Original Article

Exploring Key Stakeholders' Perceptions of Air Quality and its Effects on Children in School Environments in Kigali, Rwanda: A qualitative study

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Abstract

Bacground
There is limited knowledge about educational stakeholders' perceptions of air quality in school environments and its effects on schoolchildren. This study explored various perspectives of educational stakeholders, including their perceptions of air quality in school settings, the perceived effects, and the current strategies employed to enhance air quality in schools.

Methods
This study was conducted with a qualitative approach. The researchers conducted a total of 16 in-depth interviews with schools and staff of the city of Kigali. The collected data were analyzed using thematic analysis.

Results
Participants perceive the morning and evening as the most polluted period of the day. Overcrowding, poor quality of chalk, and inadequate ventilation are perceived as the primary contributors to poor air quality within school premises. The perceived adverse effects include respiratory problems, increased absenteeism, poor school performance and school dropout. Additionally, the unavailability of well-defined air quality standards was highlighted as a barrier to achieving optimal air quality in school environments.

Conclusion
This study has revealed that most educational stakeholders perceive air pollution as a significant environmental problem that adversely affects the health and comfort of schoolchildren. The study advocates for the promotion of collaborative efforts across various disciplines to formulate and implement strategies aiming at improving air quality in schools.

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Introduction

Air pollution is a global challenge to the environment and health [1], and it refers to the presence of air pollutants in the atmosphere in quantities that are beyond acceptable limits.[2] These pollutants are harmful to human health.[3] High concentrations of air pollutants have a detrimental impact on the air quality that individuals inhale. The World Health Organization (WHO) indicates that the acceptable limits for Particulate Matter($PM_{2.5}$ and PM_{10}) are 15 µg/m³ for $PM_{2.5}$ and 45 µg/m³ for PM_{10} over a 24-hour period, while the annual average limits are 5 µg/m³ for PM2.5 and 15 µg/m³ for PM_{10}. [4] According to the WHO, 99% of the world's population breathes air that does not meet the WHO limits,[5] exposing millions of people, including vulnerable groups such as school children and those with pre-existing health conditions, to serious health risks.[6,7] Exposure to air pollutants, particularly respirable particles such as particulate matter ($PM_{2.5}$) and (PM_{10}), can cause a variety of health problems, from minor respiratory tract infections [8,9] to chronic conditions such as asthma, chronic obstructive pulmonary disease, lung cancer, and reduced lung function.[10,11] Furthermore, exposure to air pollution has been linked to millions of deaths worldwide. [1,12,13] It is reported that only in 2020, 3.2 million people died from exposure to indoor air pollution, and 237,000 deaths were of children under five years.[14]

Good air quality in school environments is crucial for the health of school communities, particularly school children, as they spend considerable time indoors, and their vulnerability is higher than that of adults.[11,14,15] Unfortunately, indoor air quality in schools has been deteriorating .[17–19] A study in Pakistan reveals mean concentrations of PM_{10} at 1433.04 µg/m3 and $PM_{2.5}$ at 153.8 µg/m³ in schools in Lahore.[20] Similarly, a study in German schools found PM10 values ranging from 16 µg/m3 to 33 µg/m3 and $PM_{2.5}$ values ranging from 3.7 µg/m³ to 81 µg/m³ .[21] Another study in Italy reported high levels of $PM_{2.5}$ and PM_{10} ranging from 10.7 µg/m³ to 59.2 µg/m³ for indoor $PM_{2.5}$ and 40.9 µg/m³ to 282.3 µg/m³ for indoor PM_{10}, and these values exceed WHO guidelines.[22] Poor indoor air quality has been linked to adverse effects on children's health, comfort, attendance, and academic performance .[23–25] Scholars reported factors affecting indoor air quality in school environments, including emissions from outside, overcrowding, poor ventilation, chalk dust, and unpaved playgrounds, among others. [26–28] Therefore, controlling indoor air pollution in schools by addressing different aspects, including perceptions towards the quality of air in schools, is essential to promote a healthy and conducive learning environment.

