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Review article

Air quality management strategies in Africa: A scoping review of the content, context, co-benefits and unintended consequences

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ABSTRACT

One of the major consequences of Africa's rapid urbanisation is the worsening air pollution, especially in urban centres. However, existing societal challenges such as recovery from the COVID-19 pandemic, poverty, intensifying effects of climate change are making prioritisation of addressing air pollution harder.

We undertook a scoping review of strategies developed and/or implemented in Africa to provide a repository to stakeholders as a reference that could be applied for various local contexts. The review includes strategies assessed for effectiveness in improving air quality and/or health outcomes, co-benefits of the strategies, potential collaborators, and pitfalls.

An international multidisciplinary team convened to develop well-considered research themes and scope from a contextual lens relevant to the African continent. From the initial 18,684 search returns, additional 43 returns through reference chaining, contacting topic experts and policy makers, 65 studies and reports were included for final analysis.

Three main strategy categories obtained from the review included technology (75%), policy (20%) and education/behavioural change (5%). Most strategies (83%) predominantly focused on household air pollution compared to outdoor air pollution (17%) yet the latter is increasing due to urbanisation. Mobility strategies were only 6% compared to household energy strategies (88%) yet motorised mobility has rapidly increased over recent decades.

A cost effective way to tackle air pollution in African cities given the competing priorities could be by leveraging and adopting implemented strategies, collaborating with actors involved whilst considering local contextual factors. Lessons and best practices from early adopters/implementers can go a long way in identifying opportunities and mitigating potential barriers related to the air quality management strategies hence saving time on trying to "reinvent the wheel" and prevent pitfalls. We suggest collaboration of various stakeholders, such as policy makers, academia, businesses and communities in order to formulate strategies that are suitable and practical to various local contexts.

1. Introduction

One of the major consequences of Africa's rapid urbanisation is the worsening air pollution in urban centres (Agbo et al., 2021; Katoto et al., 2019). This is mainly attributed to an increase in energy demand to run industrial activities, motor vehicles, for cooking (International Energy Agency, 2019; Okure et al., 2022) and challenges in waste management (Njoku et al., 2019; Wiedinmyer et al., 2014), amidst inadequate strategies to manage the resulting pollutants. Air pollutants in the urbans centres could include a mixture of emissions from vehicles, chemicals from factories, pollen, dust and mold spores suspended as particles. Although household air pollution (HAP) is still the predominant source of air pollution in Africa, it is decreasing, whereas ambient air pollution (AAP) is increasing (Fisher et al., 2021). Since many African countries

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are in the early stages of urbanisation, there is opportunity to set strategies for better air quality management as part of development plans.

The impacts of exposure to air pollution on human health, health systems and the economy have been well documented. Air pollution is one of the greatest environmental risk factors for non-communicable diseases, including asthma, chronic respiratory disease (COPD), stroke cardiovascular diseases and pneumonia, across all age groups (WHO, 2018). In 2018, World Health Organization (WHO) estimated that about 7 million premature deaths were attributed annually to the effects of ambient and household air pollution (WHO, 2018). Of the global deaths globally attributable to air pollution, 1.1 million (17 %) were in Africa (Fisher et al., 2021). Recent studies have linked air pollution exposure with increased utilisation of mental health services among people with psychotic and mood disorders (Newbury et al., 2021) and potential negative on effect cognitive development during gestation and early life (Harris et al., 2015; Porta et al., 2016). Air pollution-related diseases cause a considerable burden to the already stretched healthcare systems in Africa and national economies by reducing human productivity and increasing sick days (Landrigan et al., 2018). Addressing air pollution levels in countries has a potential reduce the burden of mortality and morbidity, but also contribute towards community and national-level development.

Interventions aimed at reducing air pollution and improving related health effects have been reported in Africa (Quansah et al., 2017; Quinn et al., 2018; Woolley et al., 2021). Most have largely focused on HAP, including the introduction of cleaner-burning fuels (Benka-Coker et al., 2018; Bruce et al., 2018B; Olopade et al., 2017) and improved stoves that burn solid fuels more efficiently (Ochieng et al., 2017; van Gemert et al., 2019; Mamuye et al., 2018; Mortimer et al., 2017) yet ambient air pollution is increasing due to rapid urbanisation currently taking place in Africa. Despite the reported interventions, tackling air pollution is still a challenge since air pollution is not an isolated area of strategic concern amongst African governments and communities. Existing societal challenges such as recovery from the Covid-19 pandemic (Agwanda et al., 2021), poverty, intensifying effects of climate change, and rising energy prices (United Nations Climate Change, 2020; International Energy Agency, 2022) are making the prioritisation of air pollution strategies a lot harder.

Notwithstanding these competing societal interests, African countries could effectively tackle air pollution by replicating strategies that have been successful else where and working with actors involved in developing and implementing these strategies whilst considering local contextual factors. Knowledge transfer and sharing of lessons learned and best practices between communities and stakeholders who have implemented successful interventions with those intending to implement similar strategies, foster efficient resource utilisation, save time and avoid pitfalls experienced by earlier developers, implementers and beneficiaries. Knowledge sharing and collaborations could also minimise duplication of efforts by tapping into efforts across sectors within a given community or across communities.

This paper aims to review strategies developed and/or implemented in Africa. The review offers stakeholders (policy makers, industry, academia, and communities) a reference of strategies that could be suitable for their contexts, co-benefits of the strategies, stakeholders who could be potential collaborators, and pitfalls that should be avoided. The review offers a unique chance for knowledge cross-pollination among stakeholders. Air quality strategies that are replicated within respective local contexts are most likely to have a widespread impact, potentially playing a significant role in reducing air pollution across the continent.

The specific research questions we sought to answer were:

(a) What are air quality management strategies developed or implemented in Africa?
(b) Who was involved in the development or implementation of these strategies?
(c) Was the implementation of these strategies assessed?
(d) Was the effectiveness of these strategies in improving air quality and/or health outcomes evaluated, and if so, which strategies worked?
(e) What unintended (co-benefits and/or negative) consequences resulted from implementing these air quality management strategies?

2. Methods

We undertook a scoping review to explore the air quality strategies implemented in Africa using Arksey and O'Malley's (2005) influential work on the 5-step framework as the basis of the protocol for conducting this review. We used this approach since a scoping review provides an overview of a vast topic (Moher et al., 2015) and is a suitable approach for exploring a body of literature to identify knowledge gaps (Munn et al., 2018).

2.1. Identifying the scope of the review

Due to the potentially vast number of research questions that could arise from the chosen topic of air quality strategies, we held virtual meetings on 30th September 2020, 10th and 24th February 2021 to develop key research domains (supplementary file S1). Meetings comprised of academics working in Uganda, The Gambia, Kenya, Sudan, Benin, Nigeria and United Kingdom, and from multiple disciplines, including air quality research, lung health, environmental health and urban epidemiology. This diverse team allowed the development of well-considered research themes and explored definitions of the research scope from a contextual lens relevant to the African continent. This was an iterative process where more search terms under each key domain were discussed, reviewed and added. Senior author, TO, provided overall guidance in the framing of our scoping review.

We defined a strategy as an action that addressed air pollution regardless of whether addressing air pollution was the focus on not. This included interventions, policies or directives, technologies, initiatives and campaigns aimed at improving air quality or where air quality improved as an unintended consequence of an act. We utilised five key themes during the search: ***air quality, health, policies, technologies and effectiveness***. This review included studies in urban and *peri*-urban African settings.

