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TEACHERS AS AGENTS OF CHANGE IN PROMOTING SMOG AWARENESS AMONG PRIMARY AND SECONDARY SCHOOL STUDENTS IN PAKISTAN: A NARRATIVE REVIEW OF ENVIRONMENTAL HEALTH LITERACY, EDUCATIONAL STRATEGIES, AND PREVENTIVE BEHAVIOURS

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ABSTRACT

Background: Smog is a public-health and educational problem in Pakistan due to recurrent haze and particulate pollution. Although air quality science and health risk and decision making in everyday life are closely linked, there is limited evidence of how teachers can link them. **Aim:** To review how teachers can promote smog awareness, environmental-health literacy and preventive behaviours among Pakistani primary- and secondary-school students. **Methods:** A narrative search and thematic synthesis were conducted in PubMed, OpenAlex and Semantic Scholar. The available publication window was 2016–2025. Abstracts were assessed and accessible full texts read; SANRA principles informed transparency and appraisal. This is not a systematic review and does not claim PRISMA compliance. **Findings:** Pakistan research identifies diverse pollution sources, with limited evidence of the impact of pollution on school-age smog-literacy. The results obtained regarding student surveys of the Malakand University reflect the result of the student who has been selected for the participation of the university. Low levels of general environmental literacy are found among teachers and difficulties are identified in transferring the knowledge of the environment into practice in studies conducted in Punjab. There is some evidence of international school interventions to achieve improvements in knowledge or reported protective choices, but not necessarily in behaviour change. This should be a balance of accurate science, alert interpretation, inquiry, school protocols and community engagement, with consideration to structural barriers in effective teaching. **Conclusion:** Teachers are key role-players in the knowledge about smogs but education alone cannot take the place of emission reduction or safe school environment. Continual teacher development, curriculum resources relevant to Pakistan and school response plan and rigorous evaluation are needed in Pakistan.

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Introduction

Global overview of air pollution and smog

Particulate matter and gases such as ozone, nitrogen dioxide, carbon monoxide, sulfur oxides, and others are included in the list of air-pollution reviews in Pakistan (Alamgir & Shan, 2024; Iram et al., 2025). Smog is defined as "visible air pollution" in a Pakistan review and is related to causes, detection and health effects of smog (Raza et al., 2020). The pollution, ventilation and building practices in the school also affect the school-air condition (Chithra & Nagendra, 2018).

Children can be exposed in the school environment, at home, and when traveling. A review concluded that enhanced ventilation in classrooms may help to reduce short-term indoor air quality, but the effects on cognition were variable and the studies used for interventions were generally poorly designed (Fernandes et al., 2023). School level protection needs to be complemented by teachers who interpret environmental information.

Smog as an emerging environmental and public-health concern in Pakistan

Lahore, Karachi, Faisalabad, Islamabad and Rawalpindi are the metropolitan cities that have been mentioned in a Pakistan-specific review as air-pollution issues (Iram et al., 2025). Lahore is at the forefront of the retrieved smog literature. Two heads of schools in government primary schools from the south of Punjab have been interviewed on the topic of school closures and continuity planning in the context of smog, but this does not provide evidence of the prevalence of school closures or learning losses across the country (Hayat, 2025).

Major causes and sources of smog in Pakistan

According to the reviews, the sources of pollution are industrial activities, traffic, burning processes, brick kilns, and the combustion of wastes in agriculture in Pakistan (Iram et al., 2025). Construction dust, household biomass combustion, and the indoor pollutants are also listed as sources in another review in Pakistan (Alamgir & Shan, 2024). The relative contribution is dependent on location and can only be determined at a single location.

Health consequences of smog exposure among children

The best child-health evidence relates to respiratory outcomes. A review of PM exposure in children shows that studies typically associate lung-function reduction and exacerbation of asthma with exposure to PM (Liu et al., 2018). A panel of schoolchildren in Jinan reported symptoms and school absence due to short-term exposure to PM2.5 (Zhang et al., 2018). Both do not give an estimate of diseases specific to Pakistan.

A systematic review from Pakistan includes all age and sex groups, and provides respiratory and cardiovascular outcomes, without specifically focusing on primary- or secondary-school children (Iram et al., 2025). There is a need to consider neurological, cognitive and psychological outcomes, and it is difficult to interpret causes. Malakand survey recruited 4100 self-reported students from universities; largest age group in Malakand survey was 26–30, which is not clinical evidence of children (Ullah et al., 2021).

Educational consequences of smog episodes in Pakistan

Education may be impacted during smog episodes by school closures, school time adjustments, school outdoor activity changes, and worry about the health effects from smog exposure while traveling or playing outside. The case study for a school in the south of the province of Punjab specifically mentions continuity as an area of concern, although the two-school sample used does not attempt to measure effects at system-wide levels (Hayat, 2025). Higher PM2.5 was related to school absence in a non-Pakistani panel and there was only design-limited evidence on the relation between the PM2.5 exposure and educational and health outcomes (Fernandes et al., 2023; Zhang et al., 2018). The results of a 2025 study on classroom air purification in Lahore are preliminary and have yet to be evaluated by others and replicated, thus it is not yet published in a peer-reviewed journal, but can be found here as a repository paper (Bharti et al., 2025).

Importance of smog awareness among schoolchildren

Awareness that smog is bad is not enough. Students must be able to identify potential sources, identify pollutants and exposures, interpret an air-quality message, assess the relative risks with age and/or health status, make choices about appropriate protective measures, and understand the importance of personal protection in addition to emission reduction. This wider literacy is important because learning, caring and doing are not correlated. The students' attitudes towards the environment in a Colombian school survey were positive, but the knowledge and preventive-practice scores were quite low, which shows how education should not end at "awareness" as a final goal (Marín et al., 2024).

Teachers as agents of environmental and health education

Teachers link science explanations to school activities, warnings and home communication. The importance of active teacher involvement in the identification of misconceptions was highlighted in a primary-school citizen science project which engaged 258 children aged 5–11, as well as interviews with ten teachers (Varaden, King, et al., 2021). The evidence found in Pakistan is more related to environmental literacy and climate teaching in general rather than to the specific teaching about smog (Gill et al., 2023; Taj et al., 2020).

Rationale for the review

A teacher-led synthesis is required since the knowledge that supports health, the curriculum content, and classroom practice are interdependent, as is the preparedness of the school. An account that only addresses pollution sources would not be adequate to explain how children learn to use risk information and a purely pedagogical account would fail to consider that schools might not have alerts, resources or clean indoor space. Review, therefore, connects air science and child health to student literacy, teacher competence, age appropriate methods and institutional conditions.

Existing research gap

In the literature identified for this literature review, there was no evidence found for direct Pakistan evidence measuring the impacts of teacher-led smog education on students' knowledge, AQI interpretation, protective behaviour or sustained environmental action in primary or secondary schools. There are also teacher studies that have been retrieved which address environmental literacy and climate teaching more broadly (Gill et al., 2023; Taj et al., 2020). The studies in Lahore do not include students and teachers as they focus on community and universities (Ahsan et al., 2020; Qasim et al., 2025), but do not focus on teachers as school teachers. This does not indicate the absence of such work, but rather that it has not yet been reviewed.

Aim and objectives of the review

To critically discuss the role of school teachers in creating awareness of smog and health knowledge about the environment and preventive measures among primary and secondary school students of Pakistan. In particular, the review addresses sources of pollution and impacts on health, the current evidence concerning students' awareness and teacher readiness, the educational and protective function of the teacher, developmentally appropriate strategies, curriculum opportunities and barriers, and evidence-based recommendations. The book is differentiated throughout, using direct evidence from Pakistan, and from the wider evidence of air pollution and environment education.

Review Methodology

Narrative review design

This is a traditional narrative review and not an empirical study, systematic review or meta-analysis, as no searches were conducted.

Academic databases and information sources

The attached Library contained no citable papers, PubMed, OpenAlex and Semantic Scholar were searched. The full texts were read for central studies and abstracts were evaluated from other sources.

Evidence was organized by geographical and directness to smog/air pollution/environmental education or theory.

Literature search period

PubMed, OpenAlex and Semantic Scholar databases were searched. The requested period of 2010–2015 and older (2026 and beyond) foundational literature was not covered, due to the publication window available being 2016–2025.