When various stakeholders, including educational key partners, have positive perceptions of air quality in schools and are aware of the detrimental effects of poor air quality on children, they can play a crucial role in promoting appropriate remedial actions.[29] Studies have assessed school air quality, and they primarily focused on levels of concentrations of different air pollutants such as particulate matter [30–34] and associated factors such as the location of the school, the construction materials used, the age of the building, and the ventilation system.[7,15,22,35–37] However, perceptions about air quality and its associated adverse health impacts remain understudied, while it is a crucial element in reducing the risk.[29] The theoretical framework of risk perception illustrates that for people to reduce the risk, they must have knowledge of the issue, knowledge about the cause and the effects, experience, and knowledge about the response to reduce the risk.[13, 38]

There is limited knowledge about the people's perception of air pollution in school environments in Kigali. It is reported in the existing body of literature that perspectives such as risk perception and multi-disciplinary collaboration can effectively determine protective actions,

preparedness, and positive behaviors to respond to hazards.[24, 25] However, the available information on air quality in Kigali indicates that the perception of air pollution has been largely overlooked.[39–41] Given the lack of in-depth knowledge regarding the perception of educational stakeholders on air pollution in school environments and its effects on children, this gap underscores the need for this research. The study was carried out to explore the perceptions of various educational stakeholders on air pollution in primary school settings in Kigali, perceived effects on children, and the existing practices, specifically institutional measures, to improve air quality and promote the health of school communities.

Materials and Methods

Study design

An exploratory qualitative design was used. Data were collected once from key study participants. A qualitative approach using in-depth interviews was employed to understand the perceptions of key educational stakeholders towards air quality in school environments and its adverse effects on school children. Patterns and disparities in indoor particulate matter levels in selected primary schools in Kigali, Rwanda. Manuscript submitted for publication, Journal of Heliyon , it was found that the levels of particulate matter ($PM_{2.5}$ and PM_{10}) in schools exceed WHO limits. The decision to adopt a qualitative approach was influenced by multiple factors, including quantitative data gathered before as the study wanted to figure out how the educational stakeholders perceive air pollution in schools and its effects, insights from other quantitative research, the theoretical framework for risk perception, and the multi-disciplinary collaboration model, stating that addressing complex problems requires a collaborative approach involving different specialists.[42–44]

Study setting

The study was carried out in Kigali, the capital of Rwanda. Although declared the cleanest city in Africa, it is not immune to air pollution resulting from rapid industrialization, an increase in automobiles (including fossil fuel powered motorcycles), urbanization, and agricultural activities. The three districts of the city were represented in the study population. This study was conducted in six (6) selected public primary schools in three districts of the City of Kigali (CoK\), Rwanda.

Selection of participants

Schools were selected based on their locations. Three schools were selected as they are located in highly exposed areas within (500 m to 1km) of major roads with high traffic, garages, petrol stations, bus stations, and other notable sources of pollution like construction activities, among others.[45] The other three schools are situated in suburban areas (Moderately exposed areas). The selection of schools was made in close collaboration with the directorate of education in the city of Kigali.

This study targeted two participants from each school and were selected purposively. Their selection was based on responsibilities such as being school administrators and representatives of teachers. The selection of other stakeholders at the Kigali city level was based on their participation in school building, schoolchildren's health, and education, such as school building engineer, director of education, director of health, and director of environment. Therefore, sixteen participants were recruited as the initial sample size, including eleven from selected schools and five from the city of Kigali. The selection of these study participants was based on their ability to help us achieve the study objective. The selection of participants from different settings to include a variety of perspectives and experiences relevant to the studied phenomena enhanced the transferability of the current study.

Data collection process

A semi-structured interview guide with open questions was used to facilitate discussions about the themes. The interview guide underwent development and validation prior to its use.

Experts in the field of air pollution have validated the tool. The key informants were two from each school, including the school administrator and another educator (representative of teachers). However, at one school, only one participant was involved in the study. The interviews focused on participants' perceptions of the term' air pollution', the most polluted period of the day and the year, the causes of air pollution, the effects of air pollution on children, and what can be done to reduce air pollution in classrooms. Key informant interviews lasted 30 minutes and took place in semi-private locations chosen by the participants at their workplace. The researchers continuously assessed whether new data provided additional insights or whether the same topics were repeated.

