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Advancing indoor environmental quality in African countries: A call to action for awareness, research, and policy

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A B S T R A C T

Indoor Environmental Quality (IEQ), including indoor air quality (IAQ), thermal comfort, lighting, and noise, is a critical determinant of health, well-being, and productivity. However, African countries remain underrepresented in IEQ research, policy, and advocacy, despite facing unique challenges such as energy poverty, reliance on biomass fuels, inadequate building practices, poor ventilation, overheating, inadequate lighting, and pervasive noise pollution. These conditions increase health risks and compromise learning, working, and living environments.

This paper highlights the urgent need for a comprehensive approach to IEQ in Africa, addressing not only indoor air pollution but also thermal discomfort from rising temperatures, insufficient indoor lighting, and chronic exposure to harmful noise levels. It introduces the "Promoting IEQ and IAQ in Africa" initiative launched by the International Society of Indoor Air Quality and Climate (ISIAQ), which aims to foster research collaboration, raise awareness, support context-specific solutions, and influence policy development tailored to Africa's diverse climates and socio-economic realities. By aligning with the United Nations Sustainable Development Goals (SDGs), this initiative advocates healthier and more sustainable indoor environments across the continent. This paper serves as a call to action for researchers, policymakers, and practitioners to work together to advance IEQ research, innovation, and advocacy for African communities.

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1. Introduction

Human exposure to suboptimal indoor environmental conditions, such as poor air quality, inadequate lighting, noise, and thermal discomfort, remains a critical issue of public health concern. This is becoming increasingly evident in emerging cities across Africa. Indoor environmental quality (IEQ) is critical for reaching Sustainable Development Goals (SDG) of the United Nation (UN), particularly SDG 3 which aims to ensure "Good Health and Well-Being," with a specific focus on Target 3.9, which calls for the reduction of illness and death caused by hazardous chemicals and pollutants. Good indoor environment is intertwined also with several other SDGs such as 5: Gender Equality, 7: Affordable and Clean Energy, 11: Sustainable cities and communities, 13: Climate Action, 15: Life on Land, so the efforts to improve IEQ have a potential to widely affect human wellbeing and health.

Adverse environmental conditions within indoor spaces may negatively impact on the health of occupants [35,34]. This issue is one of the main reasons why the United Nations Environmental Programme (UNEP) declared clean air a fundamental human right [40]. In addition, some indoor environmental quality (IEQ) specialists recently proposed mandating indoor air quality (IAQ) standards for public buildings to improve health and productivity [9,22]. While the significance of IEQ is widely acknowledged in many parts of the world, research and advocacy on this topic remain underdeveloped in certain regions, particularly in Africa. Even though technologies and standards have been developed to improve IEQ, their applicability in African context should be investigated.

According to Agbo et al. [3], indoor air pollution research, monitoring infrastructure, and policy advocacy in Africa are fragmented and limited. Indoor pollution studies are fewer compared to those on ambient pollution, and many African countries lack air quality monitoring stations and national standards. In addition, there is a widespread reliance on firewood and biomass for cooking in poorly ventilated indoor environments, which exposes millions of people, especially women and children, to harmful pollutants such as fine particulate matter ($PM_{2.5}$), carbon monoxide (CO), and nitrogen dioxide (NO_2). Supporting this, Toyinbo et al. [36] show that most African countries still lack tailored IEQ standards that reflect regional needs and realities, despite rapid urbanization and increased time spent indoors in African cities.

All of these factors highlight the importance of promoting IEQ research and practical solutions that are sensitive to the unique challenges and climate conditions in Africa. Fig. 1 presents a conceptual framework illustrating how various contextual challenges in African settings influence IEQ, and by extension, affect health, learning, and productivity.