Search keywords and Boolean search strategies

Searches combined smog, haze, air pollution, air quality, PM2.5 and PM10 with schoolchildren, primary/secondary students, adolescents, teachers, preparedness, environmental-health literacy, awareness and preventive behaviour. A representative string was ("smog" OR "air pollution" OR "air quality") AND (teachers OR "teacher education") AND (schoolchildren OR adolescents) AND (awareness OR education OR "preventive behaviour") AND Pakistan. Broader searches omitted Pakistan.

Inclusion criteria

Studies and reviews that were published within the last six years (2016–2025) were considered for inclusion if they were related to Pakistan or transferable evidence related to child health, school air, teacher preparedness or environmental education. Preferring peer-reviewed research, the papers in the relevant repositories and papers presented at conferences were qualified to be retained.

Exclusion criteria

There was no evidence of treatment of adult or university samples as school-pupil evidence. Climate education was only provided as contextual evidence, rather than as evidence of effectiveness for smog. All claims were not synthesized if they were irrelevant or duplicated or unsupported.

Literature identification and selection process

Thematic synthesis was used after screening and appraising search results for relevance. The number of deduplicated records were not produced, and only process stages are indicated. No official institutional websites and some requested databases were searched, and current official guidance and curricula are not independently verified.

Data extraction and organization

Sources were noted in terms of: setting, population, design, topic, finding and evidence directness. The university samples were differentiated from school-age samples, and intention and symptom reporting were not correlated with clinical outcome or observed behaviour.

Thematic synthesis

Categories of evidence included: environmental context, child outcomes, student literacy, teacher roles, developmental and curriculum differences, interventions, school practices and implementation barriers. The findings of the international results were treated as cautiously transferrable and not as the success of Pakistani.

Quality considerations and methodological limitations

Checks were carried out on rationale, search transparency, referencing and scientific reasoning guided by SANRA principles with no numerical score claimed. No double screening and no formal risk-of-bias assessment. The central studies had full texts, and many of the claims were based on abstracts, thus preventing a detailed examination of the instruments and implementation.

Scientific and Environmental Understanding of Smog in Pakistan

Definition and characteristics of smog

Smog is defined as visible air pollution and the causes and methods of detection of smog are discussed in a Pakistan review (Raza et al., 2020). Ozone, nitrogen dioxide and carbon monoxide (Alamgir & Shan, 2024) are some examples of particles and gases listed in a health review. Teachers can differentiate emissions, atmospheric transformation, measured concentration and personal exposure; instruction strategy.

Photochemical and industrial smog

Sunlight-induced reactions between nitrogen oxides and volatile organic compounds leading to the formation of ground-level ozone, and other pollutants released by fossil-fuel burning and industry (Arif, 2016). Do not mistake all haze for ozone and all causes of haze for local causes; local causes need to be measured too.

Major pollutants associated with smog

The PM2.5 and PM10 represent the particulate size range of up to 2.5 and 10 micrometres respectively, a Pakistan review indicates that fine particulate matter is more dangerous due to its small size and tendency to stay airborne (Alamgir & Shan, 2024). The review undertaken in Pakistan

also lists ozone, nitrogen dioxide, carbon monoxide and sulfur oxides as relevant pollutants (Alamgir & Shan, 2024; Iram et al., 2025). The AQI does not show all pollutants or exposure routes.

Sources of smog in Pakistan

Source category	Pollutants or contribution	Educational interpretation
Road traffic and transport	Identified among major Pakistan air-pollution sources (Iram et al., 2025)	Map school routes and distinguish roadside from school-site conditions.
Industry and power generation	Industrial activity and coal-power emissions are identified in Pakistan reviews (Alamgir & Shan, 2024; Iram et al., 2025)	Link local observations to regulation and cleaner production.
Brick kilns and other combustion	Brick-kiln emissions are identified in Pakistan reviews (Iram et al., 2025)	Discuss source control as a system-level issue.
Agricultural and waste combustion	Agriculture and waste combustion are identified as sources in a Pakistan review (Iram et al., 2025)	Teach these as contributors, not a complete explanation of every episode.
Construction and urban dust	Construction dust is identified in a Pakistan public-health review (Alamgir & Shan, 2024)	Use school surroundings to discuss local exposure and limits of visual observation.
Household fuel use and indoor sources	A Pakistan public-health article lists household biomass and indoor pollutants (Alamgir & Shan, 2024)	Explain that indoor location alone does not guarantee low exposure.

Table 1. Major sources and types of smog in Pakistan. The sources are interactive and location specific; the table is a teaching synthesis, not a quantified source apportionment estimate. A preprint from Lahore also notes crop burning and construction in the area, but this one raises the potential for crops burning in 2025, in the absence of peer review (Hussain et al., 2025).

Seasonal and meteorological factors

The particulate concentrations at one residential monitoring site are higher in November and December (seasonal period) than in March (dry season) as measured in Lahore, but the data is local and may not reflect the national pattern (Bukhari et al., 2024). Seasonal graphs can be used by teachers to identify changes in concentration as opposed to continuous emission sources.

Geographical distribution of smog in Pakistan

The literature retrieved from Pakistan is unevenly distributed across geographical boundaries. Lahore, Karachi, Faisalabad, Islamabad, Rawalpindi and a few other cities are identified as being affected by air pollution in a review (Iram et al., 2025). In the context of the Malakand study, it has

been reported that there is variation in the concentration of pollutants not only between the districts but also between the months (Ullah et al., 2021). No similar evidence of school exposure was found in this search for Balochistan, Gilgit-Baltistan and AJK, but this is an evidence limitation rather than evidence of lack of pollution.

Air Quality Index and air-quality monitoring

An AQI is a communication index that is based on concentrations of pollutants measured in a specific calculation system; the educator should teach the data source and the scale, but not a number without its method. A local monitoring of AQI was conducted in Malakand in the form of a study amongst a sample of Pakistan students, which also measured PM2.5, PM10 and gaseous pollutants, with the majority of the participants being university students (Ullah et al., 2021). Simple classroom monitoring and participation (Castell et al., 2021; Varaden, Leidland, et al., 2021) is described as Citizen-science studies. Teachers should explain that an educational sensor reading is indicative and is not necessarily a calibrated regulatory monitoring (Castell et al., 2021).

Health and Educational Consequences of Smog Exposure Among Schoolchildren

Respiratory health effects

The health domain that is most clearly talked about is respiratory outcomes. Children's PM studies frequently involve assessing changes in lung function and exacerbation of asthma (Liu et al., 2018). A panel study in the city of Jinan linked short-term exposure to PM2.5 to school absenteeism and symptoms, however it is not a Pakistani estimate (Zhang et al., 2018). Iram et al. (2025) carries out a Pakistan review on mixed-age populations, and does not specifically focus on school children.

Cardiovascular and systemic health effects

Cardiovascular outcomes for mixed-age exposed populations have been reported by the Pakistan systematic review, but causal estimates for schoolchildren were not reported (Iram et al., 2025). Teachers are able to discuss this wider evidence without generalizing to say that a certain incident precipitated a specific child's cardiovascular disease.

Neurological and cognitive implications

An appropriate discussion of cognitive and developmental outcomes is warranted. The results of a systematic review showed inconsistent cognitive effects of school ventilation interventions (Fernandes et al., 2023). Children exposed to air pollution have been reported to experience a number of adverse outcomes including neurodevelopmental disorders, according to a school-health editorial (Fussell et al., 2025). The Lahore grade-2 classroom purifier study reported a short-term test-score improvement of 0.15 SD after a pulse of initial reduction in PM2.5 in the classroom, but the

estimate should be treated with caution as it comes from a repository paper rather than a final one (Bharti et al., 2025).

Psychological and emotional consequences

According to the Malakand university survey, there are emotional and behavioral changes in relation to polluted environment such as depressed mood, changes in exercise behaviour (Ullah et al.,2021). The results are self-reported and the sample consisted predominantly of university students, so effects are not child specific (Ullah et al., 2021). Reducing concern with accurate risk information and practical response options should be addressed in lessons.