Before collecting the data, a workshop was conducted to give the data collectors a common understanding of the questions and interview techniques. The data collectors worked in pairs, and one of them conducted the interviews while the other took notes and recorded the discussion. The interviews were conducted in Kinyarwanda. To prevent missing information and to ensure the accuracy of the information, interviews were first transcribed into the local language (Kinyarwanda) and then translated into English. For the purpose of maintaining consistency in transcription, one translator was engaged. Likewise, to minimize issues related to the language and other technical terms specific to the field, bilingual researchers who are familiar with the context of air pollution and health were involved.

Data analysis

The data from the interviews were analyzed thematically, which helped researchers to understand experiences, thoughts, or behaviour across a data set. Thematic analysis helps identify, interpret, and report repeated patterns.[46, 47]The researcher employed an inductive approach to identify themes, patterns, and categories emerging from the data.[46]

The researcher read and re-read the transcripts and field notes, which allowed the researcher to identify important themes related to indoor air pollution in school settings. The main themes identified were perceptions of air pollution, perceptions of the effects of air pollution on children's health, and current institutional arrangements that can help reduce school air pollution.

To identify, enhance, and authenticate themes, the researcher adhered to a procedure that encompassed several key steps. Initially, the process involved data familiarization, where the researcher engaged in reading, reviewing, and organizing the data. Subsequently, during the phase of initial coding, the researcher performed actions such as data segmentation, identification of pertinent information, and code assignment. Moving forward, theme development took place, during which the researcher examined the coded data, formulated potential patterns, named each theme, and ensured the coherence of themes. Following this, there was a stage of theme review and naming, where the researcher assessed the coverage of themes, checked for overlaps, and sought feedback from the field. Finally, validation was conducted, where the researcher deliberated on the developed themes with experts in the field of air pollution.

To increase the credibility of the study, the researchers organized peer-reporting sessions, which involved in-depth discussions of the results and interpretations of the study with experts in the field of air pollution.

Ethical considerations

Ethical clearance was sought prior to data collection. The Institutional Review Board of the Faculty of Medicine and Health Sciences of the University of Rwanda provided ethical approval (Notice No. 108/CMHS 110/2021). Additionally, the city management provided permission to collect data at the schools. Before starting interviews, the researchers provided a comprehensive explanation of the study

to clarify its purpose and the right to participate and withdraw from the study, as well as give assurance of confidentiality pertaining to the information shared. The transcripts do not contain identifiers, and the transcript and the social characteristics of the participants were recorded separately. Prior to the interviews, participants provided informed consent.

Results

Table 1.Characteristics of the participants and study sites

Variable	Numbers	Percentage
Age		
< 35 years	4	25.0
≥ 35 years	12	75.0
Sex		
Male	9	56.0
Female	7	44.0
Job category		
Educator	6	37.5
School administrator	5	31.2
The staff of the City	5	31.2
Education		
A2 level	6	37.5
Advanced Diploma	1	6.25
Bachelor's degree	6	37.5
Master's degree	3	18.7
Work experience		
< 5 years	1	6.25
5–10 years	5	31.2
> 10 years	10	62.5
Location of schools		
Schools in highly exposed areas	3	50.0
Schools in moderately exposed areas	3	50.0

This section presents the results related to the socio-demographic characteristics of the participants and study sites as well as the findings related to the three main identified themes, namely perception of air pollution, the negative impact of air pollution on school children's health, and current institutional arrangements to reduce school air pollution. Quotes from key informants are used to reinforce the findings.

The table illustrates that 56% of respondents are male. The majority (37.5%) have attained an A2 level or bachelor's degree as their highest level of education, while over 60% possess more than 10 years of professional experience.

The study identified three main themes, and each theme has subthemes. Those three main themes are (1) the perception of air pollution in schools, (2) the perceived health effects associated with exposure to air pollution, and (3) the institutional arrangements in place to mitigate air pollution within the school environment.

Perceptions towards air pollution

This main theme emerged from the following subthemes: How participants perceive air pollution, the most polluted period of the day, the most polluted period of the year, and the leading causes of air pollution.

