


REVIEW

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Addressing the asthma crisis in Africa: challenges, strategies, and recommendations for improved management

Ayodeji Amos Faniyi¹, Olalekan John Okesanya², Ruth Nimota Nukpezah³, Deborah Oluwaferanmi Ibiwoye⁴, Gilbert Eshun⁵, Olaniyi Abideen Adigun⁶, Inibehe Ime Okon^{7*} , Bonaventure Michael Ukoaka⁸, Olaleke Noah Olabode⁹ and Don Lucero-Prisno Eliseo III¹⁰

Abstract

Asthma poses a significant health burden in Africa despite being often underdiagnosed and undertreated. With rising incidence rates and large variations in healthcare infrastructure, its management remains threatened by limited access to medical resources and qualified specialists. The prevalence of asthma in Africa is highlighted, with broad estimates and insufficient information on the disease's burden and determinants. In addition to diagnostic challenges, under treatment, medication unavailability, sociocultural misunderstandings, and poor healthcare infrastructure remain the hallmarks of asthma management in Africa. This review synthesized evidence on the prevalence of asthma in Africa, explored the challenges in managing asthma across the continent, and proposed potential strategies to improve treatment outcomes. Literature was obtained via electronic databases, including PubMed, Web of Science, and Scopus, with additional searches conducted via Google Scholar to identify all available studies. Studies have reported a staggeringly high prevalence of asthma, exceeding 12% on average. Notably, a significant number of these cases are suboptimally controlled, with limited access to healthcare and deficiencies in healthcare delivery systems identified as major contributing factors. Numerous strategies have been proposed to circumvent the limitations faced in effective asthma management. Measures such as the development of national and regional evidence-based asthma guidelines, the provision of affordable medicines and diagnostic equipment, and the improvement of community-based asthma education programs can expedite the goals of asthma control programs. Furthermore, reorienting health systems to incorporate asthma care into primary care and investing in human resource capacity are critical steps. Adopting evidence-based treatment guidelines, such as those established by the Global Initiative for Asthma (GINA), can drastically reduce asthma morbidity and mortality. Through concerted collaboration and synergistic integration of these strategies, the potential for effective asthma management across the continent holds, transcending existing disparities and ushering in an era of improved healthcare services for individuals grappling with this chronic respiratory ailment in Africa.

Keywords Asthma, Asthma control, Asthma management, Chronic disease, Africa

*Correspondence:

Inibehe Ime Okon
inibeheokon3@gmail.com

Full list of author information is available at the end of the article



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Introduction

Chronic respiratory diseases (CRDs) rank prominently among the leading contributors to global mortality. Asthma, a chronic inflammatory disorder of the airway, has emerged as the most widespread chronic ailment affecting children, underscoring its significance on a global scale [1]. Early diagnosis of asthma can be daunting because its clinical symptoms often overlap with those of other respiratory diseases, particularly chronic obstructive pulmonary disease (COPD) and bronchopneumonia. This overlap often leads to misdiagnosis and, consequently, ineffective management. Both asthma and COPD are respiratory disorders with different etiologies and standards for diagnosis. The reversible blockage of airways caused by allergens, exertion, or respiratory infections is a typical symptom of asthma, an immune-mediated or allergy-mediated illness that frequently begins in childhood. Spirometry demonstrating reversible airflow blockage is one of the diagnostic criteria, along with recurrent wheezing, coughing, and dyspnea [2]. On the other hand, chronic exposure to toxic gases or particulate matter, such as cigarette smoke, results in a progressive and irreversible illness known as COPD. Its diagnostic criteria include persistent airflow blockage that does not improve with bronchodilators, along with chronic respiratory symptoms such as cough, sputum production, and dyspnea [3]. In 2019, an estimated 262 million people were affected by asthma, resulting in 455,000 deaths [4]. Globally, nearly 300 million individuals currently live with asthma, and projections indicate that an additional 100 million individuals will be affected by asthma in 2025 [5]. The International Study of Asthma and Allergies in Childhood (ISAAC) noted a rising prevalence of asthma among children in Africa, significantly escalating the burden of the disease and impacting overall quality of life [6].

