. Confidentiality was maintained by assigning participant identification codes, removing personal identifiers from transcripts, and reporting quotations with non-identifying demographic descriptors. Audio files, transcripts, field notes, and analytic documents were handled by the research team using restricted-access storage. Community gatekeepers were approached before fieldwork where necessary to facilitate culturally appropriate access, but participation remained voluntary and individual consent was obtained directly from participants.

RESULTS

The analysis generated five interrelated themes describing how urban communities in Pakistan perceive, experience, normalize, and respond to air pollution-related health risks. The themes were: awareness and understanding of air pollution sources; perceived health risks and vulnerability; normalization of pollution exposure; adaptive and protective behaviors; and structural and policy-level barriers. Together, these themes indicate that participants recognized air pollution as a visible and recurrent urban health problem, but their ability to interpret risk and respond effectively was constrained by limited technical knowledge, economic vulnerability, occupational exposure, weak institutional trust, and the normalization of polluted air as an unavoidable feature of city life.

Table 1. Qualitative Data Collection Profile and Participant Categories

Data Source	Participant Group	Main Contribution to Analysis	Key Domains Explored
In-depth interviews	Urban adult residents	Lived experience of routine exposure	Pollution awareness, perceived sources, symptoms, household coping
In-depth interviews	Parents of young children	Household-level perception of child vulnerability	Children's respiratory symptoms, school/outdoor restrictions, parental anxiety
In-depth interviews	Healthcare providers	Clinical interpretation of pollution-related illness	Respiratory exacerbations, patient counseling, seasonal disease patterns
In-depth interviews	Community leaders/local representatives	Governance and enforcement perspectives	Institutional response, regulatory failure, community-level barriers
Focus group discussions	Factory and transport workers	Occupational exposure and economic constraint	Outdoor work exposure, income dependency, feasibility of protection
Focus group discussions	Community groups	Shared social meanings and collective norms	Normalization, fatalism, peer influence, community expectations

Table 1 summarizes the qualitative data sources and participant categories included in the study. The inclusion of residents, parents, healthcare providers, community leaders, and occupationally exposed workers allowed the analysis to capture both household-level and structural perspectives. Individual interviews provided detailed personal accounts of illness, coping, and vulnerability, whereas focus group discussions highlighted shared norms, collective resignation, and community-level interpretations of pollution exposure.

Table 2. Themes, Subthemes, and Representative Participant Accounts

Theme	Subtheme	Representative Quotation	Participant Identifier
Awareness and understanding of air pollution sources	Visible pollution as primary cue	"The smoke from cars and factories is everywhere. You can see it in the air, especially in winter. Some mornings, you cannot even see the building across the street."	Male urban resident, age 42, Lahore
Awareness and understanding of air pollution sources	Seasonal smog as a salient exposure event	"In October and November, the whole city fills with smoke. The children cannot go outside. Even adults get headaches just from breathing outside."	Female participant, FGD, Rawalpindi
Awareness and understanding of air pollution sources	Industrial and brick kiln emissions	"Brick kilns near our area never stop. They burn day and night. You can taste the smoke sometimes. But nobody comes to check them."	Female community member, industrial zone, Faisalabad
Perceived health risks and vulnerability	Respiratory illness as primary perceived risk	"Children get sick more often during smog. They have breathing problems, they cough all night, sometimes they need to go to the hospital. Every winter it is the same thing."	Mother of two young children, Lahore
Perceived health risks and vulnerability	Clinical observation of seasonal exacerbations	"My patients with asthma and COPD are always worse in November and December. I see three to four times as many attacks during smog season. It is directly linked to the air."	General practitioner, Rawalpindi
Perceived health risks and vulnerability	Vulnerability of older adults and children	"Old people and children suffer the most. My mother-in-law has asthma—every smog season, she is hospitalized at least once. We keep the windows closed, but it still gets in."	Female participant, mixed residential zone, Karachi
Normalization of pollution exposure	Acceptance as urban inevitability	"We are used to it now. This is part of city life. Everyone breathes the same air—what can one person do? Even rich people cannot escape it entirely."	Male participant, age 35, dense residential zone
Normalization of pollution exposure	Habituation to chronic exposure	"I have lived here for fifteen years. In the beginning, it was difficult. Now I just accept it. You get used to the smell, the haze. It is normal here."	Female vendor, inner-city market, Lahore
Adaptive and protective behaviors	Restricting children's outdoor exposure	"During bad smog, I stop the children from going out. I keep the windows shut even though the house gets stuffy. But my husband cannot stop working—he drives a rickshaw. He breathes it all day."	Mother, Lahore
Structural and policy-level barriers	Perceived government inaction	"Every year, there is smog. Every year, they say they will do something. Every year, nothing changes. The factories run, the cars run, the smoke stays. The government makes announcements, not solutions."	Community leader, Faisalabad
Structural and policy-level barriers	Limited individual control	"Even if we want to protect ourselves, what can we do? The environment is not in our control. The government needs to act—individuals cannot solve this problem alone."	Community member, FGD, Rawalpindi