School attendance and academic performance

There is evidence that air pollution is associated with absenteeism and evidence that that school air conditions may have an impact on learning, though causal estimates vary by design, and setting. There was a correlation between PM2.5 and absence in Jinan (Zhang et al., 2018); a school-based interventions review rated the overall evidence as modest and found poor study design (Fernandes et al., 2023). The study conducted in two schools in the southern part of Punjab reported that head teachers of the two schools closed their schools due to smog and continuity planning was necessary, but no estimates of the number of school days lost and learning recovery were made for the study (Hayat, 2025).

Vulnerability of primary and secondary school students

Exposure and protective capacity is influenced by the child's developing respiratory system, outdoor time and reliance on adult decisions. The international school-exposure review suggests that the school environment is an exposure setting, pollutant concentration is variable by school, by building conditions, by ventilation and by outdoor conditions (Chithra & Nagendra, 2018; Oliveira et al., 2019). Younger children require adults to explain warnings and set up protective procedures, while older children may be involved in a more active way of monitoring and decision making. Vulnerability is not uniform: asthma, other health conditions, school location, commute, housing, language and access to health resources all condition exposure and response.

Outcome domain	Evidence and plausible pathway	Strength and Pakistan-specific limit
Respiratory symptoms and asthma	Child reviews report PM-related respiratory symptoms and asthma exacerbation; schoolchild panels document short-term symptom associations (Liu et al., 2018; Zhang et al., 2018)	Most consistent child-health domain, but available quantified panel evidence is non-Pakistani.

Lung function	School-age panel evidence links PM exposure with short-term pulmonary-function changes (Yang et al., 2020)	Biologically and epidemiologically relevant; local school-age longitudinal evidence was not retrieved.
Cardiovascular/systemic effects	Pakistan review reports cardiovascular outcomes across mixed populations (Iram et al., 2025)	Do not infer schoolchild-specific incidence from mixed-age evidence.
Neurodevelopment and cognition	Reviews identify developmental concern; intervention reviews find inconsistent cognitive outcome results (Fernandes et al., 2023; Fussell et al., 2025)	Plausible and important, but causal effects and educational translation remain uncertain.
Psychological/behavioural responses	Malakand respondents self-reported psychological and behavioural effects (Ullah et al., 2021)	Cross-sectional self-report among mostly university students; not clinical or schoolchild-specific evidence.
Absence and learning continuity	PM2.5 panel evidence associates exposure with absence; two southern Punjab heads describe closure-related continuity challenges (Hayat, 2025; Zhang et al., 2018)	International association plus local qualitative evidence; Pakistan-wide learning losses are not quantified.

Table 2. Health and educational consequences of smog exposure among schoolchildren. Evidence strength refers to the directness and design of the cited literature, not a formal GRADE assessment.

Smog Awareness and Environmental Health Literacy Among Students

Definition and dimensions of smog awareness

Here, EHL means the ability to access, understand, appraise and use information about environmental exposures and health. Smog awareness is not just recall, but the knowledge of sources, health-risk appraisal, and information use and participation. The difference can be explained by the school studies that have evaluated separately knowledge, attitude, and practice (KAP) (Marín et al., 2024; Ullah et al., 2021).

Knowledge of smog causes and sources

There are limited retrieved sources of evidence by Pakistani school-age learners regarding the causes of the smog. A study conducted in Lahore is described as an assessment of the awareness of the teenagers about air-pollution, however, the abstract provided does not provide any prevalence or intervention effects (Nabeel et al., 2023). The sources, mentioned by Malakand university

respondents were vehicle exhaust, biomass burning and industrial emissions, which are not school children's responses (Ullah et al., 2021).

Awareness of health consequences

In a sample of 189 undergraduate students in Lahore, the majority highlighted both the seriousness and harm of smog, while fewer knew what causes smog or felt that individual efforts were important (Qasim et al., 2025). The survey of Beijing middle school students revealed that most students were aware of the respiratory effects of haze, but few students were aware of the cardiovascular effects of haze (Hu et al., 2017). These aren't Pakistan studies, but they do illustrate why a local pupil baseline is required in a Colombian school survey, with the median knowledge score being 33.8% and 38.6% knew the AQI.

Risk perception and attitudes

Knowledge does not always result in protective behaviour. In a study of 913 Lahore respondents, threat and coping appraisals were correlated with reported coping behaviours but were not shown to cause coping (Imran et al., 2025). Among Bangkok upper-secondary students, teacher, peer and family support were associated with PM2.5 prevention (Boonkla et al., 2025). A study on secondary school haze knowledge, attitudes, and reported practices was also carried out in Malaysia (Rahman & Bahari, 2020). Risk messages should thus accompany social support with a feasible action.

Knowledge of AQI and air-quality warnings

There were no available school-based Pakistan school literature that establish pupils' AQI or alert literacy. The SAMHE initiative introduces classroom monitors and an application to enable teachers and students access to indoor air data, co-designed together (Chatzidiakou et al., 2023). Competence among students in understanding AQI and health warnings should be assessed, not taken for granted, in Pakistan.

Preventive health literacy

Preventive literacy involves understanding how to follow guidance from school, to change activity and communicate symptoms, and that personal protection is not protection from emissions. In Malakand university sample, 71.2% mentioned that they use respiratory face mask; however, this is not considered to be effective school-age practice (Ullah et al., 2021). In the regression analysis, there were 639 Korean elementary students, and the awareness of particulate-matter was a significant predictor of reported health-promoting behaviour (Park et al., 2020).

Environmental responsibility and community participation

Environmental literacy may be personal protection or inquiry and civic participation. Primary schoolchildren in London took part in collecting exposure data and/or running campaigns in the school/ community (Otu et al., 2024). Some local evidence was seen in the form of a study conducted in the city of Rawalpindi among 70 secondary school students on general awareness about the environment and hygiene practice, which did not relate to smog (Andleeb et al., 2025). It is not the responsibility of the pupil to solve structural pollution.

Pakistan evidence	Population and design	What it can support	What it cannot establish
Malakand air-pollution survey (Ullah et al., 2021)	4,100 recruited; 4,021 analysed; university students from six Khyber Pakhtunkhwa districts (Ullah et al., 2021)	Pollutant variation across districts and months (Ullah et al., 2021); reported symptoms and practices (Ullah et al., 2021); knowledge and perceptions (Ullah et al., 2021)	Primary/secondary student awareness or causal health effects.
Lahore teenager air-quality awareness study (Nabeel et al., 2023)	Study is described as assessing teenagers; abstract-level detail is limited (Nabeel et al., 2023)	Indicates a local adolescent-awareness research topic exists.	A defensible prevalence estimate or detailed intervention effect.
Lahore university smog survey (Qasim et al., 2025)	189 undergraduates; cross-sectional questionnaire (Qasim et al., 2025)	Illustrates knowledge gaps between concern, source knowledge and perceived agency.	School-age knowledge or teacher effects.
Lahore general-population KAP (Saleem et al., 2019)	607 community respondents; cross-sectional (Saleem et al., 2019)	Shows socioeconomic and educational gradients in adult knowledge/practice.	Student-specific literacy or causal education effects.
Environmental literacy among Punjab secondary teachers (Taj et al., 2020)	Survey of 1,500 sampled secondary teachers from five of 36 districts; 52% response rate (Taj et al., 2020)	Baseline evidence about teachers' general environmental literacy (Taj et al., 2020)	Smog-specific teaching competence or student learning gains.

Table 3. Summary of Pakistani studies on smog and environmental awareness. "Student" in a study title does not imply school-age participants; population distinctions are retained.

Teachers' Role in Promoting Smog Awareness

The teacher is at the heart of the implementation link between the environmental information and the student's competence; teacher agency depends on competence, permission of the curriculum and school support. The evidence from Pakistan reveals the identified capacities and barriers with respect to general EE and climate change education rather than through actual testing of smog education (Gill et al., 2023; Taj et al., 2020).

Teachers as providers of scientific knowledge

Teachers convert terms like PM2.5, ozone, emission, exposure and AQI into explanations which students can understand. Content accuracy is important because, for climate change and environmental education, there is a risk of blurring the line; interviews with 13 Pakistani grade 10 and 12 chemistry teachers revealed that participants believed that it was important to teach climate change but some had inaccurate views of the scientific meaning of climate change and its relationship to pollution and ozone depletion (Gill et al., 2023). While climate change may not be smog, the finding illustrates the need to rely on subject familiarity alone for accurate teaching of environmental health is not guaranteed.