Globally recognized as a multifactorial respiratory disorder, asthma is influenced by a combination of genetic predispositions and environmental triggers [7]. Urbanization has significantly impacted the prevalence and management outcomes of asthma due to increasing exposure to polluting industrial and vehicular emissions, as well as to common allergens such as pollens, dust mites, animal fur, and traffic and workplace dust, which play a substantial role in exacerbating asthma [8]. Lifestyle changes, socioeconomic disparities, and poor dietary habits further contribute to a heightened risk of asthma. Notable risk factors, particularly in pediatric patients, include smoking and viral infections [9, 10].

According to the World Health Organization (WHO), asthma is often underestimated as a driver of poverty in low- and middle-income nations, perpetuating cycles of economic deprivation and compromising the well-being

of affected individuals and their families [11]. It has been observed that “in children with asthma, poverty worsens the condition, and asthma, in turn, contributes to increased poverty” [12]. The disease also disrupts educational pursuits for children, diminishes work productivity for adults, strains healthcare systems, and increases healthcare costs as a result of excessive costs related to medication, emergency care, and hospitalization [13].

The goal of asthma care and treatment is to control exacerbating symptoms and improve patients' quality of life, even as the disease burden abounds. According to the Global Asthma Report 2022, 1 in 10 children have asthma symptoms, with only approximately half of these children achieving suboptimal control [10]. This burden and recorded challenges in attaining optimal treatment and prevention saturation underscore a critical need for novel and precise management options [14]. An in-depth review of asthma incidence and challenges in control and management techniques is now imperative to uncover the factors associated with poor treatment, control, and adherence. Addressing these concerns allows researchers to develop evidence-based therapies suited to the region's specific healthcare landscape, with the ultimate goal of reducing the burden of asthma-related morbidity and mortality while improving the overall health outcomes of afflicted people [15]. This review aimed to assess the prevalence of asthma in Africa, explore the challenges in managing asthma across the continent, and propose comprehensive approaches to address these issues successfully.

Methodology

A narrative review of the literature was conducted to address the challenges of asthma management in Africa while proposing recommendations and strategies to curb the mayhem caused by this debilitating respiratory disorder. Relevant research articles were identified using electronic databases with no limitation to study year using keywords such as “asthma,” “asthma control,” “asthma management,” “chronic disease,” and “Africa” in PubMed, Scopus, Web of Science, and Google Scholar. Only full-text articles with pertinent information available on the topic and those published in English were included. Additional papers were discovered by applying the snowball search approach, which entails filtering the references listed in the publications that are retrieved through keyword searches. Google Scholar was searched for gray literature, which included reports, conference papers, government documents, working papers, and non-peer-reviewed works that made significant contributions to the field. Books that were preprints, unavailable in their entirety, or not published in English were excluded. The

conclusions of the review are succinctly and narratively discussed under several headings.

Overview of the prevalence and burden of asthma in Africa

Asthma incidence is on the rise across Africa, with reports ranging from 1 to 18% and varying from 1.7 to 53% across countries and age groups. Additionally, an average prevalence of 12% and a range of 2% to 53% among individuals aged under 2 to 64 years have been documented [16]. The overall reported prevalence of asthma in Africa was as follows: South Africa had the highest frequency in 1997 (53%), followed by Egypt in 2005 (26.5%), Nigeria in 1995 (18.4%), and Ethiopia in 1997 (16.3%), while Gambia had the lowest prevalence in 1997 (1.9%) [17]. In 1990, 11.7% of the global population (74 million, including 34.1 million children) were diagnosed with asthma; by 2010, this number had increased to 12.8% (119 million, including 49.7 million children) [17, 18].

Asthma management in Africa has been associated with higher rates of mortality. In Uganda, an asthma mortality rate of 19 deaths per 1000 person-years has been reported, which is 90 times greater than that reported in the UK [15]. Approximately 33% of this population had well-controlled symptoms, 33% had used inhaled controller medications, and approximately 60% experienced at least one episode of asthma exacerbation per year [19]. For children under 5 years of age with symptoms of asthma, more than 90% were diagnosed with pneumonia and treated with antibiotics, which is a major disease misdiagnosis experienced across most low- to middle-income countries (LMICs) [20].