Table 2 presents the main themes, subthemes, and representative quotations. The quotations show that participants' understanding of air pollution was grounded primarily in visible and sensory experience, especially smoke, haze, smell, and seasonal smog. Health risks were most strongly associated with respiratory symptoms, particularly among children, older adults, and people with asthma or chronic respiratory illness. Across themes, participants repeatedly described pollution as both harmful and difficult to avoid, creating a tension between awareness and perceived helplessness.

Theme 1: Awareness and Understanding of Air Pollution Sources

Participants across community groups recognized air pollution as a familiar urban problem, but their awareness was mainly experiential rather than technical. Visible smog, black smoke, dust, unpleasant smell, and reduced visibility were the most common cues used to identify polluted air. Seasonal smog during October, November, and winter months was described as a particularly severe and memorable exposure period, often disrupting outdoor movement, children's activities, and routine life.

Participants commonly identified vehicles, factories, brick kilns, crop burning, construction dust, and open waste burning as major sources of polluted air. These accounts showed a broad lay understanding of visible sources, especially traffic and industrial smoke. However, participants rarely referred to pollutant-specific terminology such as PM2.5, PM10, nitrogen dioxide, ozone, or air quality index thresholds. This indicates an important gap between recognizing pollution through sensory cues and understanding invisible or technically measured exposure risks.

A further limitation in community understanding was the under-recognition of indoor and household sources of exposure. Although the manuscript describes biomass burning, poor ventilation, and household-level exposure as relevant to Pakistan's pollution burden, participants' accounts focused more strongly on outdoor visible sources. This suggests that health communication strategies should not only address outdoor smog but also explain indoor exposure, invisible particles, and risk on days when the air appears visually clear.

Theme 2: Perceived Health Risks and Vulnerability

Participants associated air pollution most strongly with respiratory illness. Cough, wheezing, throat irritation, breathing difficulty, asthma exacerbation, and recurrent respiratory symptoms among children were repeatedly described as consequences of smog and polluted air. Parents expressed particular concern regarding children's breathing problems during smog periods, while healthcare providers described seasonal increases in asthma and chronic obstructive pulmonary disease exacerbations.

Children, older adults, and people with pre-existing respiratory disease were consistently viewed as vulnerable groups. Participants described children as less able to tolerate polluted air and more likely to develop cough, breathing difficulty, and sleep disturbance during smog episodes. Older adults with asthma or chronic respiratory conditions were also perceived as highly vulnerable. Occupationally exposed workers, including rickshaw drivers, vendors, factory workers, construction workers, and traffic-exposed groups, were recognized as exposed, but their risk was often framed as unavoidable because work-related exposure was tied directly to income.

Cardiovascular and long-term health consequences were less prominent in community accounts. Although some participants and healthcare providers recognized that pollution could affect general health beyond the lungs, chronic outcomes such as cardiovascular disease, lung cancer, developmental harm, or cumulative lifelong exposure were not as strongly represented as acute respiratory symptoms. This pattern suggests that community risk perception was shaped more by immediate and visible symptoms than by delayed or less observable disease pathways.