Perceived air pollution

Participants had a comparable comprehension of air pollution. The vast majority of participants acknowledged that the term 'air pollution' refers to the introduction of substances into the atmosphere that are not normally present. This contamination changes the quality of air that people breathe, as we all depend on clean air.

> *"Air pollution occurs when harmful gases are released into the air, making it unsafe for humans to breathe". "I believe air pollution occurs when industries or vehicles release harmful fumes into the air, degrading the quality of the air we breathe".* (R1/School3)

> *"Air pollution results from various human activities, including vehicle emissions, residential burning, and potentially construction work."* (R2/CoK)

Perception about the most polluted period of the day

The majority of participants perceive that the rush hour in the morning is the most polluted time as it coincides with people commuting to work and increased vehicular traffic. The other period was found to be the evening hours to be the most polluted due to various activities, such as cooking and burning wood, occurring during this time. Some participants even suggested that the air is more polluted at night due to the presence of large trucks and people starting work very early in the morning. However, most participants agreed that the air is most polluted during the day, particularly during working hours. They mentioned increased human activity during the day, such as industrial work, transportation, and smoking, as significant contributors to air pollution.

"The air is most polluted during the morning and evening when traffic is high on our roads. The emissions from those vehicles and motorcycles contaminate the air we breathe. In addition, in the evening hours, people start cooking in their residential areas, and they generate much smoke, which is not good for the air." (R1/School2)

"In my opinion, the air is the most polluted period of the day starting from 10:00 a.m. onward, as this is when human activities start to pick up, including industrial work, burning, and vehicles emitting fumes on the roads. Those emissions from such human activities may contain some pollutants that may contaminate our air. " (R2/CoK)

Perception about the most polluted period of the year

Most participants believe that the air is most polluted during the dry season or summer. They explained that the combination of dry ground and light air makes it easy for the wind to raise dust particles that carry various pollutants. Additionally, activities related to food production and crop processing, which release pollutants, increase during this time. Furthermore, farmers in agricultural areas burn grass and other materials, adding to the already high levels of pollution. In general, the participants showed a good understanding of the factors that contribute to air pollution during the summer and recognized the negative impact of air pollution on human health and the environment.

"Air pollution exacerbates during the dry season than during the rainy season because the air is light, and air pollutants from various sources can spread more easily in the atmosphere during the dry season". (R1/School3)

"Most pollutants like dust are raised by moving cars, which results in the dust covering homes in the neighbourhood. This is not the case during the rainy season when the rain prevents dust from rising and during the dry season some human activities such as agricultural burning and construction become many than during the rainy season" (R3/CoK).

The causes of air pollution in Schools

The participants mentioned the different causes of air pollution, including emissions from human activities and poor waste management, as significant contributors to air pollution. Participants indicated that the primary causes of air pollution are the rapid increase in economic development activities, specifically the exponential increase in the number of industries and vehicles that emit fumes containing chemicals that affect air quality, especially in Kigali. Participants associated the most air pollution with peak hours when people travel to work, as the high number of cars and motorcycles on the road generates fumes.

"I believe that some of the causes of air pollution are a result of our development, such as industries that emit fumes into the atmosphere. The vehicles we use for transportation and the fumes generated by their engines also pollute the atmosphere. There may be some hidden chemical products, but they mix in the air and contribute to its pollution." (R2/School5)

"Look, there is this rapid development of industries here in our city. Although there is an industrial zone according to the master plan, I think those air pollutants have no boundaries. They can move anywhere and pollute our air" (R4/CoK)

Additionally, participants pointed out that burning forests, plastic, paper, clothes, or domestic waste significantly deteriorate air quality. Furthermore, burning grass to generate fresh grass for livestock, burning charcoal, using wood for cooking, and poor waste management in landfills contribute to air pollution.

"Let us take an example of cutting trees that contributed to air purification. Without trees, there is no natural filtration of air pollutants. This results in air pollution. All that changes affect the quality of air in all settings, not only the school environment". (R1/school4)

Violating building codes and destroying vegetation were also mentioned as a cause of air pollution. Although the city has a master plan, some people do not respect it, especially when building their houses. Some houses are built in a disorganized way without leaving space for gardens or trees. Since trees purify the air, when they are destroyed or cut for cooking, burning charcoal, or construction work, air pollution can increase.