2.2. Identifying relevant studies: Eligibility criteria, information sources and searching

The review was based on literature published from 1 January 2000 to 31 December 2020. Seven key databases, including MEDLINE, EMBASE, CINAHL, Global Health, SCOPUS, Web of Science and Global Health Africa Index Medicus, were searched using medical subject headings and text words. Following a pilot in March 2021, the final database searches were conducted in April 2021 in consultation with a medical librarian (Supplementary File S1).

We also conducted a grey literature search to identify reports by international and national agencies focused on air quality management and policies relating to air quality strategies in African countries. We contacted various agencies to contribute any relevant material. Lastly, we used citation and reference chaining from the academic manuscripts and reports to get more articles to be included in the scoping review.

2.3. Articles selection

We used Covidence software[1] to import citations and remove duplicates, then paired team members performed title-and-abstract

[1] https://www.covidence.org.

screening and full-text screening with a senior team member serving as arbiter whenever discrepancies arose. Trained researchers (GO and BA) performed title-and-abstract screening, full-text screening (DO and GO) while a senior team member (RN) served as an arbiter. RN double-checked all the level 1 and 2 screening decisions. Despite being ineligible (Table 1), literature reviews were mined for additional citations, and other studies were identified through forward and backward searching. All additional studies identified via these routes were captured in Covidence and single screened by RN. Our filtering methods included scientific peer-reviewed articles, conference articles, government reports, technical reports, policies or intervention reports related to air pollution strategies implemented in Africa, published in English language only from 2000 to 2020. Our focus on articles published after 2000 is linked to the start of the Millennium Development Goals (MDGs). Limiting the scope by focusing only on articles published in English means that some potentially relevant papers were not included here but was necessary from a time and resources perspective. Articles with interventions implemented outside Africa were excluded.

2.4. Data extraction

We customised, piloted and refined a Covidence data extraction template (Supplementary File S2), including fields for authors and their affiliations, funding sources, geographic setting, data collection dates, publication year, research design, methods, air quality strategies and outcomes. The extraction template also included who developed the strategy, who was involved in the implementation, and whether the strategies' effectiveness, co-benefits and any unintended negative consequences were assessed. GO and RN extracted eligible studies, and BA and DO then double-extracted selected fields for a randomly selected 20 % of the studies. The group met to resolve the discrepancies when this double-extraction process revealed an unacceptable inconsistency of > 50 %.

Aside from the formal data extraction processes, we had check-ins every-two weeks to share updates of any challenges experienced or new information discovered during the screening and extraction. A WhatsApp group was also set up as a means of faster communication in case a team member wanted to convey any urgent information.

2.5. Data analysis

Full-text study characteristics were tabulated, and data extracted into a spreadsheet was organised by domain for included studies. We extracted the first author, title, year of publication, journal/source, study region, study focus, strategy/intervention, and evaluation method. Team members analysed the data, each analysing the theme most closely related to their own area of expertise, using a broad thematic analysis (air quality, health, strategies, technologies and effectiveness) to develop the sub-themes from each theme. The researchers came together to discuss the themes and key findings across all and within each theme. Full-text study characteristics were tabulated, and data extracted into a spreadsheet, organised by domain for included studies. The data were analysed by four team members (GO, BA, DO, RN), each analysing the domain most closely related to their own area of expertise (e.g. health, environment). We used a broad thematic analysis to develop the main themes from each domain.

Table 1
Scoping review inclusion and exclusion criteria.

	Inclusion criteria	Exclusion criteria
Study design	Studies must contain empirical data (primary or secondary) and present an analysis of these data. All study designs (quantitative and qualitative) are eligible	Literature reviews, narrative overviews, commentaries, opinion pieces, or any format not providing sufficient information to allow for data extraction
Timing	1st January 2000 – 31st December 2020	Studies before 1st January 2000 and after 31st December 2020
Location	Africa	Implemented outside Africa
Setting	Urban and *Peri* urban	Rural
Language	English language only	All other languages

3. Results

Our initial search yielded a total of 18,684 articles and reports. We identified an additional 43 articles and reports through reference chaining and contacting topic experts and policy makers. From these, 192 studies met the criteria for full text screenig. A final subset of 65 studies and reports met the eligibility criteria and were eventually included in the review (Fig. 1). Of these, 36 (55 %) were quantitative, 13 (20 %) were mixed methods, and 16 (25 %) were qualitative. 78 % (n = 51) were academic manuscripts whereas 22 % (n = 14) was grey literature which included government reports, white papers, policy statements, working papers and evaluation reports.

The majority of the included articles and reports (40/65) focused on evaluating improved cookstoves (ICS) that burn less solid fuels to reduce HAP and stoves that use more modern fuels, e.g., electricity, ethanol, biogas, ethanol or liquified petroleum gas (LPG).

Most quantitative studies were cross-sectional, randomised controlled trials (RCTs), case studies, cross sectional studies, applied surveys, interviews, data from experiments and reviews of secondary data, with widely varying sample size of households sampled from 23 to 3,343 households. RCTs involved "control" and "experimental" groups to explore health effects of adopting improved household energy using improved cook stoves or cleaner fuel, with widely varying sample sizes ranging from 30 to 8,626 households.

The qualitative studies, predominantly case studies and ethnographic studies, applied several methods such as in-depth interviews with key informants, observations, semi-structured interviews, field visits and informal discussions. The sample sizes varied (from 6 to 150 households) but were smaller compared to quantitative studies as would be expected.

Mixed methods studies used both quantitative and qualitative approaches including questionnaires, semi-structured interviews, household surveys, focused group discussions, air quality monitoring, key informant interviews and Health and Demographic Surveillance System (HDSS).

3.1. Geographic distribution of interventions identified

Strategies were implemented across 44 (81 %) countries in Africa, with some countries appearing multiple times and some not at all (Fig. 2). Majority of the studies (n = 52) reported interventions implemented in one country, thus providing a single dataset/number count. Thirteen (n = 13) studies reported strategies in more than one country and region, thus providing more number datasets. These included Baskin, 2019 which reported strategies in 37 countries (Table 2), IRENA, ADFD, 2020 which reported in four countries (Sierra Leone, Togo, Liberia, Mauritius), Painuly and Fenhann, 2002 which reported in three countries (Egypt, Ghana and Zimbabwe), Pennise et al., 2009 reported in two countries (Ghana and Ethiopia), Vaccari et al., 2017 reported in two countries (Chad and Cameroon), Vaccari et al., 2012 in two countries (Chad and Cameroon) and Jürisoo et al., 2018 in two countries (Kenya and Zambia).

The Eastern Africa region had the highest representation (36 %) of datasets, followed by West Africa (27 %), then Southern Africa 20 %. Central and Northern Africa had the least representation with 9 % and 8 % respectively.

Most air quality strategies identified were implemented at local/community (62 %) levels followed by district/provincial/city (20 %) and national (18 %) levels.