Theme 3: Normalization of Pollution Exposure

Normalization emerged as a central theme. Participants frequently described polluted air as an expected part of urban life, using language that conveyed resignation and limited perceived control. Rather than denying that air pollution was harmful, participants often acknowledged the risk while simultaneously presenting it as unavoidable. This normalization reduced the urgency of protective behavior and weakened expectations of meaningful change.

Habituation was evident among participants who had lived for long periods in highly polluted areas. Some reported that smoke, smell, and haze had become familiar over time. This adaptation appeared to reduce conscious attention to pollution cues, especially when exposure was constant. In focus group contexts, normalization also appeared to be socially reinforced: when everyone in the community experienced similar exposure, pollution became less exceptional and more likely to be accepted as routine.

The normalization theme is important because it helps explain why awareness did not consistently translate into protective action. Participants could identify pollution sources and health effects, but many perceived individual action as insufficient. The repeated framing of pollution as "part of city life" or outside personal control suggests that interventions based only on information may be inadequate unless they also address perceived controllability, community agency, and visible institutional response.

Theme 4: Adaptive and Protective Behaviors

Participants described several protective behaviors, including mask wearing, keeping windows closed, reducing children's outdoor play, avoiding unnecessary outdoor travel during severe smog, and using home remedies such as steam inhalation, honey, ginger, lemon preparations, herbal teas, and dietary practices. These behaviors were usually adopted during visible smog episodes rather than through routine air quality monitoring.

Mask use was common in participant accounts but appeared inconsistent and limited by cost, comfort, availability, and lack of knowledge about mask type. Participants did not consistently distinguish between cloth masks, surgical masks, and particulate respirators such as N95 or KN95 masks. This is important because perceived protection may not match actual protection against fine particulate matter.

Indoor confinement and activity restriction were more feasible for some households than others. Parents reported restricting children's outdoor exposure during severe smog, but these strategies were difficult for outdoor workers and low-income families living in small or poorly ventilated homes. Occupational exposure was a major barrier because workers such as rickshaw drivers and vendors could not reduce outdoor time without losing income. The findings therefore show that adaptive capacity was socially patterned: those most exposed were often least able to protect themselves effectively.

Theme 5: Structural and Policy-Level Barriers

Participants repeatedly located air pollution within a broader context of weak governance, poor enforcement, limited public communication, and economic constraint. Government action was perceived as temporary, reactive, and insufficient. Participants described annual smog episodes followed by announcements or advisories, but little visible long-term improvement in emissions control, traffic regulation, industrial monitoring, or waste burning practices.

Weak enforcement was a recurring concern, particularly in relation to factories, brick kilns, vehicles, and open burning. Community leaders and residents described a disconnect between formal environmental rules and actual practice. This perceived enforcement gap contributed to institutional distrust and reinforced the belief that individual protective behaviors could not solve the problem.

Poor risk communication also limited effective response. Participants wanted practical guidance on when air was dangerous, which masks were useful, how children and older adults should be protected,

and what actions households could realistically take during high-pollution days. Health messages were perceived as generic and insufficiently tailored to low-income households, outdoor workers, parents, and people with respiratory illness. The findings suggest that effective intervention must combine risk communication with structural supports such as affordable protective equipment, workplace protection, clean fuel access, better monitoring, and visible regulatory enforcement.