"Disrespect for building regulations and the destruction of vegetation contributes to air pollution. Despite the city's plans, some buildings did not take into account green spaces. Trees, which are vital to the purification of air, are lost by cooking, burning coal and construction, aggravating air pollution" (R3/CoK)

Participants indicated particular factors that are associated with air pollution in school environments. They highlighted some activities and other elements like burning different items near schools or smoking in school neighbourhoods, overcrowding, poor ventilation, poor-quality chalk, running or dancing in classrooms, and the absence of gardens and trees, as well as kitchens used for school feeding programs.

"There are schools located near busy roads, bus stations and garages. Fumes from these cars that move around can contribute to air pollution and invade school environments. In addition, smoke from some school neighbourhoods when people cook, the smoke from there may enter the learning environment and affect the quality of air here in school". (R2/school3)

Participants stated that other elements, such as overcrowding and poor ventilation, negatively affect the quality of air in the school environment. It was stated that a classroom with 90 schoolchildren differs from one with 25 pupils. It worsens when confined to a smaller room with small windows, especially when they come from a break, perspiring and breathing deeply, and thus, exhaling a lot of carbon dioxide. The participants highlighted that teaching in a closed environment is not good as it does not allow for proper air circulation, which pollutes indoor air and forces people to breathe polluted air.

"Overcrowding also spoils children's breathing because a classroom with 90 or 70 children is different from one with 25 in terms of the air they breathe. The number of children in a classroom and the size of the classroom also play a role in children's respiration. Windows should be large enough and open to facilitate air movement on the premises".(R1/School1)

"In some classes, there is a big number of children; even though we have two shifts, the number is still big compared to the size of the classrooms" (R1/School 5)

The quality of chalk used to write on blackboards was also underlined by participants as another reason for air pollution in school environments. They mentioned that the poor quality of chalk generates dust that contributes to indoor air quality on school premises and significantly affects children who sit in the front.

All teachers raised the problem of chalk quality, and representatives of teachers and one participant from Kigali city also raised the issue of the lack of dust-free chalk.

> *"These chalks that we are using are problematic to the health of the school community! Those chalks are not good. They generate much dust. Even teachers are uncomfortable, let alone children. We decided to buy our chalk of good quality".* (R2/School2)

> *"The chalks we use are of poor quality and produce much dust, which can cause health problems"* (R2/school3)

Playing in the classroom affects the quality of air that children breathe. Participants stated that air pollution worsens when children run and dance in classrooms or sweep the floor because it creates dust, which does not easily leave due to the size of the windows and the number of students. This dust contains many particles that are harmful to the health of school children. Participants also stated that some school grounds do not have pavements, gardens, or trees. When it is windy, or the pupils play during break time, much dust is generated, which can enter the classrooms and stay there if there is poor ventilation. Sweeping also raises dust that contains particles.

> *"They can also play inside the classroom when the teacher is distracted. When they play inside, if the classroom is narrow and the windows are not big enough, the air will be polluted. When they sweep the floor that is not cemented, the rising dust can pollute the indoor air that children breathe".*(R2/School3)

Perception about the adverse effects associated with exposure to air pollution

Human activities negatively impact the quality of air, and polluted air negatively impacts children's health. The two main subthemes are air pollution causing various diseases, especially diseases affecting the respiratory system, and air pollution negatively affecting school performance.

Air pollution causes various diseases

Most of the participants revealed that polluted air could cause respiratory diseases such as asthma, rhinitis, tuberculosis, sinusitis, flu, and bronchitis, as well as impaired brain development and function. This is because children's lungs are not yet fully developed, and their immune systems are still immature. This is why children are more affected by air pollution, even though air pollution also harms adults.

> *"First of all, the lungs of a child are not yet strong; that is why when they are breathing polluted air, they can develop respiratory diseases. When your respiratory system is not working properly, your body will suffer".*(R2/School4)

> *". I think that fine PM may access the nervous system and cause inflammation. I believe that, promoting a safe learning environment for a safe life in school settings is crucial."* (R2/CoK)

Air pollution adversely affects school performance and school absenteeism

The participants indicated other consequences of exposure to air pollution on school premises. They stated that exposure to air pollution could lead to school dropout among school children. In addition, they stated that all the diseases mentioned in the previous section could affect children's school performance. If the brain is not fully developed, it impinges on children's capacity to memorize, which influences their learning abilities. In addition, when children get sick, they miss classes because they have to be taken to health facilities or because they are fragile and unable to attend classes.