Approximately 31.5% of South African children with asthma were reported to have well-controlled conditions, with 17.6% requiring hospitalization in the previous year. Among adolescents, the prevalence of asthma was 17% in rural regions and increased to 21% in urban areas. The prevalence of diagnosed asthma was 16.6%, although more than half of the population exhibited severe asthma symptoms [21, 22]. According to a multicountry study conducted by the ISAAC, the intercountry prevalence was approximately 9.1% for Ethiopia, 15.8% for Kenya, 13.0% for Nigeria, 8.7% for Algeria, 10.4% for Morocco, and 11.9% for Tunisia, while South Africa had the highest prevalence of 20.3% [23]. Over 298 disability-adjusted life years (DALYs) per 100,000 people were associated with asthma in 2017 [24]. The African Severe Asthma Project study indicated that the prevalence of severe asthma is 19.9% in Ethiopia, 27.1% in Uganda, and 27% in Kenya. Additionally, severe refractory asthma accounts for 3.9% of the cases in Uganda, 7.7% in Kenya, and 3.2% in Ethiopia [25, 26]. This burden is set to take a toll on limited

healthcare infrastructure, logistics, and communication, particularly for residents of hard-to-access regions [27].

Challenges in managing asthma in Africa

The management of asthma in Africa faces significant challenges, reflecting a complex healthcare management system with numerous obstacles. One major challenge to asthma management in Africa is inadequate knowledge among healthcare professionals (HCPs) and patients regarding the intricacies of asthma treatment modalities and complex disease pathogenesis [28]. This poses a unique challenge, as most HCPs grapple with differentiating asthma from other respiratory diseases, which further complicates treatment [28, 29]. This poor knowledge contributes to delayed diagnosis, suboptimal treatment, and poor management outcomes, most often setting the pace for refractory disease. Poorly managed asthma causes more frequent exacerbations and emergency department visits, further complicating the disease progress and quality of life of the patient [30] (Figs. 1 and 2).

Various factors, such as limited access to specialized diagnostic facilities [31], the social stigma associated with asthma diagnosis, nonacceptance at initial diagnosis, and the subjective nature of patients' judgments of asthma control, contribute substantially to the poor treatment outcome and retention in care associated with asthma management [35, 36]. Asthma is said to be controlled. A large proportion of patients do not meet the criteria for well-controlled asthma, even among cohorts who experience frequent episodes of exacerbations. Achieving asthma control encompasses various perspectives, including minimal symptoms and freedom from frequent exacerbations [37]. On examination, it implies normal peak expiratory flow (PEF) readings or low scores on validated asthma control questionnaires. In clinical trials, a combination of these measures, known as composite endpoints, is often used to assess asthma control efficacy [38].

The scarcity and high cost of inhaled steroids [32, 33], coupled with low compliance, contribute significantly to the deadly impact of asthma in Africa, resulting in adverse effects, treatment resistance, and fatalities [37, 39]. A high index of suspicion among clinicians is imperative for a good asthma prognosis. However, most asthma cases are misdiagnosed, with symptoms often confused with other respiratory illnesses, such as bronchopneumonia, bronchitis, and even tuberculosis (TB). Undertreatment has been widely reported, with increasing use of medication without proper disease staging [40]. Management in resource-constrained settings is also limited by the availability of asthma devices and drugs such as spacers, which, when available, are not readily affordable. Furthermore, misconceptions