Teachers as environmental health educators

Teachers can link exposure to symptoms, and protection to illness or treatment without making a diagnosis or prescribing treatment. Sarani et al. (2022) conducted a cross-section study with 250 teachers in primary schools of Zabol County and found that awareness and HBM measures were correlated with the reported protective behavior. A study based on structured interviews with 95 kindergarten teachers revealed that knowledge about air-pollution went hand in hand with low levels of child-protection strategies (Rokhmah et al., 2025). The two are evidence-based and not estimates for Pakistani pupils.

Teachers as behavioural role models

Students see if adults are monitoring alerts, informing changes in outdoor activity, discussing pollution sources without stigma and following school procedures. Emission conscious routines shall be role modellers wherever possible and structural constraints shall be discussed. It shouldn't place a burden on families that cannot afford purifiers, private transport, medical service. Adult behaviours in the classroom, such as opening windows or operating air purifiers, were associated with variation in indoor pollutant reduction in a study of classroom air conducted in the school environment, highlighting the need for adult routines to be seen as a driver of exposure management (Fussell et al., 2025).

Teachers as facilitators of critical thinking

A primary-school toolbox for 6 to 12 years old to hypothesize, experiment and conclude (Castell et al., 2021). Teacher involvement in the identification of misconceptions was mentioned in a different project, that involved 258 children aged 5-11 and interviews with 10 teachers (Varaden, King, et al., 2021). These examples are to aid guided inquiry and teacher mediation, and are not evidence of proven effectiveness of Pakistan's education on smog.

Teachers as communicators of air-quality warnings

A warning should be communicated as a calm, actionable message (what it is warning about, who needs more protection, which school routine changes, and where the warning is coming from. Teachers should rely on a trusted source that has been identified by the school authorities and not pass on unverifiable claims from social media. A cross-sectional survey in Lahore, reported that trust and coping appraisal were related to protective behaviors, but not tested among schoolchildren (Imran et al., 2025).

Teachers as promoters of preventive behaviours

Teachers have the opportunity to practice routines for indoor/outdoor transitions, activity modification, symptom reporting, and family communication. The recommendations must be in line with current public-health guidelines and the school's infrastructure: masks, ventilation and stay indoor should not be seen as a one-size-fits-all solution. The literature on the school intervention shows that there are several exposure control options, but no single stand-alone measure that can address all types of school air (Rawat & Kumar, 2023).

Teachers as environmental advocates

Teachers can lead students to source awareness using locally gathered evidence and practical collective action. A London school project refers to pupils gathering exposure data and co-planning mitigation with groups in the school-community (Otu et al., 2024). Such advocacy should be grounded in evidence and the studies do not support consistent emissions reductions in Pakistan and should be age and context appropriate, safe (Otu et al., 2024; Varaden, Leidland, et al., 2021).

Teachers' collaboration with parents and communities

Parent communication can coordinate school alerts, commute decisions and symptom reporting; health professionals can check and make recommendations on referrals. In the Lahore and Faisalabad secondary school health-literacy study, the teachers' knowledge was higher than that of the students on the health topics measured, but this study was not conducted to assess knowledge about air pollution (Sulehri et al., 2016). No evaluation of a sustained programme of parent–teacher collaboration on smog is found in the retrieved studies from Pakistan.

Teachers' contribution to school-level smog-response planning

Teachers can support administration in developing a response plan that includes who is responsible for watching for alerts, who is responsible for adjusting outdoor activities, notification to the families, protection of students who have health needs, and how learning will continue in the event of a closure. It is not appropriate to expect teachers to make unsupervised clinical or air-quality judgments. The two-school southern Punjab leadership study is useful for advance planning and usage of available technology for continuity, but is too small of a qualitative sample to be generalizable (Hayat, 2025).

Teacher role	Core practice	Student capability supported	Necessary school condition
Scientific interpreter	Explain environmental science and distinguish climate change from air pollution (Gill et al., 2023)	Accurate causal models	Short, vetted teaching resources and time.
Health educator	Link risk information with age-appropriate protective choices (Sarani et al., 2022)	Risk appraisal and help-seeking	Alignment with current health advice.
Model and mentor	Demonstrate alert-checking and transparent action (Fussell et al., 2025)	Self-efficacy and norms	Consistent whole-school routines.
Inquiry facilitator	Use observation, low-cost measurement and evidence critique (Castell et al., 2021)	Scientific reasoning and data literacy	Safe methods and sensor caveats.
Risk communicator	Convey trusted warnings and actionable school changes (Imran et al., 2025)	Information appraisal	A designated alert and communication channel.
Advocate and partner	Connect classroom inquiry to family and community action (Otu et al., 2024)	Civic and environmental agency	Administrative support and safe participation.
Response-plan contributor	Contribute to planning for alerts, activity and continuity; qualitative interviews examined two school heads' strategies during smog-related closures (Hayat, 2025)	Preparedness and continuity	Clear delegated roles and resources.

Table 4. Teachers' roles in promoting smog awareness. Roles are evidence-informed functions; the table does not imply that each has been experimentally validated in Pakistan.

Differences Between Primary and Secondary School Education

Smog awareness in early primary education

For younger students: Stories, simple demonstration, symptom vocabulary, adult-led safety choices. A European programme based on leaflets, cartoons and games was found to increase the knowledge of 266 children in grades 1 through 2 in primary schools, with a greater increase in grade 2; this transfer is yet to be tested in Pakistan (Casini et al., 2016).

Smog awareness in upper primary education

In the upper primary students are able to map a route, compare and interpret basic observations. Teaching and exposure monitoring were integrated in a citizen-science project involving elementary school children (aged 5-11) and their teachers helping to identify misconceptions (Varaden, King, et al., 2021). Maintain guided and shared interpretation.

Smog awareness in secondary education

Secondary students can investigate particles, AQI, uncertainty and policy compromises. In the BREATHE pilot, immediate increase in reported behavioural choice was observed (77 eighth graders), however not in understanding, and the between-group difference was not significant at 1 month (Abrham et al., 2023). Just engagement does not provide long-lasting results.

Age-appropriate teaching approaches

The sequence of the instruction should start with concrete experience and vocabulary in early primary, proceed to inquiry and simple data interpretation in upper primary, and culminate in systems analysis, risk communication and civic reasoning in secondary school. The approach is an age-oriented developmental recommendation based on the age-specific intervention evidence which is not a validated Pakistani progression. Not only should attendance be used as a criterion for outcomes, but they should also be validated at each step.

Differences in cognitive development and learning outcomes

Concrete representations, adult guidance is appropriate for younger pupils; older pupils can compare explanations and uncertainty. Language is important as well as prior learning and context. MAPEC's grade-level gains suggest the use of materials adaptations instead of scaling up with no changes in the materials (Casini et al., 2016).

Appropriate educational assessment methods for each level

Use pictures, oral explanations, scenarios of safety for younger pupils, simple data, sources for upper-primary pupils, AQI interpretation, risk measures, protocol practice for secondary students. In each grade, differentiate knowledge, purpose and actual behavior.

Educational stage	Learning emphasis	Suitable teacher-led methods	Assessment focus
Early primary	Recognition, simple cause–effect, trusted adult guidance	Teacher leaflets, cartoons and games (Casini et al., 2016)	Oral/picture-based understanding and safe response scenarios.
Upper primary	Sources, exposure pathways, simple monitoring and comparison	Route maps, observation journals, guided citizen science (Castell et al., 2021; Varaden, King, et al., 2021)	Source identification, basic interpretation and misconception checks.
Secondary	Pollutants, AQI, evidence appraisal, policy, self-efficacy	Proposed: evidence appraisal, structured discussion and guided investigation	Knowledge, risk appraisal, protocol competence and delayed behaviour outcomes.

Table 5. Comparison of primary and secondary smog education. The progression is a proposed developmentally responsive design; local validation is needed.