> *"This causes school absenteeism in both pupils and teachers, leading to poor results in class. Their school performance is affected due to these problems. Once these diseases become chronic, they can result in school dropout or delays in studies due to frequent illness, repeated school years, and loss of focus. Therefore, schoolchildren need a safe learning environment."* (R1/School4)

Current institutional arrangements to reduce air pollution in schools

This theme was divided into two subthemes, namely policies, plans, and guidelines on air pollution in schools and the participation of different stakeholders in school construction processes to improve indoor air quality.

Policies, plans, and guidelines on school air pollution are needed

Policies and guidelines on air quality in schools are necessary. The question about guidelines and policies for air pollution in the school environment was asked only to staff from the City of Kigali who participated in the study. The responses were contradictory: Some said there are no policies or guidelines, and others said there are. Some participants said that there are guidelines and policies indicating, for example, where schools should be located, the distance between buildings, the distance between classrooms and other activities, the size and number of windows, and the distance between toilets and classrooms. They also said that instructions are given daily about planting trees and preparing gardens, but they could not confirm that these are official guidelines. The interviews revealed that there are no clear policies or guidelines on indoor air pollution. However, participants recognized that there should be policies and guidelines.

"I cannot confirm that the guidelines are there because I do not have them in my hands, but the policies are there. What I am not sure of is that there are written guidelines". (R4/CoK)

"Policies and guidelines are not there, but they should be there. They are crucial to improve air quality in school settings as they will indicate what people should do and how to do it to protect our children in the school environment" (R3/CoK).

In fact, there are no guidelines for clean air in our schools. If it is possible, it would be better if we could send it to the schools so that we can protect the health of children and teachers in our schools. Because when they are affected by polluted air, it hurts us and impacts the country's economy in general and specifically the families of those children "(R2/CoK)

Stakeholder participation in school construction processes to improve air quality

Working with a multi-disciplinary team is key to determining the most appropriate solutions to indoor air pollution in schools. The interviews revealed that only engineers are fully involved in school construction processes. Participants also indicated that other people involved are government authorities who provide the authorization documents for building schools. However, the role of other stakeholders, such as public health and education officers, was not mentioned in the interviews. Their role seems minimal during both the planning and implementation phases.

"Engineers, of course, because if you plan to construct in a certain place, engineers are the ones who will make the design and who will follow up the work because they are knowledgeable about building matters. No role. The only role they can play is to say that there is a need to build a school". (R2/CoK)

"If that collaboration happened, it would be better because possible consequences on children's health would be identified ahead of time".(R5/Cok)

Participants also revealed the role of parents and school children in improving air quality in schools. A multi-disciplinary approach to air quality in school settings and other aspects should be emphasized to create a healthy school environment.

Discussion

The findings of this study revealed that participants have a positive perception towards air pollution in schools, including their awareness of potential sources of pollution within the school premises and their understanding of its adverse effects on children.

The findings indicated the unavailability of air quality guidelines or policies to guide the practices related to the improvement of the quality of air in the school environment. There is also an issue of undefined collaboration among different educational stakeholders when it comes to school building.

The present study's findings indicated that the participants perceive air pollution as when air consists of harmful substances. These findings are consistent with the results of other studies that assessed public awareness perception of air pollution in different settings. In those studies, the participants were aware of air pollution as air consists of excessively harmful substances that negatively impact humans and other living beings.[48, 49] It is also consistent with the results of a study conducted to assess what the public thinks about the problem of air pollution, which indicates that people think of air pollution as a high concentration of pollutants in the atmosphere.[50] This is also supported by the real definitions given by the Respiratory Health Association and the WHO, which define air pollution as contamination or modification of the natural characteristics of the atmosphere by physical, chemical, or biological agents.[51]