Africa comprises 54 internationally recognized countries with diverse climatic zones and different built environmental practices that can affect IEQ (Fig. 2). These zones range from the humid tropical climates of the Congo Basin in Central Africa and parts of West and East Africa, where high temperatures and heavy rainfall can lead to mold growth, thermal discomfort, and poor air quality, to the arid northern regions, characterized by extreme heat and dust storms that can compromise IAQ. The Mediterranean zones along the northern coast, with hot, dry summers and mild winters, and the savanna belts stretching across West, East, and Southern Africa, characterized by distinct wet and dry seasons, all present unique IEQ challenges such as ventilation inefficiencies and seasonal air quality fluctuations. In cooler highland regions, such as parts of East and Southern Africa, the lack of adequate heating and insulation can further exacerbate IEQ problems [29]. Beyond climate, factors such as energy poverty, reliance on biomass fuels, inadequate building practices that limit ventilation, overcrowding, and limited awareness of the risks of poor IEQ all contribute to the problem of poor IEQ [14]. These interconnected challenges amplify the impact on health and well-being, highlighting the need for tailored, sustainable solutions across the African continent.

2. Overheating: a growing concern in African buildings

Overheating is an increasingly critical challenge in the face of climate change in African buildings, including schools, where temperatures are already high, especially during hot seasons [39]. Rising temperatures, exacerbated by climate change, are expected to push indoor environments in schools, workplaces, and homes to unprecedented levels of discomfort, negatively impacting performance, productivity, and overall well-being [44]. The urgency of addressing overheating is further heightened by the increasing frequency of wildfires and smoke pollution [16], which could further degrade IAQ and pose additional health risks. Although countries in Africa face a variety of socio-economic challenges, small investments in IEQ solutions could make a significant difference. Unlike in many western countries where extensive research on IEQ has been carried out to identify the causes of poor IEQ and propose mitigation strategies, countries in Africa are still grappling with fundamental challenges such as limited infrastructure, inadequate funding, and a lack of comprehensive research on a local or regional scale [13]. Tackling these problems with innovative, locally adapted solutions will be crucial, requiring new thinking that is both sustainable and cost-effective.

The first study to investigate IEQ in Tanzanian schools was recently conducted, covering five schools and 15 classrooms [38,37]. Papyrus mats were suggested as an example of a cost-effective local strategy for classroom ceilings to mitigate against heat radiating from the roof and noise reduction during rainfall. Another intervention involved painting the roof white to help with overheating mitigation. However, the lack of funding, which is a major challenge in IEQ studies in developing countries, often limits the length of the study and the extent of intervention

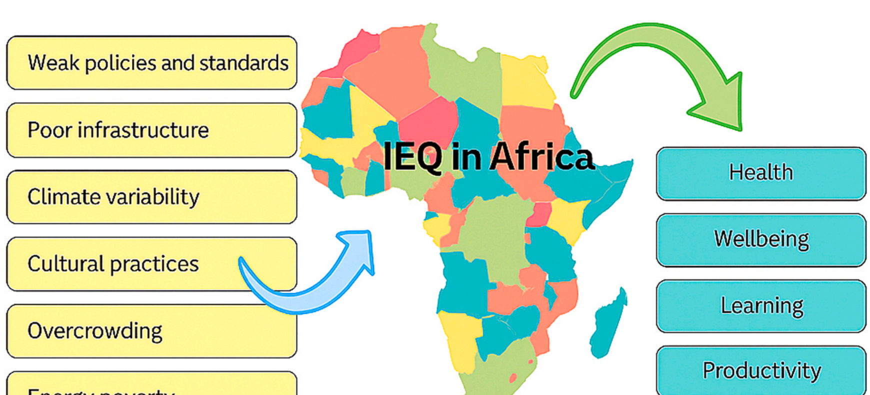

Fig. 1. Overview of key challenges impacting IEQ across diverse African countries contexts.

that can be implemented and assessed. It may be the case that favorable IEQ resulting from interventions could be scalable in other schools due to their cost-effectiveness and the use of locally sourced materials, offering a remarkable opportunity for young scholars and students to engage in meaningful research and interventions that yield high-impact results. Exploring affordable ways to manage heat in schools and e.g. enhancing hospital ventilation is imperative to reveal new, sustainable solutions to improve IEQ in these resource-constrained settings. Sustained exposure to high indoor temperatures can lead to heat stress, dehydration, fatigue, and reduced cognitive function. Children, pregnant women, and older adults are particularly vulnerable. Research has also shown that thermal discomfort indoors can reduce both learning and work performance [18,44].