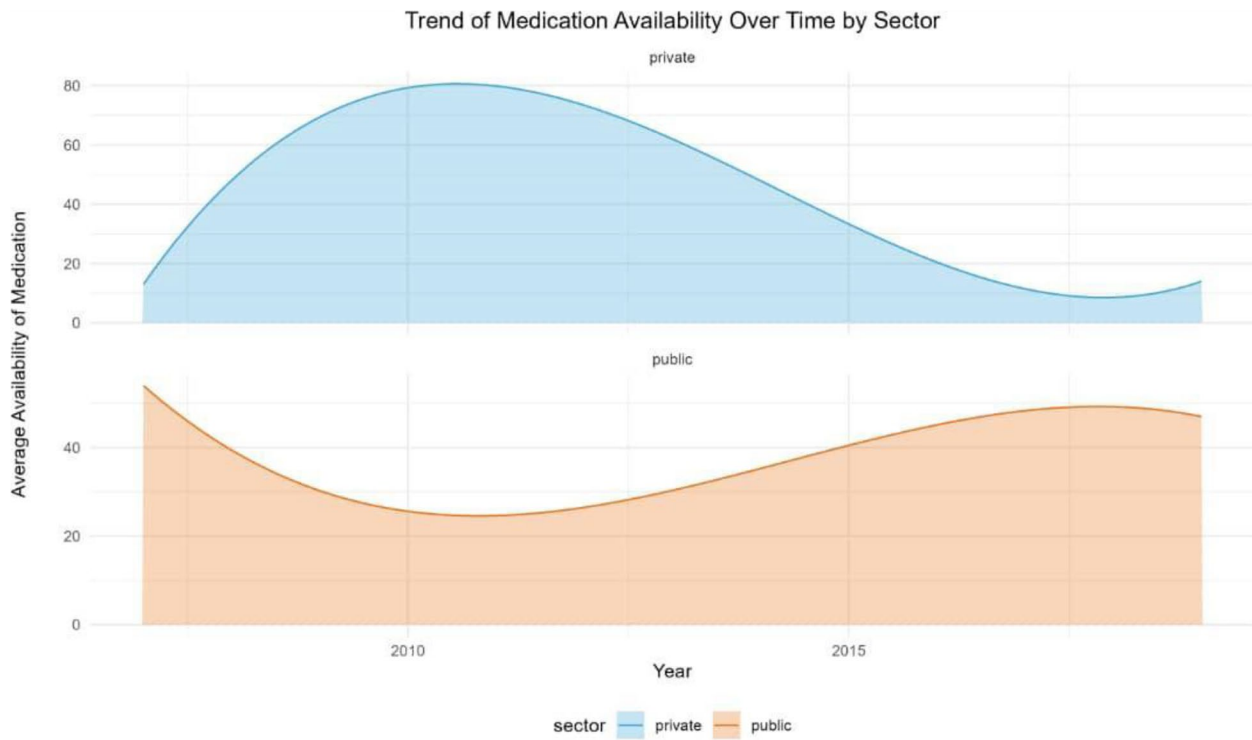


Fig. 1 Trends of medication availability over time by sector [31–34]