8. Integration of Smog Awareness into Pakistan's School Curriculum

Existing environmental education in Pakistan

A survey conducted among secondary teachers revealed moderate composite environmental literacy among the teachers in five selected districts with 52% participation rate (Taj et al., 2020). Another research conducted by the researchers of 200 teachers from Islamabad Model College reported differences in environment understanding among the teachers which is related to discipline (Amir et al., 2020). These research studies focus on general EE, not competence on smog.

National Curriculum of Pakistan and environmental learning outcomes

No specific documents of current curriculum were directly examined. In one study, Pakistani chemistry teachers interviewed reported a lack of environmental content and very few examination questions related to climate change (Gill et al., 2023). The accounts are not a province by province curriculum inventory.

Environmental content in science and biology textbooks

Science, chemistry and biology can be used to explain particle properties, combustion, atmospheric chemistry and respiratory pathways. Gill et al. (2023) conducted a study on 13 chemistry teachers, who indicated that they supported climate-related content in chemistry, and in related topics, which are commonly taught as part of chemistry. Health, geography and social studies are also good subject areas for reinforcing smog learning.

Integration into geography and social studies

Exposure and source control can be linked to the roles of transport, land use, and agriculture in the context of geography and social studies. Pollution sources have been reviewed with a geographical variation, with additional case studies in Pakistan (Iram et al., 2025; Raza et al., 2020).

Integration into health and physical education

Symptoms of health/PE, help-seeking and school-approved activity change. The goal is to get people to move safely, not that it is unsafe to exercise outside. Current local guidance was not found.

Curriculum gaps concerning smog-specific knowledge

No use of current official curriculum text. A textbook analysis conducted in the province of Punjab, Sindh and KP found very little contextualized environmental information with isolated and sporadic presence of environmental information and no smog-specific information audit (Riaz & ShahidaNaz, 2025). No total omission is found.

Opportunities for curriculum improvement

Proposed outcomes may increase to include understanding approved alerts, selecting appropriate actions and engaging in discussions about source reduction, depending on teacher reported gaps in literacy and in covering syllabus content (Gill et al., 2023; Taj et al., 2020). Local languages, low cost activities and closure adaptations should be included in teacher guides, which must be consulted with and piloted.

Teaching Strategies and School-Based Educational Interventions

Classroom awareness sessions

Lessons can begin and build pollutant, health pathways and responses in a short amount of time. BREATHE reported behaviour-choice increased instantly, and understanding did not but the behaviour difference was not maintained for 1 month (Abrham et al., 2023).

Interactive teaching and demonstrations

Utilize demonstrations, source cards, route maps, video and scenarios. Primary pupils scores on knowledge gains were related to MAPEC's teacher leaflets, cartoon and games (Casini et al., 2016). Do not assume pollutant chemistry and risk by visible dust.

Project-based environmental education

Projects can plot routes, monitor alerts or compare school locations. A London backpack-monitoring study mapped children's commute exposures (Varaden, Leidland, et al., 2021) while a primary-school toolbox study used an affordable visual approach, and compared to official PM10 data available from stations (Castell et al., 2021). Safe sites and privacy safeguards are required for activities.

Digital learning and AQI applications

Digital tools can be used for air data and provide extension of learning during school closures, however, there is a need for low-tech options and a trusted source in school. SAMHE is an example of co-designed classroom monitoring, which may not be applicable in resource constrained schools (Chatzidiakou et al., 2023).

Posters, debates and awareness competitions

The posters and debates must involve claims that are sourced and they must differentiate between personal protection and emission prevention. Look for participation, not for score accuracy and feasibility; appearance is not the only indicator of participation; participation is not an indicator of durable learning.

Environmental clubs and school campaigns

Environmental clubs may keep log, discuss idling and present monitoring results. There are reports of student engagement in ideas for local mitigation by London projects, but not for sustained ambient-air improvements or for Pakistani effectiveness (Otu et al., 2024).

Parent–teacher awareness initiatives

Family sessions may include warnings, travel, and symptoms and elicit concerns regarding access. The Lahore survey data indicates that while education and income are associated with reported protective practice, this does not make communication enough to address resource issues (Saleem et al., 2019).

Teacher professional development

Professional development should include air science, child-health literacy, risk communication and inquiry, including practice deciphering alerts and correcting misconceptions. Studies conducted by teachers in Pakistan reveal general literacy needs and subject knowledge needs, but not smog-specific training (Amir et al., 2020; Gill et al., 2023; Taj et al., 2020).

Evaluation of educational interventions

Use baseline and delayed measures, comparison groups if available, and observation of protocol use to evaluate. Differentiate between knowledge, intent, acts, exposure and health. A rapid review was conducted to map 79 communication studies, and for 10 of them, behavioural evidence was often a form of observational design, intentions or self-report (Cibin et al., 2025).

Strategy	Teacher action	Expected proximal outcome	Main limitation / evaluation need
Structured lesson	Teach pollutants, health pathways, AQI and response steps	Knowledge and confidence	Knowledge may not change or persist after a single session (Abrham et al., 2023).
Audiovisual package	Use teacher guides, cartoons or age-suited games	Engagement and factual learning	Replicate locally and assess delayed retention (Casini et al., 2016).
Citizen science	Guide safe monitoring, data interpretation and reflection	Inquiry, local relevance and misconception correction (Varaden, King, et al., 2021)	Sensor uncertainty; access, safety and privacy.
Digital alert activity	Use trusted AQI data and a low-tech alternative	Warning interpretation	Digital access and scale-specific AQI literacy (Chatzidiakou et al., 2023).
Debate/poster/campaign	Require evidence-backed claims and feasible action	Communication and civic agency	Participation is not equivalent to behaviour change.
Teacher development	Rehearse content, pedagogy, communication and protocols	Teacher environmental-literacy competencies (Taj et al., 2020)	Needs follow-up coaching and classroom observation.

Strategy	Teacher action	Expected proximal outcome	Main limitation / evaluation need
School response drill	Practice alert, activity adjustment and family notification	Preparedness and consistent routine	Must align with verified local health advice.

Table 6. Teaching strategies for school-based smog awareness. Expected outcomes are proposed proximal targets, not claims of proven Pakistani intervention effect.

Teachers' Knowledge, Attitudes, and Practices

Teachers' knowledge of smog

No study has been found in Pakistan that directly examined the knowledge of primary and secondary school teachers on the smog composition, AQI interpretation and child protection practice, as a bundle of knowledge. The Punjab environmental-literacy survey is relevant but reflects general environmental knowledge, dispositions, general cognitive skills and responsible behaviour (Taj et al., 2020). The difference should inform future surveys; general environmental concern is not a good indicator of smog competence.

Teachers' understanding of air pollutants

Misconceptions about climate science and the lack of clarity in the distinction between environmental change and pollution and ozone depletion (OE) were identified in the qualitative study of 13 Pakistani chemistry teachers (Gill et al., 2023). This discovery is not a reflection on the lack of all air-pollution knowledge of these teachers, but rather indicates a need for diagnostic assessment, and for proper separation of particulate pollution, ozone and climate change.

Teachers' perceptions of students' vulnerability

Children spend a significant amount of time at school, and it is identified as a potential danger in terms of their health, through this review (Oliveira et al., 2019). The evidence retrieved did not directly define the vulnerability of children as perceived by the teachers in Pakistan.

Teachers' attitudes towards environmental education

The chemistry teachers in Pakistan supported the teaching of climate change, and they also mentioned that there is lesser content in the syllabus, and there are less questions asked in the examination (Gill et al., 2023). A survey in Mardan shows positive teacher role in EE in secondary schools, however, the abstract does not give enough information to evaluate the role of teacher in EE in classroom (Daraz et al., 2023). Having good attitudes is a facilitator, not a proof of good teaching.

Teachers' classroom practices

During interviews, 13 Pakistani chemistry teachers were asked, 9 of whom indicated that they covered climate change in the topics they already covered in their classes, and 10 teachers felt that there was a lack of content in the curriculum on this topic (Gill et al., 2023). Dedicated classroom instruction is not indicated by endorsement.