3. Indoor air quality and ventilation challenges in Africa

Energy poverty is a critical driver of poor IEQ across the African continent. Limited access to clean, affordable energy restricts the adoption of modern technologies, such as heating, ventilation, and air conditioning (HVAC) systems. This forces reliance on natural ventilation and traditional energy sources, such as biomass fuel, for daily activities such as cooking, which can be a source of harmful emissions [29]. Ventilation rates and thermal conditions in a naturally ventilated building with window and door openings depend heavily on outdoor wind speeds and thermal conditions. Simply opening windows and doors without air filtration can introduce outdoor pollutants, such as dust, vehicle exhaust, and industrial emissions, into the indoor environment, especially in highly polluted areas [12]. Warm, unconditioned air introduced indoors through natural ventilation can also affect thermal conditions indoors [39].

The use of biomass fuels is not only a result of energy poverty but may also be deeply rooted in cultural practices. In many communities, cooking over an open fire or using charcoal is a traditional and familiar method [5]. These cultural norms often outweigh the adoption of cleaner cooking technologies, even when available. However, the combustion of biomass fuels releases harmful air pollutants, such as particulate matter (PM) and carbon monoxide (CO), which contribute to indoor air pollution and adverse health effects [29].

Urbanization further compounds IEQ challenges. The migration of people from rural to urban areas in search of economic opportunities has led to overcrowding in many African cities, particularly in informal settlements [29]. These areas often lack adequate infrastructure, such as proper ventilation or access to clean energy. Overcrowded indoor environments amplify exposure to air pollutants, while outdoor air pollution in urban areas from vehicles, industries, and construction infiltrates homes, further worsening IAQ.

A complex relationship exists between features of poor-quality housing and poor IAQ [11]. Weak enforcement of housing standards in Africa exacerbates the problem of IEQ. This is evident in the use of low-quality building materials, poor maintenance culture, improper