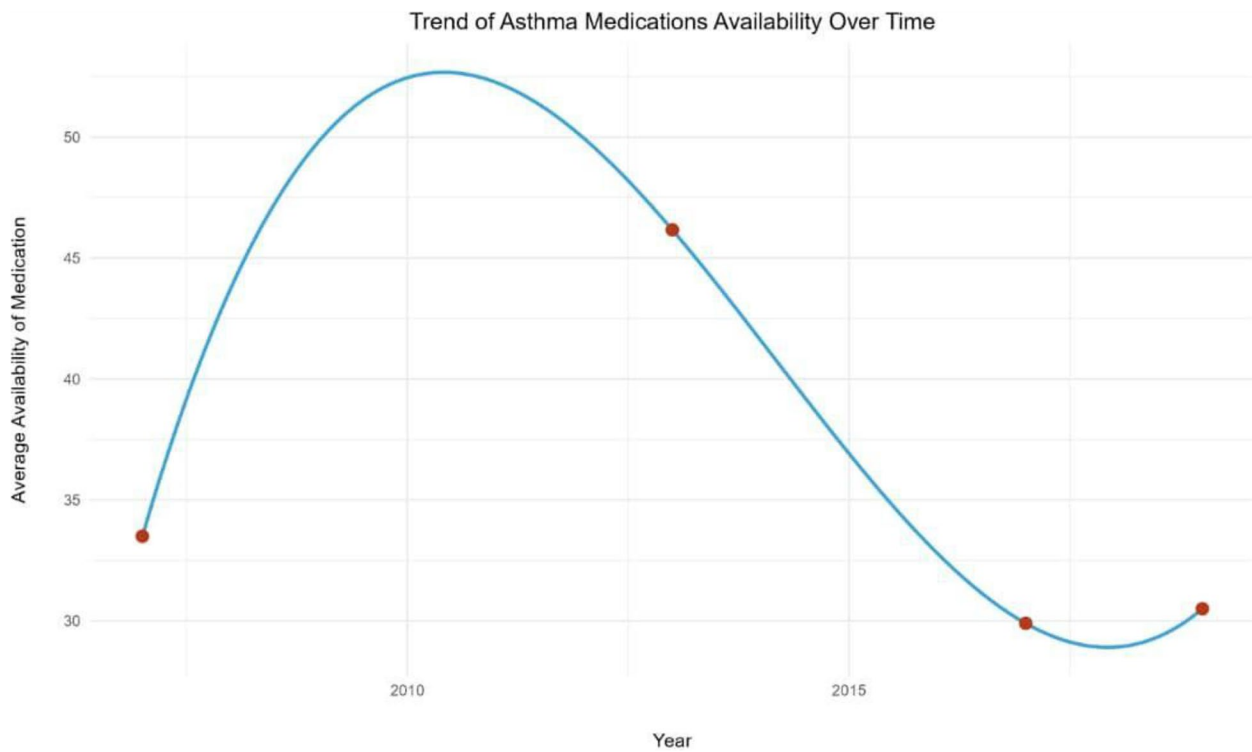


Fig. 2 Trend of asthma medication availability over time [31–34]

and anxieties regarding treatment outcomes and adverse drug effects lead to a poorer prognosis [41–43].

The challenges are vast and include overreliance on short-acting β -agonists (SABAs) due to poor education among healthcare providers on optimum asthma management practices, underprescription of inhaled corticosteroids, nonadherence to recommended medications, misconceptions regarding medication use, and limited access to care and treatment due to out-of-pocket health financing as a consequence of limited health insurance coverage [34, 44]. Negative treatment outcomes are further aggravated by the poor adherence of HCPs to standardized guidelines. Most countries across LMICs lack coordinated national asthma initiatives due to poor health policy implementation. This impact is heightened by the lack of regional asthma guidelines specifically designed for the region [45, 46]. Sociocultural misunderstandings and individual values pose additional barriers to the acceptance and use of medications, especially among parents of children with asthma [14, 47]. Unfortunately, government funding in numerous African countries is focused primarily on infectious diseases, with noncommunicable diseases (NDs), such as asthma, receiving very limited attention and resources for treatment and associated services [48] (Figs. 3 and 4).

Tackling inadequate management of asthma in Africa

The basic ideas and approaches for treating asthma are the same in high- and low-income countries (HICs and LMICs) [49]. Improving asthma care in Africa necessitates a diverse strategy, necessitating the harmonization of guidelines set by the WHO, the Global Alliance against Chronic Respiratory Diseases (GARD), the Global Initiative for Asthma (GINA), and similar health guideline developing bodies [50]. The WHO emphasizes integrated care for chronic respiratory disorders by developing diagnostic and treatment guidelines through projects such as the Practical Approach to Lung Health (PAL) and the WHO-Package of Essential Noncommunicable Diseases (WHO-PEN) [51]. GARD focuses on the special needs of those in LMICs, including the vulnerable population, with a target of improving diagnosis and increasing access to treatment [52]. Regional initiatives, such as the Practical Approach to Care Kit (PACK) in sub-Saharan Africa (SSA), help to improve asthma care by providing practical tools and recommendations to healthcare providers [53].