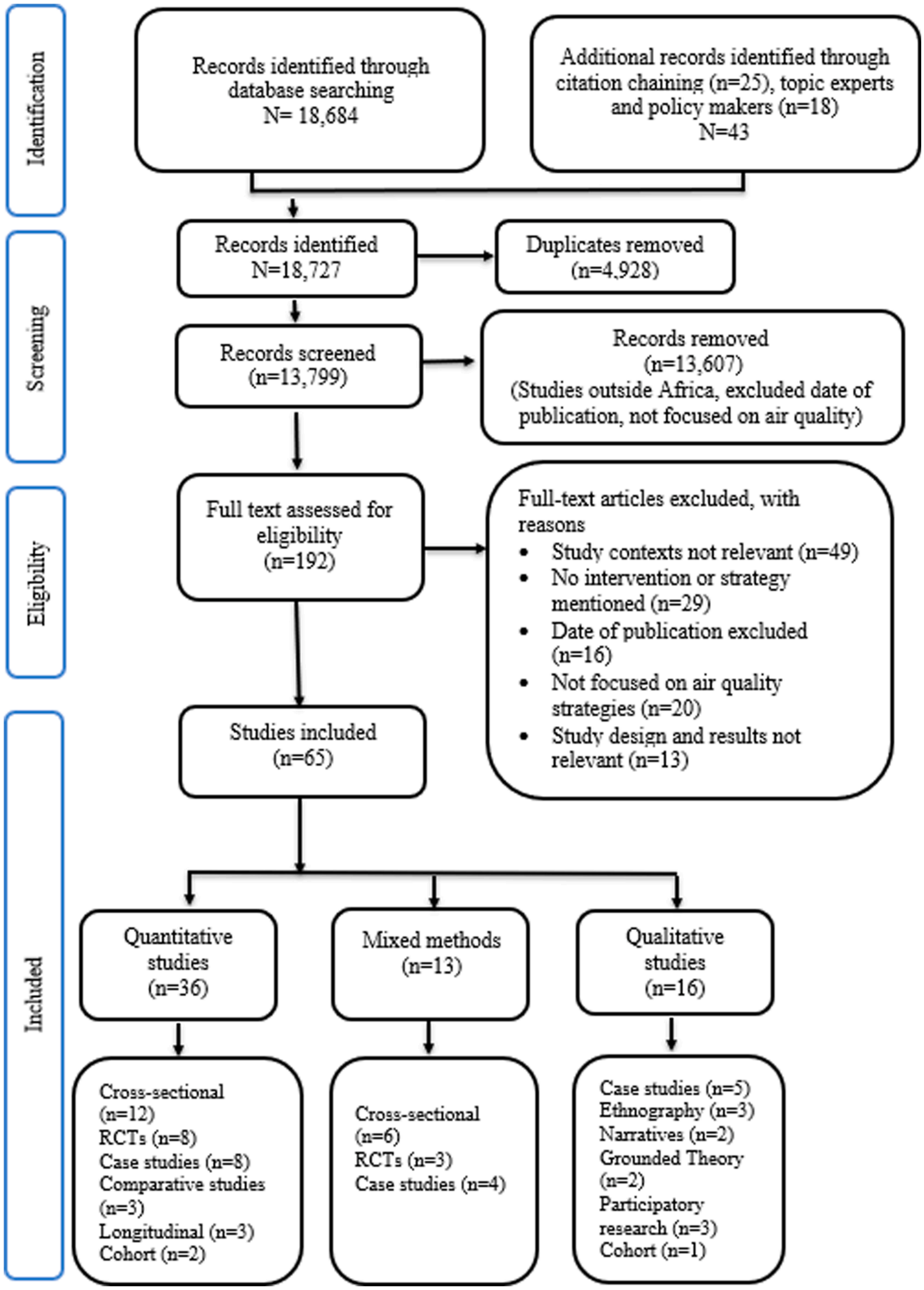

Fig. 1. PRISMA Diagram.

3.2. Author affiliations

We noted a phenomenon of out-of-country author affiliation with 53 % (n = 34) of the studies having first and last authors affiliated to institutions in countries other than where the research occurred (Fig. 3). 11 % (n = 7) of the studies had the first author affiliated to institutions out-of-country with the last author affiliated to an institution in the country where the research occurred whereas 6 % (n = 4) of the studies had the first and last author affiliated to institutions in the country where the research occurred.

Most out-of-country authors were affiliated with institutions in high-income countries in the United States of America (11) and the European region (UK 6, Sweden 5, Netherlands 2, Italy 2, Germany 1, Denmark 1, Spain 1); others had affiliations in Canada (1), Uruguay (1) and Saudi Arabia (1).

3.3. Air quality strategies developed in Africa and actors involved

A total of 63 % (n = 41) of the studies involved strategies developed in Africa, 12 % (n = 8) of the studies had a combination of strategies developed in and outside Africa and 25 % (n = 16) had strategies developed outside Africa. Strategies developed in Africa were defined as interventions including technologies and/or policies developed in various African countries. The strategies developed from outside Africa included solar products, improved wood burning stoves, hybrid cars, hydro technology, optical particle counters, Liguified Petroleum Gas

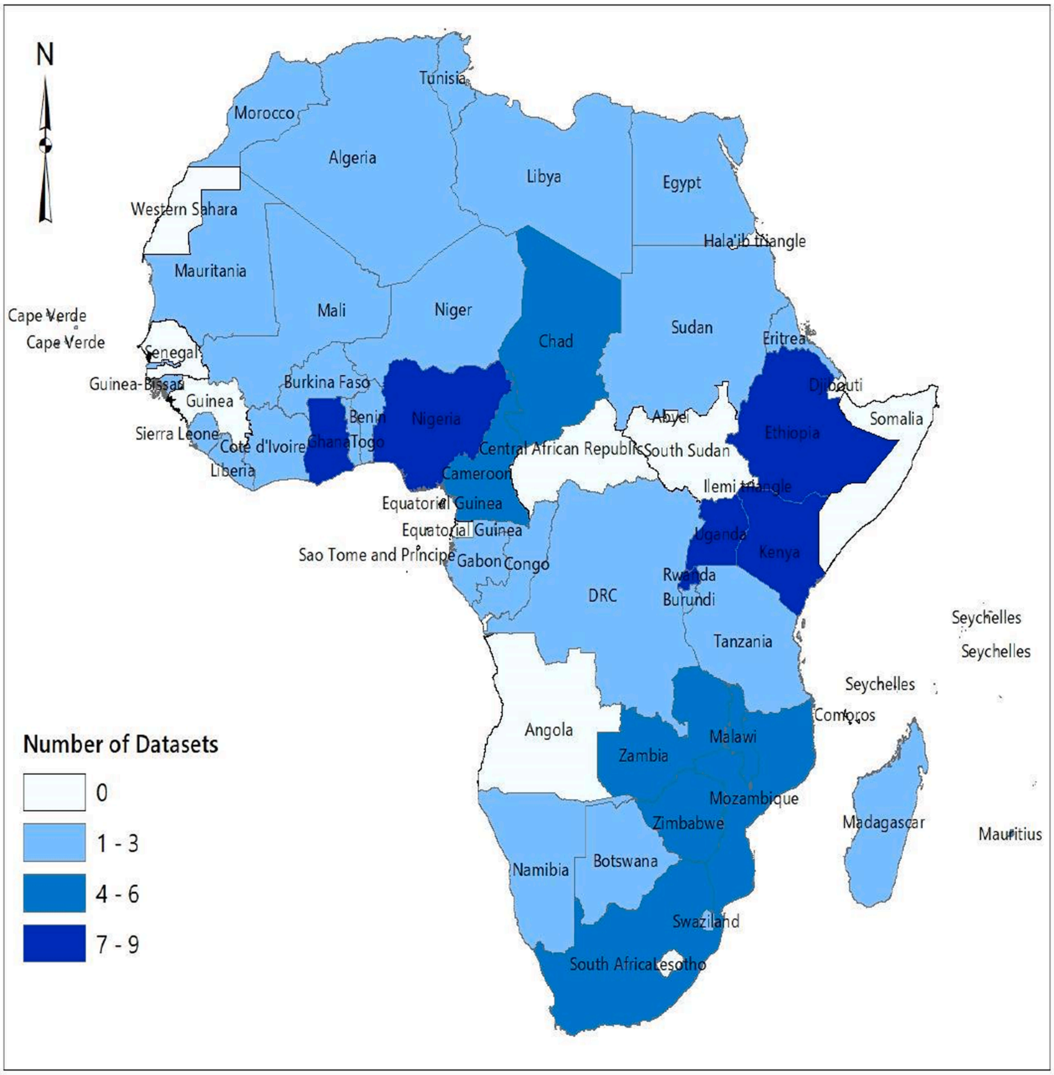

Fig. 2. Geographical distribution of datasets of air quality interventions implemented in Africa.