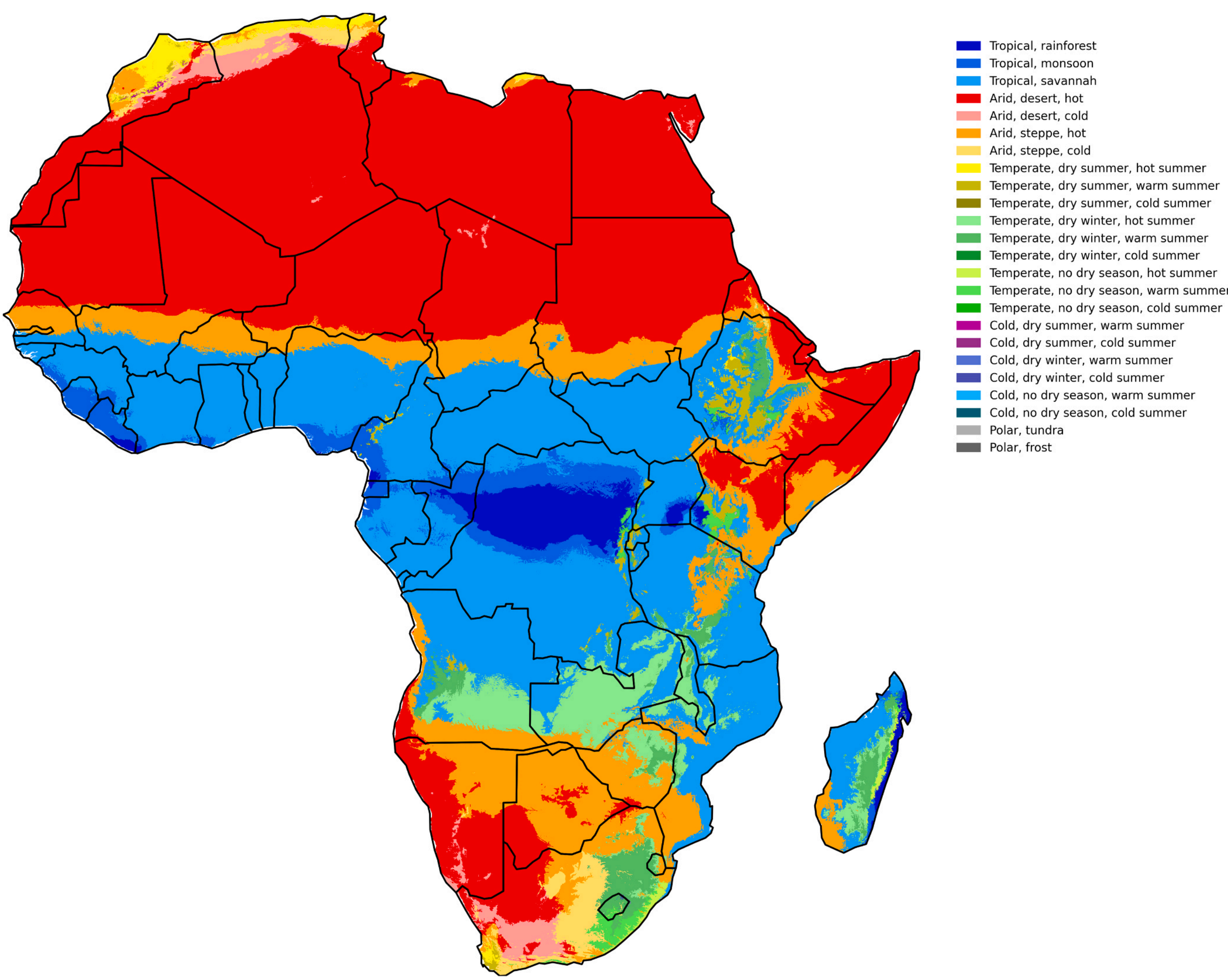

Fig. 2. Köppen–Geiger climate classification map of Africa. Data for climate zones based on Beck et al. [4].

housing location, poor housing designs, and improper waste disposal which favors the release of various pollutants that negatively impact IAQ.

In many African settings, energy poverty significantly limits access to reliable electricity that can help with artificial lighting when natural lighting cannot be used. According to a recent United Nations estimate, about 600 million Africans lack adequate electricity, which accounts for over 80 % of the global electricity gap [41]. Oseni [28] stated that over 40 % of Nigerian households have no access to electricity. As a result, households and schools often depend on kerosene lanterns, candles, and other traditional lighting methods during nighttime hours. These sources emit pollutants that degrade IAQ and pose additional health and safety risks to occupants, especially children and the elderly [25].

A dearth of IAQ champions or advocates also amplifies the issue of IEQ. Without IEQ champions, there continues to be a lack of knowledge among stakeholders, including building occupants on the importance of IEQ. This invariably affects public demands and policy changes that would help bring about the desired result.

From a health perspective, chronic exposure to indoor pollutants (e.g., PM, CO, NO_2) is associated with increased risk of asthma, bronchitis, and COPD in adults and children [31]. Children exposed to poor IAQ during critical developmental periods also show poorer cognitive outcomes and learning ability [21]. In addition to disease endpoints, occupants commonly report non-specific “sick building” symptoms such as headache, fatigue, difficulty concentrating, mucosal irritation, and skin symptoms when IAQ is poor [33]. At the population level, indoor air pollution remains a major contributor to the global burden of disease, underscoring the urgency of Africa-appropriate IAQ solutions [19].