The WHO, Médecins Sans Frontières (MSF), and the International Union against Tuberculosis and Lung Disease also developed guidelines for asthma treatment in LMICs. These guidelines outline a stepwise approach based on disease severity, with mild asthma patients

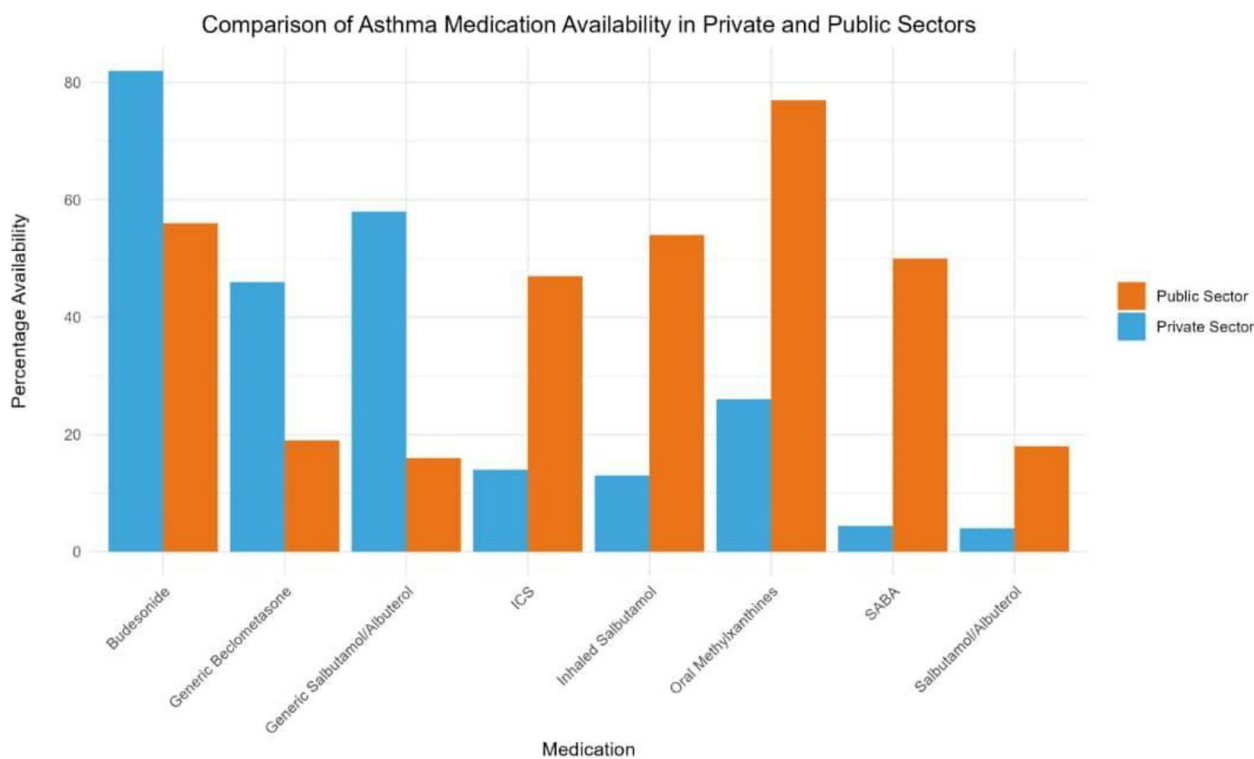


Fig. 3 Comparison of asthma medication availability in private and public sectors [31–34]