(LPG), ethanol and bioethanol cookstoves and these were from USA, China, Sweden, United Kingdom, Norway and the Netherlands. The origin of some technologies, including solar, hydro and hybrid cars was impossible to trace as authors did not report that information. The majority (82 % (n = 53) of strategies were implemented at local levels compared to the 18 % (n = 12) implemented at national level.

3.3.1. Actors involved in the development.

Actors involved in development of strategies included government (departments and agencies), non-governmental organisations (local and international), private sector and academic institutes. Collobaration among actors involved in developing of the strategies was identified in 44 (68 %) of the studies and reports while strategies developed by actors in the same sector were identified in 21 (32 %) of the studies. The common types of collaborations involved actors across sectors including government and non-government organisations (NGOs) (n = 9), followed by private sector and local non-governmental organisations (NGO) (n = 7), academic organisations and non-governmental organisations (n = 7) and academic organisations and private sector (n = 4). We also identified collaborations among actors across three sectors including private sector, government and NGOs (n = 5); academic organisation, government and NGOs (n = 4); and private sector, academic organisations and NGOs (n = 3).

3.4. Air quality strategies implemented in Africa and actors involved

We identified three main types of air quality strategies implemented in Africa: policies, technology and education strategies (Table 2).

A total of 83 % of the strategies predominantly targeted indoor air pollution whereas 17 % targeted outdoor air pollution. The technology category was the most common type of strategy (75 %) followed by policy (20 %) while education/behavioural change (5 %) strategies were the least common.

3.4.1. Technology

Technology-associated strategies identified were associated to clean cooking technologies (86 %), clean household energy including solar and hydro energy (8 %), air quality management (4 %) and clean energy (compressed natural gas) for transportation (2 %).

3.4.1.1. Clean cooking technologies. Improved cookstoves (ICSs) for solid biomass were the predominant clean cooking technologies (81 %), followed by biogas (7 %), Liquified Petroleum Gas (7 %) and electric mitads/stove (2 %). Studies that reported clean cooking focused on:

(a) assessing the benefits of ICSs, including the potential to reduce air pollution, save cooking costs, improve health impacts, and reduce environmental degradation (n = 15)

Table 2
Nature and type of strategies implemented in urban and *peri*-urban areas and actors involved.

Nature of strategies	Type of strategy (Area of implemented)	Nature of Implementation	Countries covered	First Author and Year of publication	Actors involved
Policies	Regulations on vehicles (National)	Total ban on used vehicles	Egypt, South Africa, Algeria, Sudan and Morocco	Baskin, 2019; Schwela, 2012	Government (n = 37)
		Regulating importation of vehicles based on age of the vehicles/year of manufacture	Chad, Mauritius, Seychelles (<3yrs), Gabon (<4yrs), Libya, Tunisia, Cote d'Ivoire (<5yrs), Congo (<7yrs), Guinea, Kenya, Mauritania, Namibia, Reunion, Senegal (<8yrs), Benin, Burundi, DRC, Eritrea (<10yrs), Liberia (<12yrs), Ethiopia, Nigeria, Niger, Swaziland, Uganda (<15yrs)		
		Implementing Emission Standards (Petrol and/or diesel driven standards).	Morocco, Algeria, Botswana, Nigeria, Rwanda, Egypt, South Africa, Burkina Faso, Kenya, Madagascar, Uganda		
		Incremental Tax or additional excise duty on age	Kenya > 3yrs; Cape Verde, Sierra Leone (>4yrs); Ghana, Tunisia, Uganda, Zimbabwe (>5yrs); Mozambique (>7yrs); Tanzania (>8 yrs); Gambia, Liberia, Mali, Rwanda (>10yrs)		
		Applying carbon on vehicles to promote hybrid cars	Mauritius	Barry and Damar-Ladkoo, 2016	Government (n = 1)
	Car free Sundays (Local)	Restricting moving of vehicles on streets of Kigali on Sundays	Rwanda	Subramanian et al., 2020	Government (n = 1)
	Renewable energy technologies (National)	Promote renewable energy technologies including biogas, briquettes, solar, hydro electricity	Uganda	Ministry of Energy and Mineral Development, 2019	Government (n = 1)
	Tobacco control (National)	Increased tax on tobacco and restrictions on the sale of tobacco products.	Mauritius, Uganda	Ross et al., 2018; Gravely et al., 2018	Government (n = 2)
	Air Quality management plan/ policy (National and Local*)	Develop comprehensive Air Quality Management plan	Ghana, South Africa	Environmental Protection Agency Ghana 2018; Mokonyane, P.N. 2019	Government (n = 2)
		Build capacity to develop and support development air quality management and strategies	Rwanda*	Smaoun et al., 2018	Government (n = 1)
	Household Energy (National)	Master plan to increase use of LPG in households	Cameroon	Bruce et al., 2018	Government (n = 1), International development partner (n = 2)
	Solid Biomass Fuel (National)	Regulating the collection and sale of biomass fuel wood, introduction of Briquettes	Zimbabwe	Painuly and Fenhann, 2002	Government (n = 1)
	Electricity (National)	Improve access to modern energy services (electricity)	Zimbabwe, South Africa	Davidson and Mwakasonda, 2004	Government (n = 2), Private sector (n = 2)
Technologies	Clean Cooking – Solid biomass Improved cookstoves (Local)	Data sets ranged from assessing the benefits of ICSs including potential to reduce air pollution, save cooking costs, improve health impacts and reduce environmental degradation.	Ethiopia, Ghana, Kenya, Chad, Cameroon, Tanzania, Senegal (2), Ghana, Malawi (2), Burkina Faso, Gambia, Guinea Bissau, Madagascar, Nigeria (2)	Bensch et al., 2015; Cundale et al., 2017; Dutta et al., 2018; Grimm and Peters, 2015; Kelly et al., 2018; Mazorra et al., 2020; Mortimer et al., 2017; Ochieng et al., 2017; Olopade et al., 2017; Omar Makame, 2007; Osei and Krämer, 2010Pennise et al., 2009; Stokes et al., 2011; Vaccari et al., 2017, 2012	NGOs (n = 5); Private sector and NGOs (n = 5); Academic organisations and NGOs (n = 2); Private sector (n = 2); Government and NGO (n = 1)
		Assessing and Understanding factors (barriers and facilitators) that influence uptake/adoption and sustained use, impacts of sustained use, effects and acceptability of ICS	Kenya (5), Rwanda (3), South Africa, Mozambique (2), Malawi, Zambia (4), Ethiopia (3), Sudan, Uganda, Nigeria (2)	Benka-Coker et al., 2018; Beyene and Koch, 2013; El Tayeb Muneer and Mukhtar Mohamed, 2003; Jagger et al., 2019; Lambe et al., 2020; Mamuye et al., 2018; Martin et al., 2013; Mudombi et al., 2018; Northcross et al., 2016; Ozier et al., 2018; Pailman et al., 2018; Peša, 2017; Seguin et al., 2018; Sesan, 2012; Tigabu, 2017; van Gemert et al., 2019 Jagger et al., 2019; Jagger and Das, 2018; Jürisoo et al., 2018	NGOs (n = 3); NGOs and private sector (n = 6); Private sector (n = 7); Government and NGOs (n = 2); Academic organisations and NGOs (n = 3)