4. Lighting: passive strategies for African contexts

During the day, natural light is a valuable resource, but it is not consistently available indoors. On dull or overcast days, sunlight is reduced and may not provide adequate illumination. When it rains, occupants typically close windows and doors to avoid wind and water intrusion. This practice further reduces natural light levels indoors and contributes to darker and more uncomfortable indoor spaces. In many regions with high temperatures, shading devices are installed to protect against overheating, but these also reduce daylight entry, creating a trade-off between thermal comfort and lighting [10].

Although passive lighting strategies offer a cost-effective means of improving indoor light quality, they remain largely underutilized across the continent. Technologies such as solar tubes, which channel natural light into interior spaces, have shown promise in other parts of the world [26]. However, their application and effectiveness in African buildings are not well documented, mainly due to a lack of scientific studies and limited implementation. This lack of data continues to hinder the adoption of potentially impactful solutions.

Incorporating lighting into IEQ discussions is essential, especially in resource-constrained settings such as schools and informal settlements. Poor lighting in classrooms can affect students' ability to read and concentrate, which in turn impacts learning outcomes [32]. In healthcare settings, inadequate lighting compromises safety and quality of care [6]. There is an urgent need for research and pilot interventions that assess the effectiveness of passive and low-energy lighting solutions within diverse African climates and building types. Promoting safe, clean, and efficient indoor lighting must be considered a priority within the broader IEQ agenda in Africa. Addressing lighting challenges through context-specific strategies can significantly improve public health, safety, and productivity, particularly among vulnerable populations.

5. Noise: the overlooked component of IEQ in Africa

One of the unique challenges faced in African countries is that noise is understudied as a part of everyday life [8]. While noise is often overlooked in the broader discourse on IEQ, its impacts can be both immediate and long-term, significantly influencing cognitive performance, sleep quality, and overall comfort [1,24,7]. The rapid pace of urbanization in African megacities such as Johannesburg, Cairo, and Lagos, and the expansion of informal settlements exacerbate noise pollution [23,27]. Poor construction practices, lack of soundproofing materials, and the absence of regulatory frameworks contribute to elevated noise levels in homes, schools, and workplaces [42]. For example, the two African countries with IEQ standards, South Africa and Nigeria, as shown in the ISIAQ STC 34 open database [15], did not regulate noise and lighting. Additionally, external sources such as traffic, construction activities, and industrial operations infiltrate indoor spaces, particularly in metropolitan areas where noise pollution is often chronic and intense.

Lagos State, Nigeria, serves as a particularly good example of this challenge. As one of the most populous urban areas in Africa, Lagos is characterized by overwhelming vehicular traffic, heavy industrial activity, and a high population density, all of which contribute to pervasive noise levels that exceed recommended thresholds for health and well-being [1]. The absence of appropriate noise mitigation strategies, such as noise barriers or double-glazed windows, further compounds this issue. However, double-glazed windows are not a feasible solution for most households in Africa. Many homes, particularly in lower-income areas, rely heavily on natural ventilation and natural lighting for IAQ, thermal comfort, and lighting. In these settings, windows are often left open to allow airflow and natural light, which also means that noise from the outside enters the indoor space unabated, exacerbating the noise pollution problem.

The consequences of excessive noise exposure are profound. Chronic exposure to high noise levels has been linked to a range of adverse health outcomes, including hearing impairment, increased stress levels, cardiovascular diseases, and disruptions to sleep patterns (Münzel et al., 2012; [17]). In children, persistent noise exposure can lead to learning difficulties, reduced concentration, and impaired cognitive development [7]. In schools, for example, classrooms situated near busy streets or construction sites often experience elevated noise levels that negatively affect the learning environment. Teachers report greater difficulty maintaining attention in noisy classrooms, which leads to lower academic performance and hindered social interaction among students [20,7].

Innovative and culturally relevant solutions are needed to address the growing noise concerns in Africa. Simple, cost-effective interventions such as the use of locally sourced materials for acoustic insulation that can reduce indoor noise levels without placing an undue financial burden on households or schools, need more research. Moreover, community-based approaches that raise awareness about the health risks associated with noise and promote the adoption of noise-reducing practices could help foster greater public engagement in addressing this issue. Governments and non-governmental organizations can play a pivotal role by incorporating noise control measures into urban planning policies and promoting the development of noise regulations that reflect the unique environmental and socio-economic context of African countries, particularly in highly populated urban centers, where the noise problem is most pronounced.