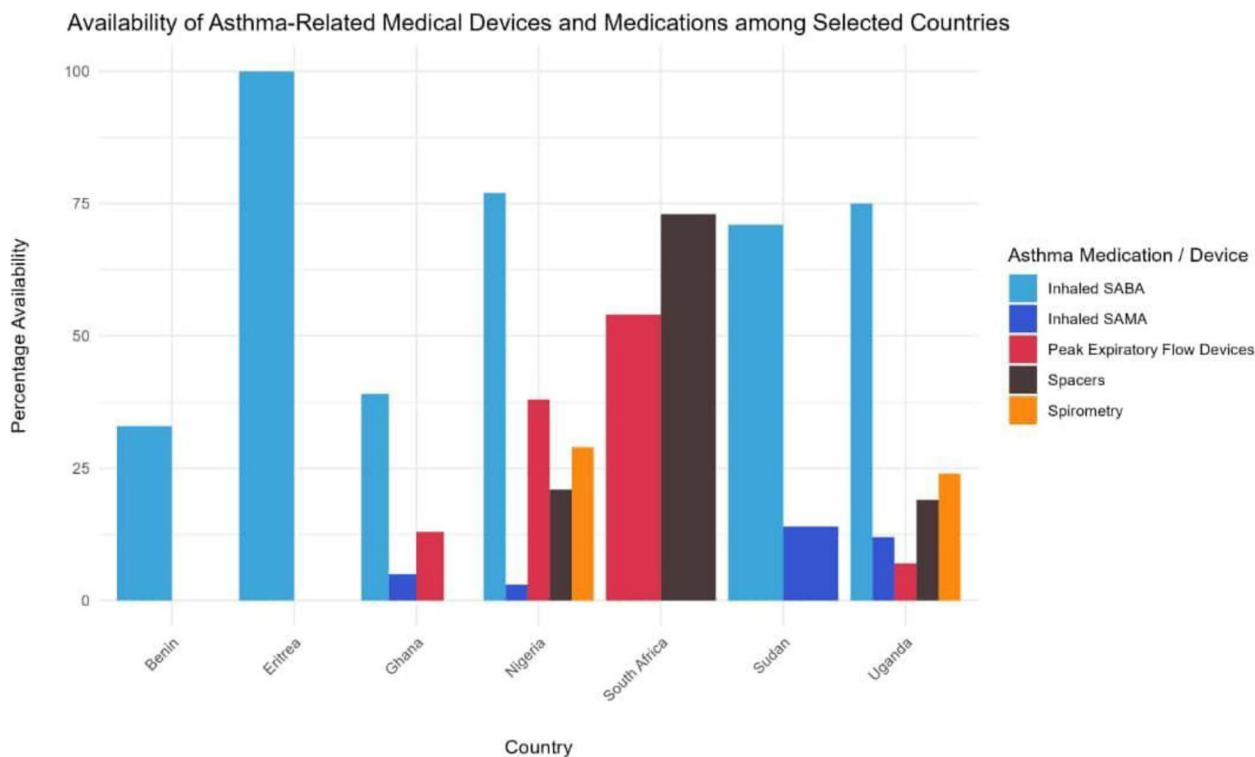


Fig. 4 Availability of asthma-related medical devices and medications among selected countries [31–34]

recommending as-needed inhaled salbutamol. However, as the severity increases, the treatment recommendations differ slightly. In moderate persistent asthma, the WHO-PEN suggests regular low-dose inhaled beclometasone alongside as-needed salbutamol, while the MSF recommends inhaled beclometasone with more frequent use [39, 44]. The Union's guidelines align more closely with those of the MSF, advocating for regular beclometasone with as-needed salbutamol but also suggesting higher doses for adults. In severe asthma, additional interventions, such as low-dose oral theophylline and prednisolone, are recommended [48].

GINA has updated its recommendations for resource-constrained settings, expanding plans to address patients' needs globally. The GINA guidelines offer detailed advice for various ages and severity levels. Intermittent high-dose inhaled corticosteroids (ICS) are considered for children ≤ 5 years old with intermittent viral-induced wheezing and no symptoms between episodes [27, 54]. For children aged 6 to 11 with mild asthma, intermittent low-dose ICS is recommended. When managing patients 12 years and older, low-dose ICS-formoterol per required need for steps 1 and 2 of the GINA recommendations is advised, with the option of using ICS whenever a SABA is taken [55]. This approach is particularly beneficial in Africa, where limited healthcare resources

and medication access hinder asthma management, optimizing control, reducing costs, and lessening healthcare burdens. The guidelines also stress patient education and self-management strategies, empowering individuals in their asthma care [56, 57]. The 2019 GINA and LMIC recommendations for treating asthma notably expanded. For adults and adolescents, GINA advises against using SABAs alone. However, if adherence is high, traditional ICS regimens with a SABA reliever are recommended. This adjustment was prompted by risks of misuse, non-compliance with maintenance ICS, and studies showing a 60% reduction in severe exacerbations compared to SABA alone, with similar benefits [58–60].