Pollution concentration changes throughout the day, and daytime is the most polluted time. The current study's findings indicated controversial ideas about the most polluted period of the day. Some participants said that the morning hours are the most polluted, while others indicated the evening and night hours. However, most of the participants stated that the air is most polluted during the day (working hours). The findings are not in line with the findings of other studies that indicate that the most polluted period of the day is the morning (8–10 a.m.) and evening hours, as during these hours, there are high traffic emissions as people move to and from work.[52]

Furthermore, during the evening hours, the increase in air pollution can be related to emissions from burning activities. However, other studies reveal that the most polluted period of the day can vary from region to region.[53] For example, literature shows that pollution is high during the day and night in Central Asia, in North America, pollution is high during the morning and evening hours, and in Europe, it increases during the night.[53] In China (Beijing), high level of air pollution is observed in the morning and evening hours due to busy roads and factory activities.[54] The perception that air pollution is high during the day might be associated with many factors and can differ from country to country or continent to continent.

The participants in the current study argued that the air is more polluted during the dry season. These results are supported by the findings of another study conducted in Rwanda that indicates that the concentrations of $PM_{2.5}$ during the dry season are twice as high as those in the wet season.[52] These findings differ from those of another study conducted in China in which public opinion was that the most polluted period occurs in winter.[55] This could be linked to different reasons, such as during winter, some countries experience cold that leads to increased use of different types of energy, including fossil fuels and gas, to keep their homes warm. The idea that there is increased air pollution in Rwanda during the dry season could be linked to factors such as many agricultural productions and burning happening in that period, dust being raised by moving cars and wind, and construction work taking place.

Some scholars documented the contribution of these factors to the high concentration of air pollutants in the atmosphere.[56,57] There is no globally common period of the year with more air pollution, and it differs depending on the region, country, and particular conditions.[27] Knowledge about air pollution, the time of the day the air is most polluted, and the most polluted period of the year has practical and policy implications since it may influence actions and alleviating strategies to reduce exposure

to air pollutants in schools and promote the health and well-being of school communities in school environments.

Several factors affect air quality in school settings. Those include weather conditions, the characteristics of the schools, building materials, and location, play significant roles in determining the quality of air.[58–60] The findings of this study indicated that people perceive overcrowding, poor classroom ventilation, playing in the classroom, and chalk quality as other factors affecting air quality in schools. These results are supported by the findings of other studies conducted in different parts of the world, which illustrated that crowded classrooms affect the concentration of air pollutants on school premises.[61,62] The quality of chalk was also highlighted as a factor that influences the concentration of particles inside the classroom. This is in line with literature that reveals a direct link between air quality in schools and chalk dust.[63]
Children in schools are likely to experience adverse health effects due to exposure to poor-quality air in school environments. Participants in the current study perceive some negative health effects that can result from exposure to air pollutants in schools. These include respiratory diseases such as asthma, rhinitis, tuberculosis, sinusitis, flu, and bronchitis. These findings are consistent with other studies that reveal that exposure to air pollution leads to poor health outcomes among different people, including children.[64–67] The literature shows that $PM_{2.5}$ can penetrate the respiratory system and cause adverse effects such as lung cancer and asthma.[60, 68, 69]

Furthermore, the literature shows a relationship between indoor exposure to PM2.5 and PM10 on school premises and poor health outcomes.[30,65,69–72] Angelica Tiotiu et al., indicate that exposure to air pollutants is a key factor that accelerates asthma among different groups of people, including school children,and the situation worsens for those with existing health conditions.[73, 74]

Exposure to air pollutants can cause liver, kidney, and heart diseases. Participants in the present study perceive that those chronically exposed to air pollutants might experience other diseases, especially liver, kidney, and cardiovascular problems. These findings align with the findings of other studies that assessed public awareness and perception of air pollution. Findings of such studies indicated that people perceive that exposure to air pollution results in various adverse health effects, including shortness of breath, among others.[49,75] Other scholars point out the strong association between exposure to air pollution, specifically PM, and poor health outcomes. [76–82] It is not only health problems that people, including school children, may experience; there is also a perception that exposure to air pollution among children may lead to reduced academic performance.