6. Summary of IEQ challenges and evidence from African studies

The preceding sections on IAQ, thermal comfort, lighting, and noise illustrate the diverse ways in which IEQ challenges manifest across African settings. To complement these narratives, Table 1 provides an overview of selected empirical studies conducted in Africa. The table highlights the domains assessed, methods used, key findings, and the main gaps identified.

These studies indicate that, although valuable insights have been generated, the existing evidence base is fragmented and limited in scope. Many investigations are small in scale, short in duration, or restricted to a single domain. Few studies have addressed all four IEQ domains simultaneously, and long-term data across diverse African climates remain scarce. Moreover, there is little integration of results to explore combined effects of multiple IEQ parameters on health, wellbeing, and comfort outcomes. These limitations underscore the need for more coordinated research efforts.

Building on the evidence, it is also important to consider the broader challenges and opportunities for improving IEQ in African settings. Table 2 summarises the main IEQ challenges identified in the literature and highlights context-specific strategies that could be further developed and tested.

7. The ISIAQ innovation network: a platform for action

The International Society of Indoor Air Quality and Climate (ISIAQ) has taken a bold step towards addressing the underrepresentation of IEQ research specific to Africa by launching the "Promoting IEQ/IAQ in Africa" Innovation Network in 2024. This initiative fosters collaborative research, advocacy, and policy development to improve IEQ across the continent. The Innovation Network's primary goal is to establish a functional African chapter within ISIAQ that can effectively tackle IEQ challenges tailored to the region's diverse climates and socio-economic conditions. It is a platform to encourage partnerships among researchers, practitioners, and policymakers, promoting the development of Africa-specific solutions and ensuring their implementation. Through this, the network aims to increase regional research output, facilitate knowledge-sharing, and enhance awareness of IEQ issues.

In its initial year, the "Promoting IEQ/IAQ in Africa" Innovation Network will focus on building an inclusive and diverse membership base, mainly targeting underrepresented groups. It is actively supporting applications for ISIAQ Conference Support Awards, providing platforms for awareness campaigns through webinars and editorials, and laying the groundwork for collaborative initiatives. The second year is set to build upon these efforts with more structured activities, such as organizing quarterly meetings, initiating Africa-specific research projects, and disseminating findings via ISIAQ webinars. These efforts aim to establish a strong research and advocacy framework that is relevant to local needs. By its third year, the network aspires to make significant advancements by publishing a comprehensive review of African IEQ needs, forming partnerships with local and international institutions, and hosting regional seminars or ISIAQ events in Africa. We also aim to have at least one student project per year that deals with potential IEQ problems in Africa and to have a conference paper or conference session at every ISIAQ conference to promote the initiative. These milestones will be critical in enhancing the visibility of IEQ challenges in Africa and driving sustainable advancements in the field. The overarching aspiration of the Innovation Network is to integrate research, innovation, and policy advocacy to address Africa's unique IEQ challenges. By aligning with global goals, such as the United Nations Sustainable Development Goal 3 on Health and Well-being, the network aims to improve public health outcomes, productivity, and overall quality of life across the continent.

Table 2
Some IEQ challenges and scalable context-specific strategies for African settings needing further research.