Professional training and preparedness

The overall environmental literacy level of secondary teachers was moderate in the survey conducted in the Punjab, with five districts having a 52% response rate (Taj et al., 2020). Amir et al. (2020) reported differences between the teachers of Science and Humanities in Islamabad. Zeeshan & Qureshi (2022) conducted a survey of 350 pre-service teachers from Punjab and found that there is support for EE in teacher-training syllabus. There are no of these studies that consider smog-specific training.

Public and private school differences

No strong evidence of a public-private assessment of teacher competence in smog was found. Intervention in one group of schools (public and private schools) focused on global warming rather than on smog or teacher preparedness (Fatima, 2023). Considerations for comparisons to include resources, class size and locality.

Preventive Behaviours and School-Level Protective Practices

Understanding air-quality alerts

Schools to appoint an adult and identified alert source. Teachers can provide clarification that alerts are not a diagnosis and practice the school response. Thresholds should be based on guidance from relevant authorities, and not be improvised from an app.

Following official health advisories

Since the official guidance was not used in this review, the manuscript does not recommend a specific AQI threshold, mask type or clinical action. School protocols must be consistent with the recommendations of the health and environmental authority at the provincial level and must provide for the updating of teachers. Teachers should not recommend changing prescriptions but should alert caregivers and health providers to any particular health concerns.

Appropriate modification of outdoor activities

Activity decisions to be made in accordance with school procedures, pupil needs and viable alternative; to try to maintain indoor mobility. There is no single measure that is applicable across all schools, based on the evidence in the school environment and social context (Fernandes et al., 2023; Imran et al., 2025).

Indoor air-quality management

The interaction of these factors is ventilation, filtration, occupancy and outdoor infiltration. Increased ventilation led to short-term improvements in indoor air quality, and the effects on cognition was inconsistent (Fernandes et al., 2023). Multiple technologies are available, and there is no single solution (Rawat & Kumar, 2023).

Personal protective practices

Educate protection as a conditional not a guaranteed value. Information on masks, filters or symptoms/illness should be based on local guidance, students should know how to contact adult assistance for assistance with breathing difficulty.

School emergency-response plans

A school plan should designate alert monitoring, communication, activity changes, health support and continuity of closure. This is qualitative rather than prevalence evidence of continuity needs that were described by two school heads from the south of Punjab in relation to leadership planning and technology (Hayat, 2025).

Environmental pollution prevention

Student participation to idling reduction, waste-burning prevention, transport and industrial control. Review of Pakistan policies have highlighted that along with regulation and source reduction, education is a key tool to control an airshed through individual choices (Nadeem et al., 2024; Shabbir et al., 2025).

Barriers to Effective Implementation

Barrier	Evidence or mechanism	Implication for implementation
Limited teacher preparation	A Punjab survey reported moderate general environmental literacy (Taj et al., 2020); an Islamabad teacher study	Provide subject-sensitive training with coaching, not a one-off lecture.

	reported differences by subject area (Amir et al., 2020)	
Curriculum and examination pressure	Pakistani chemistry teachers reported limited syllabus content and few examination items on climate change (Gill et al., 2023)	Embed short, assessed outcomes across subjects and grades.
Resource constraints	A classroom-monitoring initiative used monitors and a co-designed web application (Chatzidiakou et al., 2023)	Offer low-cost and non-digital lesson alternatives.
Weak administrative support	Adjacent Pakistan environmental-teaching evidence identifies support as a constraint (Gill et al., 2023)	Assign leadership roles and protect curriculum time.
Unequal access to protection	A Lahore general-population survey found preventive practice associated with income and education (Saleem et al., 2019)	Do not make household purchases a prerequisite for safety.
Urban–rural differences	Pakistani and regional studies describe differences in exposure and awareness by locality (Iram et al., 2025; Khattak et al., 2024)	Use local examples; avoid a Lahore-only curriculum.
Language and literacy	A Pakistan student survey used English questionnaires, justified by higher education context (Ullah et al., 2021)	Develop Urdu and provincial-language materials and test comprehension.
Limited health-sector collaboration	School intervention evidence often integrates environmental and health settings but local arrangements are not documented (Fernandes et al., 2023)	Establish clear referral and advisory links with health authorities.
Weak outcome evaluation	A review of communication interventions notes that behaviour evidence often relies on observational designs, intentions or self-report (Cibin et al., 2025)	Use delayed follow-up and objective implementation measures.

Table 7. Barriers to effective implementation. Several barriers are inferred from adjacent environmental-education or intervention evidence and need direct Pakistan school-level study.

Limited teacher training

Content and pedagogical content knowledge must be a part of teacher education. Gaps in pollutant chemistry, AQI interpretation or health communication may not be captured in a general environmental-literacy score, and should be evaluated separately in local programmes (Gill et al., 2023; Taj et al., 2020).

Inadequate curriculum coverage

If a topic is spread across subjects and examination requirements, teachers might have limited time and/or ownership. The study by chemistry teachers indicated that teachers experienced a small amount of syllabus content and a small amount of examination items on climate change (Gill et al., 2023).

Limited educational resources

Schools might not have up-to-date local data, sensors or even connectivity or prepared lessons. Use of technology in projects should be optional and combined with observation, maps, school and shared scenarios (printed) and school data (Castell et al., 2021; Chatzidiakou et al., 2023).

Institutional and administrative challenges

Ambiguous leadership in closure, outdoor learning, alerts, and parent communication can cause teachers to be unsure. While the small qualitative sample does not allow for the generalisation of administrative practice, the school-head case study in the south of Punjab highlights the role of leadership and coordination.

Public–private educational inequalities

The evidence retrieved does not confirm the existence of causal public–private differences in monitoring and responding capacity, due to differences in school resources. Evaluation needs to be based on student characteristics and place of student separate from resources of the institution.

Urban–rural differences

The types and availability of sources, warning information, and exposure routes can vary from city to city, from farm to farm, and from remote location to remote location. The monitoring of Malakand is an example of in-region variability as the selected sites were not representative of all of the rural areas (Ullah et al., 2021).

Language and socioeconomic barriers

Materials should be linguistically appropriate, cater for diverse levels of literacy and access to protective choices. Not all preventative practices were found to be related to awareness; indeed, a community survey of Lahore showed socioeconomic correlates of reported practices (Saleem et al., 2019).

Limited collaboration with health authorities

Schools need health approved guidance on symptoms, respiratory conditions and alerts. If teachers don't work cooperatively, they may be giving different directions or directions that are too specific. During the current search, it was not possible to determine how air-quality communication is coordinated routinely between the school systems and public-health organizations in Pakistan.

Theoretical and Conceptual Framework

Social Cognitive Theory

SCT stresses the relationship of personal capacity, models observed, and environment. The design of the BREATHE questionnaire was based on SCT and aimed at adolescents (age 13–15). A total of 77 students were randomized in its pilot (Abrham et al., 2023). The difference between group changes in behaviour score did not significantly differ after 1 month (Abrham et al., 2023).

Health Belief Model

People perceived susceptibility and severity, benefits, barriers and cues to action are organized by HBM. The 0.398 correlation between awareness and explained reported protective behaviour in Zabol County's 250 primary school teachers confirmed the relationship between these two variables as well as the variance of the one variable that was explained by the other variables (Sarani et al., 2022). This is an evidence report on teachers who are not Pakistani, not an effect estimate for Pakistani pupils. Lessons should include risk information with realistic response options.

Knowledge–Attitude–Practice framework

KAP is a separation of knowledge, attitudes and reported practices, but not as a causal theory (Marín et al., 2024). Students might realize that pollution is bad, but have no "red flag" or authority to change their activity; Bangkok findings indicate that teacher, family, peer, and school support are correlated with the students' report of prevention (Boonkla et al., 2025). In addition, practice was observed in a community survey conducted in Lahore (Saleem et al., 2019).

Proposed integrated teacher-led smog awareness framework for Pakistan

Figure 1 is a suggested testable framework. It builds on the observed differences in teacher environmental literacy in Punjab (Taj et al., 2020), the observed link between teacher involvement in school inquiry and environmental literacy in Punjab (Varaden, King, et al., 2021), and the observed association between risk appraisal and protective behaviour in Lahore (Imran et al., 2025). The model correlates teacher competence and school support with student literacy and then, with protective action, only in places where safe choices and resources are available. No validation is available of these pathways in Pakistan.