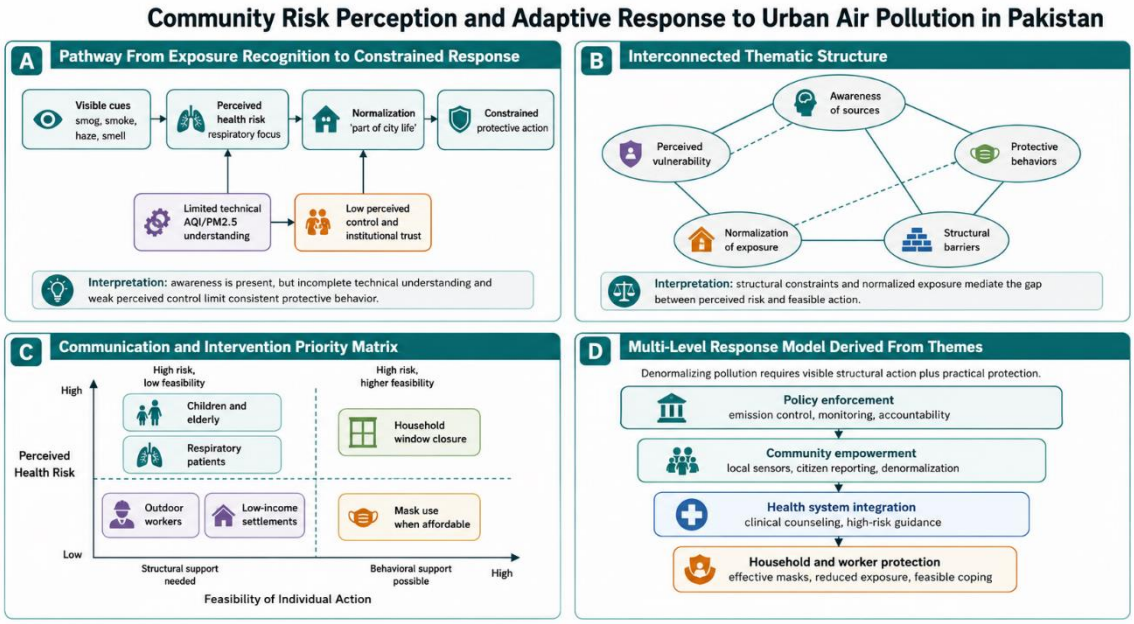

Figure 1 Community risk perception and adaptive response to urban air pollution in Pakistan. The panelled model illustrates how visible exposure cues, perceived respiratory risk, limited technical understanding, normalization of pollution, and low perceived institutional control interact to constrain protective behavior. The figure further maps thematic relationships, intervention priority groups, and a multi-level response pathway linking policy enforcement, community empowerment, health system integration, and household or worker-level protection.

Table 3 links the qualitative themes to public health interpretation and intervention implications. The findings indicate that community awareness alone is insufficient for effective protection. Participants recognized pollution and its respiratory effects, yet normalization, economic constraints, occupational exposure, and limited trust in government reduced the likelihood of sustained protective action. Public health strategies should therefore move beyond general awareness campaigns and address the social and structural conditions that determine whether protective behavior is feasible.

Table 3. Analytical Matrix Linking Themes to Public Health Interpretation

Theme	Core Finding	Public Health Interpretation	Intervention Implication
Awareness and understanding	Pollution recognized through visible smoke, haze, smell, and smog	Sensory awareness exceeds technical understanding	Plain-language AQI and PM2.5 education
Perceived health risks	Respiratory symptoms dominate perceived disease burden	Acute symptoms are more salient than chronic risks	Communication on both immediate and long-term health effects
Vulnerability	Children, older adults, and respiratory patients perceived as high-risk	Vulnerability is recognized but unevenly acted upon	Targeted guidance for high-risk households
Normalization	Pollution accepted as routine urban exposure	Fatalism may reduce protective behavior and civic demand	Denormalization through community engagement and visible enforcement
Adaptive behavior	Masks, indoor restriction, and home remedies used inconsistently	Protective behavior is constrained by cost and knowledge	Subsidized effective masks and practical household guidance
Occupational exposure	Outdoor workers unable to avoid exposure	Economic dependency limits individual protection	Worker-focused protection and occupational health policies
Structural barriers	Governance failure and weak enforcement repeatedly described	Institutional distrust reinforces helplessness	Transparent monitoring, enforcement, and community accountability

Overall, the results show that urban communities in Pakistan are not unaware of air pollution; rather, they interpret it through lived experience, visible environmental cues, and repeated seasonal exposure. The strongest finding is the coexistence of awareness and resignation. Participants recognized pollution as harmful, especially for children, older adults, and people with respiratory disease, but many perceived exposure as unavoidable and institutional response as inadequate. This combination of sensory awareness, limited technical understanding, normalized risk, and constrained adaptive capacity provides a clear explanation for why pollution-related health knowledge may not translate into consistent behavioral chang or collective demand for regulatory action.