IEQ Component	Key Challenges in Africa	Potential Local Strategies
Indoor Air Quality	– Use of biomass fuels for cooking – Poor ventilation – - Urban air pollution infiltration	– Promote clean cookstoves – Improve passive ventilation design – - Raise awareness - Cross ventilation
Thermal Comfort	– Overheating in schools/ homes – - Lack of insulation - Climate change effects	– White-painted roofs – Ceiling mats (e.g., papyrus) – - Cross-ventilation
Lighting	– Inadequate natural light – Unreliable electricity – - Use of polluting lighting sources	– Install solar tubes or light wells – Use reflective surfaces – - Optimize window placement
Noise	– Traffic and urban noise – Poor building acoustics – - Lack of regulations	– Use locally sourced acoustic insulation – Strategic window placement – - Advocate for noise regulations

8. Next steps and call to action

The "Promoting IEQ/IAQ in Africa" Innovation Network invites researchers, policymakers, non-profit organizations, practitioners, and advocates to collaborate in creating healthier indoor environments across the continent. This is more than a call to action, it is a commitment to addressing the root causes of poor IEQ, advancing tailored solutions, and fostering sustainable progress. By joining this movement, you become part of a dedicated network that is striving to enhance public health, productivity, and well-being for all. Together, we can close research and policy gaps, drive innovation, and ensure that the right to clean indoor air becomes a reality for every African community.

To advance IEQ in Africa, four priority actions are needed: (1) raise awareness and capacity through education, advocacy, and community IEQ champions, (2) expand research by generating locally relevant data

Table 1
Summary of selected IEQ studies in Africa.

Study	Country	IEQ Domains Assessed	Methods	Key Findings	Gaps and Limitations
[39]	Nigeria	IAQ and temperature	Walkthrough surveys, sensor measurements	High classroom temperature	Pilot scale, urban only
[38]	Tanzania	All four IEQ domains	Quantitative surveys, Walkthrough surveys, sensor measurements	High classroom temperature, noise, lighting not spread in class (light more in window side than middle of classroom)	Small sample, short study period, urban only
[3]	Whole African continent	IAQ	Literature review	IEQ monitoring fragmented.	Limited to published data
[14]	Rwanda	IAQ ($PM_{2.5}$)	Wearable monitors	High personal exposure in rural homes	Single pollutant focus
[25]	Uganda	IAQ	Indoor sampling	Kerosene lamps increased pollutant levels	Rural only; Only lighting and air pollution assessed
[30]	South Africa	Thermal	Classroom logging	Absenteeism linked to extreme temperatures	No IAQ or noise data
van der Walt et al., [43]	South Africa	Thermal, IAQ	Classroom monitoring	Poor ventilation and high temperature in classrooms	Very small school sample, result lack generalizability
[2]	Egypt	Thermal, IAQ, Lighting	Quantitative surveys	Pollutants infiltrate classrooms from outdoors, inadequate daylighting in classroom	Small sample, limited data collection, limited result generalizability

and piloting cost-effective interventions in schools and households, (3) influence policy by promoting context-specific guidelines and integrating IEQ into housing, energy, and health programs, and (4) actively seek funding partnerships to support research, interventions, and capacity-building initiatives. Together, these steps provide a roadmap for moving from awareness to measurable progress. You can join the network by visiting https://www.isiaq.org/promoting_ieq_iaq_in_africa.php or by sending an email to isiaqafrica@gmail.com.

CRediT authorship contribution statement

Miriam Byrne: Writing – review & editing. **Adeshokan Muktar Olawale:** Writing – review & editing. **Tunrayo Oluwadare:** Writing – review & editing. **Kati Huttunen:** Writing – review & editing, Visualization, Supervision. **Jhao-Hong Chen:** Writing – review & editing. **Oluyemi Toyinbo:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Project administration, Conceptualization. **Lucmane Koala:** Writing – review & editing. **James Waichoka:** Writing – review & editing. **Elisephane Irankunda:** Writing – review & editing. **Xiaojun Fan:** Writing – review & editing. **Jacob Mensah-Attipoe:** Writing – review & editing, Writing – original draft, Supervision, Project administration. **Pawel Wargocki:** Writing – review & editing. **Fabiano Gibson Daud Thulu:** Writing – review & editing. **Egide Kalisa:** Writing – review & editing. **Abiyu Kerebo Berekute:** Writing – review & editing. **Reginald Quansah:** Writing – review & editing. **Ibeh Gabriel Friday:** Writing – review & editing.

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Disclaimer

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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