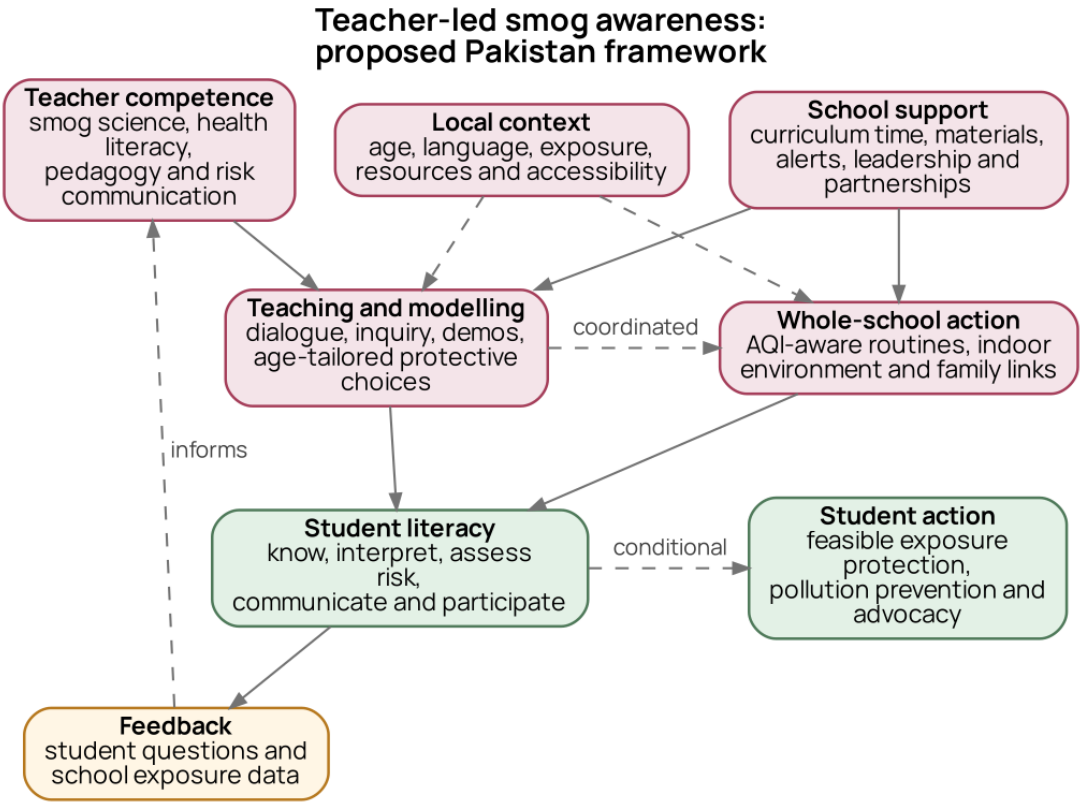


Figure 1. Proposed conceptual framework linking teacher competence and school support to student smog literacy and conditional preventive action. Dashed links represent proposed or context-dependent pathways.

Discussion

Synthesis of Pakistani evidence

The set retrieved is not a school-based smog-education literature in Pakistan studies document pollution and teacher-capacity concerns. The survey has been conducted with mostly university students in Malakand and with both community and university students in Lahore (Ullah et al., 2021; Qasim et al., 2025; Saleem et al., 2019). Studies that assessed general environmental literacy, or climate teaching, were retrieved from amongst the teacher sources, instead of smog-specific preparedness (Gill et al., 2023; Taj et al., 2020).

Comparison with international literature

International work refers to the custom made primary materials, citizen-science monitoring and adolescent lessons (Abrham et al., 2023; Casini et al., 2016; Varaden, Leidland, et al., 2021). Age and curriculum and outcome measures (COM) differences constrain transfer; evidence indicates that it is feasible, but not necessarily effective for Pakistan or ongoing emission reductions.

Teachers' influence on student awareness

Teachers can help to create accurate and actionable risk information. Studies conducted in Pakistan show that general literacy and curricular restrictions are major factors (Gill et al., 2023; Taj et al., 2020), whereas citizen-science research indicates that teacher mediation of misconceptions is a key factor (Varaden, King, et al., 2021). No direct causal evidence of the positive impact of teacher training in smog literacy for pupils was found.

Differences between primary and secondary students

Primary-pupil knowledge gains were reported with tailored material by MAPEC (Casini et al., 2016). A behaviour-choice measure in BREATHE was shown to be improved without a corresponding understanding score improvement in eighth grade (Abrham et al., 2023). Ought, then, outcomes and teaching to be age specific?

Relationship between knowledge and preventive behaviour

Awareness does not guarantee action. Lahore surveys link trust and threat assessment with the reported practice of the participants, as well as socioeconomic factors (Imran et al., 2025; Saleem et al., 2019). The reported behavioural difference in the adolescent trial did not follow up (Abrham et al., 2023).

Educational and public-health implications

While teachers can contribute to developing warning literacy, school routines, communicating symptoms, and cannot replace emission control or protective infrastructure. School-air interventions are context-dependent and complementary, as per reviews (Rawat & Kumar, 2023).

Identified research gaps

They found no evidence of a Pakistani controlled evaluation of teacher-led smog education with delayed outcomes or of a representative pupil AQI-literacy assessment, or of a multi-province curriculum-to-classroom audit. Here, no evidence related to school exposure was found outside of the urban-centred literature and studies from Balochistan, Gilgit-Baltistan and AJK (Iram et al., 2025). These are gaps which only exist in the corpus and do not signify that such work does not exist.

Implications for Pakistan's education system

Sequenced curriculum outcomes, teacher preparation, school protocols and evaluation are required in a response. Shared objectives are flexible and can be tailored for each province and exposure level. It is not only the time of the seasonal crisis that should be emphasized for smog education, but also concurrent with enforcement and source control (Shabbir et al., 2025).

Recommendations and Policy Implications

Stakeholder	Recommended action	Evidence rationale / safeguard
Teachers	Use accurate, age-tailored lessons; teach AQI and exposure interpretation; check misconceptions; separate protective action from source reduction.	Teacher literacy and climate-teaching studies identify competence and curriculum interpretation as relevant (Gill et al., 2023; Taj et al., 2020).
School administrators	Adopt a written, authority-aligned alert and response plan; assign roles for outdoor activity, family communication and continuity.	Two southern Punjab school heads described continuity planning needs during smog closure (Hayat, 2025).
Curriculum developers	Specify sequenced outcomes across science, health, geography and social studies; include local case studies and equity.	Teacher interviews describe limited/embedded content; textbook analysis reports weak local contextualization (Gill et al., 2023; Riaz & ShahidaNaz, 2025).
Teacher-training institutions	Include air-pollution science, child-health literacy, communication, inquiry pedagogy and school protocol practice in preservice and in-service training.	Pakistan teacher studies report moderate general environmental literacy and capacity gaps (Amir et al., 2020; Taj et al., 2020).
Education and health authorities	Publish consistent school-facing advisories and clarify responsibilities for alerts, closures, ventilation and referrals; coordinate air monitoring and school health.	School exposure literature shows indoor/outdoor conditions vary and interventions require context-specific decisions (Chithra & Nagendra, 2018; Rawat & Kumar, 2023).
Parents and communities	Participate in two-way school communication, share exposure constraints, and support feasible no-idling and pollution-prevention activity.	Lahore population data associate reported practice with income and education; avoid blame and unaffordable prescriptions (Saleem et al., 2019).

Researchers	Test multi-component interventions with baseline, comparison and delayed measures across provinces and school sectors.	A rapid review reports heterogeneous interventions and frequent reliance on observational, self-reported behaviour evidence (Cibin et al., 2025).

Table 8. Recommendations for teachers, schools and policymakers. These recommendations are evidence-informed proposals, not interventions already proven effective in Pakistan.

Recommendations for school teachers

A concise, locally valid teaching package should be provided for teachers, messages should be checked against designated official sources, developmentally appropriate inquiry should be used and knowledge, interpretation and behaviour should be evaluated separately. They are expected to provide support for students with health issues via a referral system and not give advice on individual health.