(continued on next page)

Table 2 (*continued*)

Nature of strategies	Type of strategy (Area of implemented)	Nature of Implementation	Countries covered	First Author and Year of publication	Actors involved
	Clean cooking - Biogas (Local)	Factors influencing adoption; dis-adoption, impact of biogas	Ethiopia, Uganda (2), Egypt, Zimbabwe	Lwiza et al., 2017; McCord et al., 2017; Shallo et al., 2020	NGO; Academic organisation (n = 1), private sector (n = 1)
	Clean cooking – Liquified Petroleum Gas (Local)	Assessing factors influencing adoption and exclusive use, designing behavioural change	Cameroon (2)	Pope et al., 2018a; Pye et al., 2020	Government and international non-profit organisation (n = 2)
	Clean cooking - Electric mitad (Local)	Factors influencing adoption and dis-adoption	Ethiopia (2)	(Alem et al., 2014; Gebreegziabher et al., 2012	NR
	Air Quality Monitoring networks (Local)	Applying low-cost sensors to measure and bring real time state of air quality	Ghana, South Africa	(Gameli Hodoli et al., 2020; Gwaze and Mashele, 2018)	Academic organisation (n = 2), Government (n = 1)
	Solar technology (National and Local*)	Solar water heating systems, Solar PV systems for electrification, Solar park, solar wind hybrid lights, promotion of solar home systems	Egypt, Ghana, Zimbabwe (2), Sierra Leone*, Mauritius*, Togo, Uganda	IRENA ADFD. 2020; Groenewoudt et al., 2020; Nyemba et al., 2018; Painuly and Fenhann, 2002	Government and Private sector (n = 5);Government and international non-profit (n = 1)
	Hydropower (Local)	Construction of hydropower and mini hydro	Ghana, Liberia	IRENA ADFD. 2020; Painuly and Fenhann, 2002	Government and Private sector (n = 2)
	Compressed Natural gas (Local)	Using Compressed Natural Gas in transportation	Algeria	(Amrouche et al., 2012)	Government (n = 1)
Education Behavioural change approach	Health education programme (Local)	Mid-wife led education to pregnant about biomass smoke exposure reduction during antenatal care clinics	Uganda	(Nantanda et al., 2019)	Academic organisation (n = 2); government (n = 1)
	Human centred approach	Design to improve use of LPG	Rwanda (2)	Iribagiza et al., 2020; Williams et al., 2020	Academic organisations (n = 2)
	Community-based participatory research	Using photovoice to advance uptake of clean cooking and improve health:	Cameroon	(Ronzi et al., 2019)	Academic organisation (n = 2); international non-profit organisation (n = 1)

* = implemented locally; < = less than; IRENA ADFD = International Renewable Energy Agency and the Abu Dhabi Fund for Development; NGO = Non governmental organisation; LPG = Liquified petroleum gas; ICS = Improved cookstoves; PV = Photovoltaic; NR – not repor.

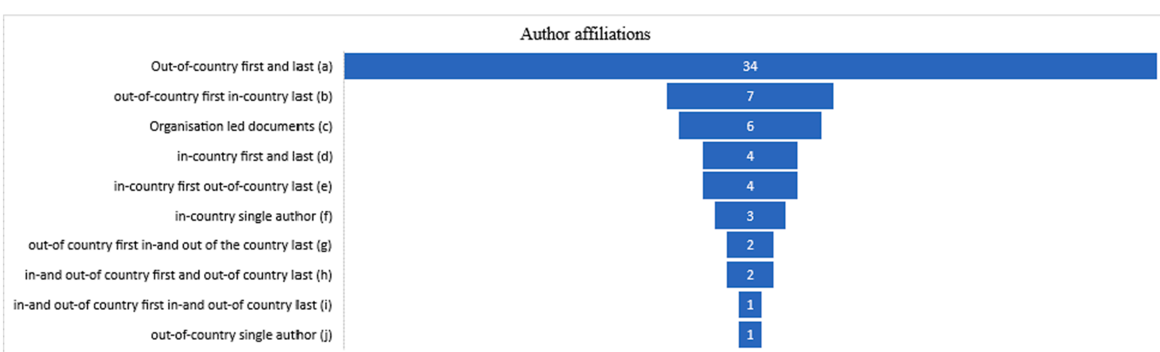

Fig. 3. Showing author affiliations (a) Painuly and Fenhann 2002; Bensch et al., 2015; Vaccari et al., 2017, Baskin, 2019; Vaccari et al., 2012; Seguin et al. 2018; Groenewoudt et al. 2020; Sesan 2012; Damte and Koch, 2011; Mazorra et al. 2020; Lambe et al. 2020; Jürisoo and Lambe, 2016; Jürisoo et al., 2018; van Gemert et al. 2019; Bruce et al. 2018; Gameli Hodoli et al., 2020; Kelly et al. 2018; Pope et al., 2018a; Cundale et al. 2017; Pye et al. 2020; Ochieng et al. 2017; Alem et al. 2014; Ozier et al., 2018; Dutta et al. 2018; Jagger and Das 2018; Williams et al. 2020; McCord et al. 2017; Jagger et al. 2019; Iribagiza et al. 2020; Levine et al., 2018; Gravely et al., 2018; Ronzi et al. 2019; El Tayeb Muneer and Mukhtar Mohamed, 2003; (b) Davidson and Mwakasonda, 2004; Mudombi et al. 2018; Ross et al. 2018; Pennise et al., 2009; Olopade et al., 2017; Martin et al. 2013; (c) Ghana Environmental Protection Agency 2018; Ministry of Energy and Mineral Development, 2019, World Bank report 2011; South African Government (Department of Environmental Affairs) 2019 (d) Amrouche et al. 2012; Mamuye et al., 2018; Gwaze and Mashele 2018; Abdalla and Makame, 2017; (e) Shallo et al. 2020; Gebreegziabher et al., 2012; Pailman et al. 2018, Nantanda et al. 2019 (f) Osei and Krämer, 2010; Tigabu 2017 (g) Grimm and Peters 2015; Subramanian et al., 2020 (h) Lwiza et al. 2017; Nyemba et al., 2018 (i) Mortimer et al., 2017 (j) Peša, 2017.

(b) assessing and understanding factors (barriers and facilitators) that influence uptake/adoption and sustained use, impacts of sustained use, effects and acceptability of the technologies (n = 16).

Some interventions combined technology with financial innovation. This involved leasing the technology (improved cookstoves and biomass pellets) to the end-users (Jagger & Das, 2018; Jürisoo et al., 2018; Jürisoo & Lambe, n.d.).

3.4.1.2. Household and community renewable energy technologies. These included the promotion of solar home systems (Groenewoudt et al., 2020), solar wind hybrid lights (Nyemba et al., 2018), solar PV systems (Painuly & Fenhann, 2002), solar water heating systems, solar PV systems for electrification, and solar park and streetlights (IRENA, ADFD. 2020). Interventions related to hydropower and mini-hydro plants for electricity (IRENA, ADFD. 2020; Painuly and Fenhann, 2002) were also identified.