This study showed that participants perceive that diseases associated with exposure to air pollution affect both children and teachers since their absence during learning and teaching hours, resulting in poor performance in schools. This finding aligns with Wargocki et al., 's findings that reducing the concentration of CO_2 by 300 ppm can increase the performance of students and that a reduction of 3000 ppm of CO_2 can increase school attendance by 2.5% .[83] On the other hand, another study conducted by Wargocki et al., shows that poor air quality in schools might reduce pupils' performance by 15–30%.[84–86] Furthermore, different scholars documented that poor air quality in schools and other indoor conditions in schools negatively affect learning activities. [87,88] All these study findings support the perceptions found in the current study. Considering these scientific views, specific policies and guidelines are needed to manage school air quality.

The findings of the present study were contradictory in this regard to the existence of police and guidelines towards the management of air quality in schools. However, considering what the participants revealed, schools lack policies or guidelines

for air quality management in school environments. These findings are consistent with the current national school health minimum package policy and its strategic plan. These documents do not mention the issue of air quality in schools.[89,90] A study conducted in the USA on school health policies and practices pointed out how in the USA, local authorities support policies and tools to monitor air quality in schools.[91] The findings of that study illustrate that 57.1% of districts requested that schools conduct regular inspections of the ventilation systems and characteristics of schools. The same study indicated that 36.3% of districts in the USA adopted policies that require schools to purchase low-emission products for use in school settings.[58] Therefore, in our context, school air quality policies are needed to benefit students, teachers, and management.[92] The development of such policies and the success of their implementation requires an interdisciplinary collaboration approach.

This study indicated that only people with engineering skills are involved in the school-building process, and this shows a lack of multi-disciplinary collaboration. This is similar to the findings of other scholars that in the building process, each discipline focuses on its own aspect.[93] Furthermore, the current study's findings contradict the school health package's recommendations, which call for multi-sectoral collaboration to set relevant, achievable, and sustainable targets for water, sanitation, and hygiene.[89] Therefore, a multi-disciplinary team is critical to promoting a healthy school environment. The literature shows that multi-disciplinary collaboration on air quality contributes positively to increased awareness, capacity building, and changes in organizational policies and practices.[94] The lack of collaboration in the current practices, including management of air quality in schools, could be attributed to the fact that it is a new approach and that people are used to working in silos.

The findings of this study have a positive implication for air quality in the school environment. The positive perception towards air pollution in school settings might be an opportunity to prioritize the health and well-being of the school communities as it might be a chance to initiate protective actions. Moreover, the gap identified in the absence of policies and guidelines towards air quality in school, as well lack of multidiscipline collaboration among different educational stakeholders, could be seen as a chance to break down working in silos and foster greater teamwork collaboration of different disciplines and appreciate the expertise that each profession brings on the table to address issues of air quality from different perspectives and make schools a healthy environment.

Limitations

This study was limited by its nature of being purely qualitative.

Conclusions

This study assessed educational stakeholders' perceptions of air quality in school environments and its effects on children. The study also assessed the institutional arrangements in place to make schools a healthy environment. The findings revealed that most educators and educational stakeholders perceive air pollution as a serious environmental problem that adversely affects the health, comfort, and academic performance of school children. Consequently, preventive measures should be taken to mitigate these risks. They perceive challenges such as poor-quality chalk, the absence of specific policies, plans, and guidelines for air quality, and limited multi-disciplinary collaboration as factors that hinder good air quality in schools. Their perception towards air pollution in schools and its effects may influence the remedial actions and policy development to guide the practices related to the improvement of air quality in school settings.

However, such perceptions of adverse effects associated with exposure to high levels of air pollutants in schools may also lead to stress, specifically among teachers who are exposed to that environment daily.

The study recommends the integration of school air quality management into the existing minimum school health package, replacing chalkboards with marker boards. Again, the study recommends enhancing collaboration among various stakeholders during the school-building process. Additionally, we advocate for specific policies and guidelines tailored towards managing air quality within school environments.

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Conflict of interest

All authors declare no competing interests.

Authors' contributions

NK wrote the proposal, collected data, and wrote the first draft of the manuscript. TN, JM, and AG provided critical input and editing. JH, AU, and UAM worked on the literature search and provided input.

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