Recommendations for school administrators

Administrators should assign responsibility for alert and decision making, have communication and closure-continuity plans in place, identify an alternative indoor activity to the cancelled outdoor activity if there is one, and have an alternative process for health-related accommodations in place and maintain confidentiality. The plan should be rehearsed before a serious event and not during a serious event (Hayat, 2025).

Recommendations for curriculum developers

There is a need to integrate the science of smogs and environmental-health literacy into the curriculum through a series of outcomes rather than through an awareness week. Learning materials should not give a common cause for all the regions regarding the smoke levels of traffic, industry, kilns, agricultural burning, dust or indoor sources (Iram et al., 2025; Raza et al., 2020).

Recommendations for teacher-training institutions

Training should provide for diagnostic processes of the existing knowledge, microteaching, interpretation of alerts, communication of risks, as well as adaptation of the query and lesson in a multilingual classroom within a low-cost framework. Confidence alone should not be used as the only means of evaluating classroom practice for follow-up mentoring (Amir et al., 2020; Taj et al., 2020).

Recommendations for education and health authorities

The development of existing school protocols should be a collaborative effort between authorities, with access to local air-quality information made available, and a determination made as to how schools will respond to air-quality official advice. They should focus on the importance of school environments and equitable protection as well as on student education; in this review, operational thresholds were not provided as authoritative guidance was not accessed directly.

Recommendations for parents and communities

Schools should solicit family information and explain real-world limitations. Community activities can be based on credible information, safe travel and source prevention, rather than blamed on infrastructure or cost limited households (Saleem et al., 2019).

Priorities for future research

Priority studies involve controlled or quasi-experimental trials with delayed follow-up, grade, subject and school-sector specific teacher knowledge, teacher PROs needs, observation of teacher-led classroom delivery and adherence to school protocols, exposure and indoor-air monitoring tied to pupil health and attendance, and evaluations of language, socioeconomic and rural–urban accessibility. Outcomes must distinguish knowledge, attitude, intention, observed behaviour, exposure and health, and not combine scores into the same outcome which may mask success or failure of the intervention (Fernandes et al., 2023; Truppel et al., 2025).

Limitations of the Review

This review focuses on 2016-2025 instead of the requested one (2010 to 2015 and 2026) and a limited number of searchable databases (PubMed, OpenAlex and Semantic Scholar). Only 50 documents were cited which are most relative and available as open access. There is no official school-health threshold is given because current WHO, UNICEF, Pakistani government, curriculum and environmental-protection documents were not included. Of the evidence retrieved from Pakistan, most are from Punjab and urban areas, and many research focus on general populations or topics off the topic of school pupils. There is variance in designs and measures and they are not directly comparable. There were many records that were unavailable except as abstracts, and this made it difficult to assess instruments and implementation. The selection of the stories does not constitute systematic review completeness or pooled effects or causal estimates. The review is a fresh window synthesis, not a conclusive national evidence map.

Conclusion

To bring smog science into the classroom, teachers need to be well-prepared, have curriculum time available, and have reliable information and institutional support. Although there is some evidence

that can be related to the Pakistan context in relation to pollution and wider environmental-education capacity issues, the literature retrieved here does not provide much direct evidence of teacher-led smog education for primary- and secondary-school children. The age-tailored, participatory approaches are supported by findings from international school studies which indicate that knowledge gains, intentions and that of durable behaviour are each distinct outcomes. Realistic Pakistan response should involve teacher preparedness to explain pollutants and exposure, interpret alerts, conduct inquiry and communicate proportionate protective action; school should have response and continuity plans; authorities should tackle ambient sources and unequal protection. Teacher training, then, is an integral component of the smog preparedness but it should not replace the implementation of clean air policies or school-level exposure control or existing official public health advice.

Author Contributions

Author 1: Conceptualization, literature search, article selection, data extraction, synthesis of findings, and original manuscript drafting.

Author 2: Literature search, screening of relevant articles, critical evaluation of the literature, data extraction, and manuscript writing.

Author 3: Interpretation and synthesis of findings, thematic organization, preparation of tables and figures, and critical revision of the manuscript.

Author 4: Supervision, conceptual guidance, critical review and editing, and final approval of the manuscript.

All authors contributed to the development of the manuscript, reviewed the final version, and approved it for submission.

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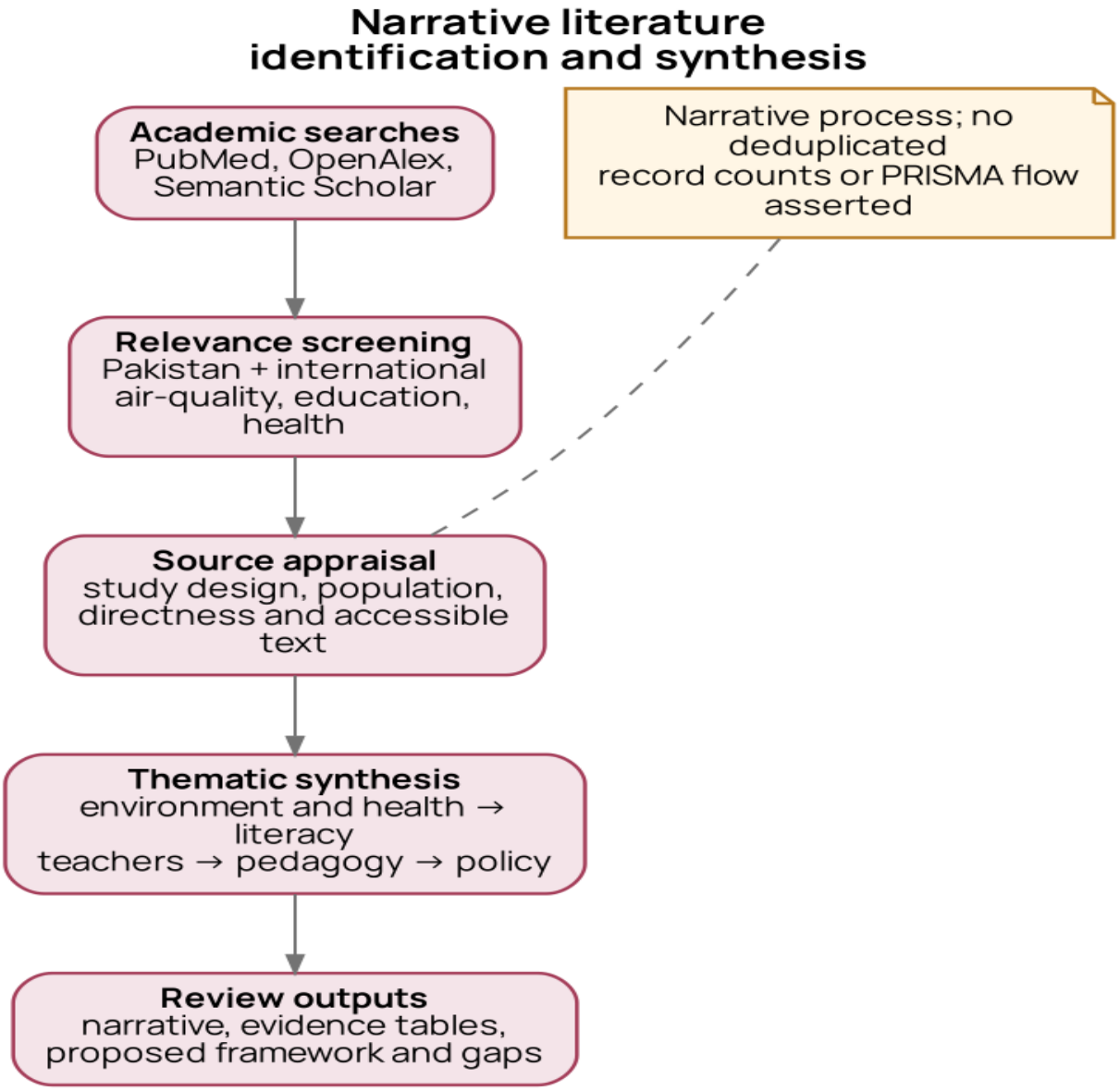


Figure 2. Narrative literature identification and synthesis process. The diagram intentionally reports stages rather than record counts because no systematic deduplication and screening log was created.

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