3.4.1.3. Low-cost air quality sensors. This involved the use of low-cost sensors to measure near real-time state of air quality with localities (Gameli Hodoli et al., 2020; Gwaze and Mashele, 2018).

3.4.1.4. Transport technology. This involved subsitutiton of petrol/diesel by compressed natural gas (CNG) in transportation (Amrouche et al., 2012). This was applied by launching two (n = 2) compressor stations located in “Gué de Constantine” and “Caroubier” (Algiers) in Algeria. Ten buses were acquired and dedicated to CNG and 125 light vehicles were converted to be powered by CNG.

3.4.2. Policy

All policies were implemented at the national level with the exception of two policies that were implemented locally: the car-free Sunday (Subramanian et al., 2020) and the Kigali Air Quality Management policy (Smaoun et al., 2018).

Policy interventions (Table 2) identified were as follows:

(a) Motor vehicle regulations included a total ban on “used” vehicles (second-hand or pre-owned), restriction on the importation of used vehicles (according to age/year of manufacture), emission standards; incremental tax/additional excise duty on old cars; introduction of a carbon tax on vehicles to promote hybrid cars; and restriction of vehicles on streets on Sundays.

(b) Household energy policies included promotion of renewable energy technologies including biogas, briquettes, solar, and hydroelectricity; a master plan to increase LPG use in households (Bruce et al., 2018); regulating the collection and sale of biomass fuel wood; the introduction of briquettes (Painuly & Fenhann, 2002); and improved access to modern energy services/electricity (Davidson & Mwakasonda, 2004).

(c) Tobacco control policies focused on increased tax on tobacco, restrictions on the sale of tobacco products, and restriction of public smoking (Gravely et al., 2018; Ross et al., 2018) to reduce indoor air pollution.

(d) Air quality management plans mainly focused on developing comprehensive plans to address air quality and build capacity to develop and support development of air quality management (Ghana Environmental Protection Agency, 2018; Smaoun et al., 2018).

3.4.3. Education/awareness to foster behavioural change

All education strategies were implemented at local level and academic organisations (87 %) mostly led the development educational interventions utilising education and consultation as an approach to drive behavioural change. Nantanda and colleagues (2019) applied a midwife-led health education approach to educate pregnant women about biomass smoke during antenatal care clinics visits in Uganda. Ronzi and colleagues (2019) applied photovoice methods as a community-based participatory research tool to advance the uptake of clean cooking and improve health in Cameroon, whereas Iribagiza and colleagues (2020) combined education and air quality sensors for feedback to improve consistent and exclusive use of liquid petroleum gas (LPG) stoves in Rwanda.

3.5. Actors involved in the implementation of the strategies

Actors involved in implementation of across the different strategy categories included government (departments and agencies), private sector, non-governmental organisations (local and international) and academic institutes. Implementation of policy strategies was predominantly led by Governments actors (92 %) followed by non-governmental organisations (4 %) and private sector (4 %). The implemented of technology strategies was led by private sector and non-profit organisation (n = 11; 21 %) closely followed by the private sector alone (n = 10; 19 %), local non-profit organisations (n = 9; 17 %), government and private sector (n = 8; 15 %), academic organisations and non-governmental organisations (n = 5; 9 %), government and non-governmental organisations (n = 3; 6 %), academic organisations (n = 3; 6 %), government led (n = 2; 4 %) and government and internation non-profit organisations (n = 2; 4 %).

Academic organisations (75 %) led the implementation of education strategies followed by government (12.5 %) and international non-profit organisation (12.5 %).

3.6. Assessment of implemented strategies as reported by authors

Studies (48 %; n = 31) that assessed outcomes of strategies either used objective instruments (n = 17) or self-reporting approaches (n = 14) (Table 3). Examples of assessed outcomes included measurement of fine particulate matter ($PM_{2.5}$), carbon monoxide (CO), blood levels of biomarkers before, during and after the intervention, quantifying stove usage using stove use monitors, assessing the impact of cookstoves on the incidence of disease (pneumonia). Self-reported assessments recorded feedback/experiences by the end-user for example, reported reduced exposure to smoke, perceived health benefits (e.g reduction of cough and chest pains), reduction in time spent on cooking, and reduced incidents of burns.Table 4..

Three categories of outcomes were identified: effectiveness related to exposure levels (n = 24; 77 %), health levels (n = 4; 14 %), behaviour change or awareness levels (n = 3; 10 %).

Effectivenesss in exposure levels included reduction in ambient $PM_{2.5}$ and black carbon (BC), kitchen $PM_{2.5}$, CO, carbon dioxide (CO_2) concentrations and daily personal exposure to $PM_{2.5}$ and CO (Table 3). Reduction in the ambient average $PM_{2.5}$ and BC was due traffic restrictions on some Sundays in Kigali with $PM_{2.5}$ and BC reducing by 10–12 μg/m^3 and 1 μg/m3 respectively (Subramanian et al., 2020). The largest reduction kitchen $PM_{2.5}$ concentrations were from biogas kitchens which had 99 % lower concentrations of $PM_{2.5}$ (21 μg/m^3) compared to fuelwood kitchens (3100 μg/m^3) for small institutional kitchens (10–30 people) (McCord et al., 2017) followed by 84 % reduction in $PM_{2.5}$ levels from 1250 to 200 μg/m^3 in kitchen using ethanol stoves. Reduced levels of kitchen CO from 38.9 ppm to 9.2 ppm were the largest, indicating a 74 % reduction of CO in the kitchen (Pennise et al., 2009). The largest reductions in personal CO and $PM_{2.5}$ exposure were from 53 % to 74 % and 44 to 62 % respectively among women, and from 35 to 64 % and 47 to 63 % among children (Stokes et al., 2011). Despite the reduction in average air pollutant concentrations at the personal and micro-environment level following HAP strategies showing improvement in air quality, post-intervention levels are generally still far above the WHO guidelines which recommend 5 μg/m^3 and 15 μg/m^3 for annual and 24-hour $PM_{2.5}$ levels and 4 mg/m3 for 24-h CO levels (World Health Organization, 2021).

Positive outcomes were identified in the majority of (n = 29) asessed strategies except two studies where there no significant reduction in the incidence of childhood pneumonia and no measurable reductions in primary school absenteeism (Mortimer et al., 2017; Kelly et al. 2018).

3.7. Co-benefits and negative unintended consequences as reported by authors

A total of 31 % (n = 20) and 17 % (n = 11) of the studies identified co-benefits and negative unintended consequences respectively, as a result of implementing air quality strategies. Four categories of co-benefits were identified: effectiveness related to stoves and fuel (n = 13; 65 %), job creation (n = 5; 25 %), awareness levels (n = 1; 5 %) and increased physical activity (n = 1; 5 %).

4. Discussion

In this study, we reviewed the content and context of air quality

Table 3
Assessment of outcomes of the implemented interventions.