DISCUSSION

The findings of this interpretive qualitative study show that urban communities in Pakistan are not unaware of air pollution; rather, their understanding is primarily shaped by lived, sensory, and seasonal experience. Participants recognized air pollution through visible smog, smoke, haze, smell, traffic emissions, industrial discharge, brick kiln smoke, and open burning. This form of awareness is practically important because it reflects how communities encounter pollution in daily life, but it also reveals a critical limitation: invisible pollutants, air quality index values, PM2.5, PM10, ozone, and nitrogen dioxide were not commonly understood in technical terms. Similar patterns have been reported in other low- and middle-income urban settings, where public recognition of pollution sources may coexist with limited knowledge of pollutant-specific exposure, chronic risk, and evidence-based protection (14,15). This gap has direct implications for public health communication because people may underestimate exposure risk on visually clear days or over-rely on sensory judgment when deciding whether to restrict outdoor activity or use masks.

Respiratory illness was the most visible and frequently recognized health consequence of air pollution in participant accounts. Parents described children's cough, breathing difficulty, and reduced outdoor activity during smog periods, while healthcare providers linked seasonal pollution episodes with worsening asthma and chronic respiratory symptoms. This finding is consistent with the broader environmental health literature showing strong associations between air pollution exposure and respiratory morbidity, including asthma exacerbation, chronic obstructive pulmonary disease, and acute lower respiratory symptoms (3,4). However, cardiovascular and long-term health consequences were less prominent in community narratives. This distinction is important because the cardiometabolic effects of PM2.5 and related pollutants are less immediately observable than cough or wheezing, and therefore may be less salient in lay risk perception. Health communication in Pakistan should therefore move beyond general warnings about "smog" and explicitly explain both acute respiratory effects and cumulative long-term risks in simple, locally understandable language.

The most consequential finding was the normalization of air pollution as an unavoidable part of urban life. Participants often acknowledged that polluted air was harmful, yet described it as routine, uncontrollable, and inseparable from living or working in the city. This pattern reflects the risk perception principle that familiarity, chronic exposure, low controllability, and perceived institutional inaction can reduce the likelihood of protective action even when perceived severity is high (8). The finding also aligns with work on environmental risk and civic response, where communities exposed to persistent environmental hazards may shift from active concern to resignation when they perceive that institutions are unresponsive or that individual action cannot change exposure conditions (16). In the present study, normalization did not indicate ignorance; rather, it reflected a social and psychological adaptation to repeated exposure, weak enforcement, and limited practical alternatives.

Adaptive behavior was present but inconsistent and socially constrained. Participants described mask use, keeping windows closed, reducing children's outdoor play, avoiding unnecessary outdoor travel during severe smog, and using home remedies. These practices indicate that communities attempt to reduce exposure and manage symptoms, but the feasibility and effectiveness of these behaviors vary

considerably. Mask use was limited by affordability, comfort, access, and lack of knowledge regarding the difference between cloth masks, surgical masks, and particulate respirators. Indoor restriction was more feasible for children in households with some flexibility but far less feasible for rickshaw drivers, vendors, factory workers, construction workers, and other outdoor workers whose income depends on daily exposure. This pattern demonstrates that air pollution protection cannot be framed only as an individual behavior problem. It is also a problem of occupational vulnerability, poverty, housing quality, access to protective resources, and environmental governance.

The findings also highlight an environmental justice dimension. Low-income residents and outdoor workers appeared to face a dual burden: higher exposure and lower adaptive capacity. This is consistent with global environmental justice evidence showing that marginalized communities are often more likely to live or work near pollution sources while having fewer resources to reduce exposure or access timely healthcare (9,17). In the present study, low-income households were less able to afford effective masks, air purifiers, cleaner housing, or reduced outdoor exposure, while workers in transport and informal labor had limited ability to avoid polluted environments without losing income. Public health interventions that only advise individuals to stay indoors, purchase N95 masks, or use air purifiers may therefore widen inequity unless supported by subsidies, workplace protections, clean fuel access, and community-level exposure reduction.

Perceived governance failure was another dominant theme. Participants repeatedly described annual smog episodes, temporary advisories, weak enforcement, and limited visible regulatory action. These accounts suggest that distrust in institutional response may reinforce fatalism and reduce community motivation to engage in collective action. Pakistan has formal environmental legislation and regulatory institutions, but effective implementation depends on monitoring capacity, enforcement consistency, transparency, and public accountability. The findings suggest that risk communication alone will be insufficient if communities do not observe credible action against major pollution sources such as industrial emissions, brick kilns, high-emission vehicles, crop residue burning, and open waste combustion. Visible enforcement and publicly accessible air quality information may help shift air pollution from a normalized condition to a preventable and governable public health threat.

These findings have several implications for intervention design. First, health communication should be practical, plain-language, multilingual, and locally contextualized. Messages should explain what AQI and PM2.5 mean, why invisible pollution can still be harmful, which groups are most vulnerable, what types of masks are effective, and what households should do during severe pollution days. Second, healthcare providers should be equipped to counsel patients with asthma, chronic obstructive pulmonary disease, cardiovascular disease, pregnancy, older age, and child vulnerability regarding exposure reduction and symptom monitoring during high-pollution periods. Third, community-level strategies such as school-based air quality education, local air quality displays, community health worker counseling, and citizen reporting of visible emissions may improve both awareness and perceived agency. Fourth, policy-level action must address emissions control, traffic regulation, brick kiln modernization, industrial monitoring, clean fuel access, and worker protection rather than placing the burden of prevention solely on individuals.

The study has limitations that should be considered when interpreting the findings. The qualitative design was appropriate for exploring perceptions, meanings, and contextual barriers, but it does not estimate population prevalence or permit statistical comparison across cities, occupations, or socioeconomic groups. Participants were selected purposively, and therefore findings are transferable to similar urban and peri-urban contexts but not statistically generalizable to all Pakistani communities. The manuscript does not report final participant numbers, city-wise distribution, number of in-depth interviews, number of focus group discussions, or detailed participant demographics, which limits assessment of sampling adequacy and transferability. The study relied on self-reported perceptions and experiences, which may be influenced by recall, social desirability, media exposure during smog periods,

and local political narratives. Translation from Urdu and Punjabi into English may also have affected subtle meanings despite review procedures. Finally, the study did not include objective pollutant measurements, clinical diagnosis, or exposure assessment, so participant perceptions cannot be directly linked to measured air quality or health outcomes.

Despite these limitations, the study provides contextually rich evidence that community responses to air pollution in urban Pakistan are shaped by more than awareness alone. The central contribution is the identification of a perception–action gap: participants recognized air pollution as harmful, especially for children, older adults, and respiratory patients, but normalization, weak perceived control, economic limitations, occupational exposure, and low institutional trust constrained sustained protective behavior. Public health responses should therefore combine accurate risk communication with structural interventions that make protective action feasible and demonstrate visible environmental accountability.

CONCLUSION

This study shows that urban communities in Pakistan recognize air pollution as a recurrent and harmful environmental health problem, but their understanding is shaped mainly by visible and sensory cues such as smog, smoke, haze, and smell rather than by technical knowledge of pollutants, AQI, or cumulative exposure risk. Respiratory symptoms, child vulnerability, older age, and pre-existing respiratory illness were the most salient perceived health concerns, while cardiovascular and long-term risks were less prominent in community narratives. The most important finding was the normalization of polluted air as an unavoidable feature of city life, which weakened the translation of awareness into consistent protective behavior. Although participants reported adaptive practices such as mask use, window closure, reduced outdoor activity, and home remedies, these responses were constrained by poverty, occupational exposure, limited access to effective protection, poor risk communication, and weak trust in institutional enforcement. Effective public health action in Pakistan should therefore combine plain-language risk communication, healthcare provider counseling, school and community engagement, affordable protective resources for vulnerable groups, occupational safeguards, transparent air quality monitoring, and visible enforcement against major pollution sources.

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