Nature of strategy	Method of assessment	Assessed outcomes	Countries where assessment was conducted	Reference of study
• Technology	• Objective	• Reduction in air pollution in households, kitchens ($PM_{2.5}$, CO) and micro-breweries (CO_2)	Ethiopia, Cameroon, Nigeria, Senegal, The Gambia and Guinea Bissau**, Uganda, Kenya, Ghana and Ethiopia*, Madagscar, Chad and Cameroon*, Burkina Faso	• Benka-Coker et al., 2018; Bruce et al., 2018; Dutta et al., 2018; Mamuye et al., 2018; Mazorra et al., 2020**+; McCord et al., 2017; Ochieng et al., 2017; Pennise et al., 2009*; Stokes et al., 2011+; Vaccari et al., 2017*, van Gemert et al., 2019; Grimm & Peters, 2015
		• Reduced health outcomes inflammation biomarkers	• Nigeria	• Olopade et al., 2017
		• Reduced incidences of burns, night phlegm, shortness of breath and blood pressure.	• Rwanda	• Jagger et al., 2019
		• No significant reduction in the incidence of child health and school absenteeism	Malawi, Senegal, The Gambia and Guinea Bissau**	Kelly et al., 2018; Mortimer et al., 2017
		• Sustained use of bioethanol	• Nigeria	• Northcross et al., 2016
	• Self-reported	• Reduced air pollution	• Senegal, Sudan, Kenya and Zambia*, Mozambique, Tanzania, Ghana, South Africa, Mozambique, Malawi and Zambia**, Cameroon, Chad and Cameroon*	• Beltramo and Levine, 2013; El Tayeb Muneer and Mukhtar Mohamed, 2003; Jürisoo et al., 2018*; Jürisoo and Lambe, n.d.*; Mudombi et al., 2018; Sesan, 2012; Omar Makame, 2007; Osei and Krämer, n.d.; Pailman et al., 2018**; Pope et al., 2018a; Vaccari et al., 2012*
		• Improved child health, reduced burns, headaches, eye irritation and in adults	• Madagscar, Malawi	• Cundale et al., 2017; Stokes et al., 2011+
• Policy	• Objective	• Reduced emission	• Rwanda	• Subramanian et al., 2020
		Reduction in share of tobacco-consumption	Mauritius	Ross et al., 2018
Education	Self-reported	Increased knowledge of air pollution and behavioural change	Uganda	Nantanda et al., 2019

*Studies that occurred in two countries therefore provided two datasets; ** Study occurred in more than two countries, + same paper.

strategies in urban and *peri*-urban areas in Africa with a focus on strategies developed, implemented and/or assessed; actors involved in the development, implementation and assessing of the strategies; air quality and/or health related outcomes; co-benefits and negative unintended consequencies. The findings show that the strategies developed and/or implemented fell into three broad categories: policy, technology and health education for behavioral change. The strategies cut across different areas including household energy (mainly cooking), transport, tobacco control and air quality monitoring. The lead actors in development and implementation of the strategies mainly included; local and international non government organisations, private sector, central and local governments and academia. The lead actors in assessing the air quality strategies were predominantly from academia.

Majority (83 %) of the air quality strategies targeted indoor air pollution which is not surprising given that the use traditional biomass dominates residential energy in sub-Saharan Africa, with over 80 % of the population relying on it (International Energy Agency, 2022). These were mainly cooking technologies. Although household air pollution is still the predominant in Africa, outdoor air pollution is increasing (Fisher et al., 2021) as a result of increased energy demand, motorised transport (Rajé et al., 2018), large-scale construction and industrialization (Cohen et al., 2017; Pope et al., 2018b) thus resulting to a mixture of pollutants from the various sources. Singh et al. (2020) assessed visibility as a proxy for particulate matter (PM) pollution and found a significant loss in observed visibility in Nairobi (60 %), Kampala (56 %) and Addis Ababa (34 %) while, PM pollution levels were estimated to have increased by 182, 162 and 62 %, respectively, in each city across four decades. Therefore air quality strategies should focus on both indoor and outdoor air pollution to realise significant reduction in the overall concentrations of air pollution and related health outcomes within urban centres and cities.

Approximately half of the studies assessed air quality and health outcomes. The findings in these studies showed reduction air pollutants namely $PM_{2.5}$, CO, CO_2, SO_2 in different locations (households, kitchens, outdoors), reduction in individual exposure to air pollutants and reduction in respiratory symptoms (Table 3). Assessing effectiveness asissts in establishing whether strategies are achieving intended aims. Assessment (through monitoring and evaluation programmes) also increases the evidence base for mid-term corrections, enablers for accelerated adoption and mitigate against unintended consequences. Most of the studies that assessed effectiveness reported co-benefits and unintended consequences. The co-benefits reported included reduction in cost and time of cooking, job creation through locally-made technologies, and reduction in the incidence of burns in children. Negative unintended consequences included loss of jobs for wood sellers, and faster wearing out of cooking utensils. Actors involved in developing and implementing air quality strategies should look beyond air quality and health outcomes and also assess co-benefits and/or unintended negative consequences as these could accelerate adoption or lead to dis-adoption of the strategies, respectively. Involving various actors including local community members could provide these valuable local contextual perspectives and lead to formulation of strategies that are suitable and practical to the various local contexts.

Results from the assessed studies showed reduced air pollution post-intervention which indicated improved air quality within the various macro and/or micro-environments. However, the levels of air quality post intervention (McCord et al., 2017; Subramanian et al., 2020) were still above the WHO guidelines at the time of the studies which guidelines have since been updated. This could be attributed to contribution of air pollution from other sources (other than the targeted source) which in turn could led to reduced overall effect of the intervention. For example, a switch to clean cooking could reduce kitchen $PM_{2.5}$ concentration but not may reduce overall exposure of an individual who might spend time in the surrounding *peri*-urban areas that are heavily polluted by rubbish burning, cottage industries and poorly regulated motorised transport. However, an energy policy that promotes renewable energy, tackles rubbish burning and regulates motorised transports could reduce overall exposure of individuals in urban areas since the mixture of emitting sources (pollutants) are being addressed simultaneously.

Table 4
Summary of co-benefits and unintended negative consequences from implementing air quality interventions in Africa.

Primary outcome of study	Positive indirect benefit	Negative indirect consequence	First Author and Year
Reduced air pollution	Stoves saved time, jobs created in communities		Jürisoo & Lambe, n.d. 2016; Levine et al., 2018
	Increased physical activity		Subramanian et al., 2020
	Reduced cooking time		Mamuye et al., 2018
	Reduced cooking time		(Stokes et al., 2011)
	Reduced missed days at school (67 % reduction)		van Gemert et al., 2019
	Reduced firewood for cooking (saves time and money for purchase)		El Tayeb Muneer & Mukhtar Mohamed, 2003; Mazorra et al., 2020
		Loss of income by wood sellers due to reduced use	(Grimm & Peters, 2015)
	Reduced cooking time and wood consumption		Cundale et al., 2017; Kelly et al., 2018; Mudombi et al., 2018
		Increase in Malaria illness	Mortimer et al.
Increased/ Scaled-up/promoted use uptake of improved cook stoves	Jobs created		Levine et al., 2018
	Job creating for staff marketing the stoves	*Increased financial burden to some households	Jagger & Das, 2018
	Saving on fuel and time, less soot thus clean cooking utensils.	Stoves got so hot, and were not durable, stoves causing pots to crack and wear out fast.	Pailman et al., 2018
	Reduced fuel wood usage; job creation		Sesan, 2012
Understanding experiences of improved cookstove users, reasons for lack of widespread adoption, value chain dynamics of improved cookstove initiatives	Saving money on fuel wood	Lack of support for stove repairs, difficulty in activating pay-as-you-cook card reader	Lambe et al., 2020
	Increased income for households due to fuel savings		Beyene & Koch, 2013
	Cost saving on fuel, Jobs created	High cost of improved stove	(Peša, 2017)
Assess consumer behaviours towards eco-cars:	Increased fuel efficiency hence reduction on fuel expenditure		Barry and Damar-Ladkoo, 2016
Designed a behaviour change intervention to promote use of LPG		Difficulty in accessibility LPG refills, fears and safety concerns	Williams et al., 2020
Examined factors causing to dis-adoption		Increase household labour supply	Lwiza et al., 2017
Analysis of fuel and cost savings		Open space deprived women of private space in the kitchen	Vaccari et al., 2012
Evaluated cooking technologies	Fast cooking, fuel saving which ultimately reduced fuel cost		Vaccari et al., 2017
Providing real time state of air quality	Increased awareness about air quality		Gwaze & Mashele, 2018

The assessment of only half of the implemented strategies highlights the big gap of lack of evidence on whether the strategies that were not assessed were effective or not. This is worrying especially where mid-term corrections are needed and in the case of policy strategies that implemented at a larger geographical scale, and a wider population. Development and implementation of strategies requires huge financial and human resource investments therefore, failure/lack of assessment of interventions will likely lead to huge wastage of resources. Assessment is also not only key towards providing evidence on the outcomes of the strategies but is also crucial to identify any co-benefits and negative unintended consequences. Such information assists actors intending to implement similar strategies in understanding how effective the strategy is and whether there are any co-benefits or unintended negative consequences. Assessing effectiveness of the implemented strategies could also support in mid-term corrections for example in 2017 the UK government announced the ban of the sale of diesel and petrol cars in the UK by 2040, over 20 years after its conceptualisation (DEFRA, 2017), this has only recently (in 2020) been brought forward to 2030 after compelling evidence against pollution from diesel cars.

Some strategies such as avoiding a smoky kitchen during cooking and using dry wood) that were reported did not to require capital investment (Nantanda et al., 2019) but present clear opportunity costs in terms of time needed. Such strategies could benefit communities especially the resource-poor communities as there is a competition for resources to tackle various challenges including poverty, disease, hunger, draught.

Another striking finding was a low number of strategies (18 %) implemented at national compared to local levels. Governments mainly took the lead on air quality strategies that were developed and/or implementated at national level whereas non-government organisations, civil society, private sector actors took lead on strategies developed and/or implemented at sub-national level. These were mainly policy strategies. To maximise the benefits of such strategies, the collaborative multi stakeholder engagement approach should involve govermments/policy makers in developing and/or implementing of air quality strategies as they will likely have capacity to implement the strategies across the whole country, larger demographic or geographic regions regions. This approach is suitable for scale up and sustability of effective interventions.

Our review identified continuous air quality monitoring in three countries namely Ghana, South Africa and Rwanda (Environmental Protection Agency Ghana 2018; Mokonyane, P.N. 2019, Gameli Hodoli et al., 2020; Gwaze & Mashele, 2018; Smaoun et al., 2018) highlighting lack of or insufficient air quality data in many African countries. This means that many national and local governments do not have or only have partial knowledge of emissions sources, concentrations, and evolution trends sometimes sometimes makes it difficult to evaluate the effectiveness of the strategies, hampers the selection of target values and the setting of priorities that are adapted to the local context. This situation could however rapidly improve due to the proliferation of portable, yet efficient low-cost sensors (LCS), including purple air

(Purple Air), AirQo (Makerere AirQo), "sensor.Africa" and others that are making air quality measurement affordable and accessible to scientists and non-scientists alike. These monitoring tools could support addressing air quality surveillance, evaluate the impact of implemented interventions and increases awareness among the local population. Whereas LCS have the potential to increase spatial measurement or air quality surveillance, they generally tend to be less sensitive, less precise and less chemically specific to the pollutant of interest. Therefore, proactive and reactive calibration and validation activities still remain an essential component of LCS operations in order to obtain more precise results (World Meteorological Organization, 2021).

Author affiliations showed that many authors were from non-African countries. Having underrepresentation of authors in African countries might create bias or cause missing out on essential local perspectives. This could be one of the reasons for lack of sustained use of ICS within some target communities (Das et al., 2018) despite over 80 million ICS having been distributed since 2010 (Global Alliance for Clean Cookstoves, 2017). Chilis (2017) highlights a need to address such deficiencies in current research approaches, by applying indigenous and local knowledge as alternative ways of conducting research.

4.1. Strengths

Our review provides strategic information in the form of a repository to support research, action and knowledge transfer in the fields of air pollution, health and urban studies. Besides focusing on Africa, this review provides critical information to increase accountability of actors, communication opportunities between actors, and inclusivity of actors in what is often perceived as an academic arena. Previous reviews have mainly focused on the reduction of HAP and/or health effects (Quinn et al., 2018; Woolley et al., 2021), clean cooking solutions (D. Pope et al., 2021), household solid fuel (McCarron et al., 2020). Reviews that have appraised ambient air pollution (AAP) have only appraised the status (Agbo et al., 2021a; Katoto et al., 2019), and air quality profiles mainly focused on policies and governance (Schwela, 2012). The most recent review focused on air quality monitoring, policy and health in West African cities (Mir Alvarez et al., 2020). However, our scoping review examined strategies for both HAP and AAP in urban and *peri*-urban areas as it considers the current trend of increased urbanisation in Africa which is crucial as it is estimated that 68 % of the world's population will live in cities and towns by 2050 (United Nations, 2018). Therefore understanding how cross-cutting challenges like air pollution can be mitigated is key to ensure that cities are economically vibrant, socially inclusive and environmentally sustainable.

4.2. Weaknesses

Despite applying robust methodology, all relevant studies may not have been identified due to the time restriction and exclusion of non-English materials. This limitation was however addressed by review of grey literature which may have significantly reduced bias as air pollution interventions in lower resource countries are frequently conducted by private or multilateral organisations. Studies with negative findings, bad experiences, or that were unsatisfactorily completed may have been less likely published. We reduced this bias by manually adding materials through consultation with experts. Finally, the interpretation of evidence must also be done with care as they are mostly based on the subjective assessment of authors. We are however confident that the iterative process involved in thematic analysis and categorisation of findings provide a strong evidence-base. Our review didn't identify strategies related to desert dust and biological air pollution from mould in indoor settings, yet addressing these forms of pollution is crucial. Some African countries experience desert dust outbreaks while others experience rainy seasons. Existing evidence shows associations between mortality and coarse particles and/or PM during dust outbreaks in urban areas (Stafoggia et al., 2016; Zhang et al., 2016) and health problems associated with building moisture and biological agents (WHO, 2009).

5. Conclusion

Air pollution within various environment including cities is a combination of various sources producing a 'cocktail' of air pollutants hence there is no "single" or one size fits all approach to address it. It is therefore crucial to apply a collaborative multi stakeholder engagement approach to synthesise a range of strategies to address air pollution.

A fundamental part of this is the inclusion of societal stakeholders, such as policy makers, civil society, communities and academia, with the participation of civil society in particular vital to the formulation of multiple solutions and action strategies that are acceptable and practicla in the local context.

Like the rest of the world, Africa is under extraordinary pressures for example from Covid-19 pandemic, climate change perils like floods, extreme drought, and consequences of Russia's invasion of Ukraine. These challenges have significantly impacted countries' commitments to tackling air pollution as it is not an isolated area of strategic concern but competes with other challenges. By synthesising information about implemented strategies, including co-benefits and unintended consequences whilst considering context-specific factors, this review could serve to minimise duplication of efforts, encourage efficient use of resources, and avoid pitfalls experienced by earlier developers implementers and beneficiaries. This could catalyse collaboration through knowledge sharing between actors intending to implement air quality interventions with those that have already implemented them.

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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.

Data availability

Data will be made available on request.

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