The National Asthma Education and Prevention Program (NAEPP) recommends a 7–10 day course of daily inhaled corticosteroids (ICS) for children aged 0–4 with recurrent wheezing due to respiratory infections. For children aged 5–11 with mild persistent asthma, a daily low-dose ICS is advised [61]. Adolescents (≥ 12 years) and adults with moderate persistent asthma are recommended either as-needed ICS with short-acting beta-agonists (SABA) or single maintenance and relief therapy (SMART), which combines ICS and formoterol in one inhaler for both maintenance and relief. SMART is particularly suggested for moderate-to-severe cases to manage symptoms and prevent exacerbations. Although the

NAEPP and GINA guidelines both endorse SMART, they differ slightly in dosage and age categories [58]. Long-acting muscarinic antagonists (LAMAs) are recommended for asthma control by inhibiting acetylcholine-induced bronchoconstriction and mucus secretion [59]. However, their use varies: NAEPP advises against adding LAMA to ICS therapy in those over 12 years unless LABA intolerance occurs, while GINA allows LAMA as an add-on therapy for individuals over 18 with poorly controlled asthma [62]. For allergen-related asthma, NAEPP suggests allergen mitigation, whereas GINA offers cautious recommendations [63]. Immunotherapy is recommended variably for allergic asthma [64]. Bronchial thermoplasty is a potential option for adults with poorly controlled asthma, but its safety and efficacy require further research [65].

Future directions

Integrating telemedicine and mobile health technologies into asthma care promises improved therapeutic outcomes. An international partnership to facilitate early detection, treatment, and adherence to treatment regimens while also ensuring consistent medication supply chains and reducing costs is strongly advocated [24, 65]. Health education programs such as the Asthma in the Black/African American Community and Achieving Control of Asthma in Children In Africa (ACACIA) study have increased asthma awareness across African communities and hold the potential for increasing asthma diagnosis and treatment acceptance [66]. Through targeted health education initiatives, people with newly diagnosed asthma can be encouraged to seek medical attention without fear of discrimination or social stigma from family, friends, colleagues, or society [67]. Furthermore, asthma action plans should contain provisions for emergency management, particularly in distant places with limited access to healthcare [68, 69].

To promote the use of recommended devices for care, creative solutions have been proposed despite obstacles, such as creating spacers out of plastic drink bottles. Essential medications have demonstrated notable advantages for the general public; for example, controllers containing ICS have been found to lower asthma-related death and morbidity. Due to their role in community care, these drugs should be made freely available or subsidized by the government [70]. Despite their drawbacks, the general accessibility and reasonable cost of these medications are significant advancements in the treatment of asthma and its results in LMICs [48]. Despite the limited data and clinical trials available in SSA, it is crucial to prioritize locally relevant research to influence policy and investment decisions and further close the

diagnostic and treatment gaps in Africa. Research should assess the therapeutic efficacy and cost-effectiveness of recommended treatment regimens [14]. Implementation studies are required to increase access to diagnosis and suitable treatments, taking into account local settings and involving service users [48]. Programs such as the PATS Methods in Epidemiological, Clinical, and Operational Research (PATS MECOR) can serve as a platform for advancement.

Finally, a multifaceted resolution approach to universal access to asthma treatment by the World Health Assembly, including policy advocacy and cost-effective interventions, is necessary to address this burden [71]. Governments, together with patients, healthcare workers, and NGOs, should recognize asthma as a priority chronic disease and advocate for equitable access to evidence-based treatment [72]. Low-cost interventions, such as decision support tools, can enhance asthma care. Streamlining treatment approaches, such as the use of single-inhaler therapy with ICS-formoterol and maintenance and reliever therapy (MART), are necessary to overcome barriers such as cost and poor adherence [66]. Holistic care incorporating additional support from social networks and mentorship programs for asthmatic patients can help improve the understanding of the disease, possible preventive measures, treatment alternatives, attack triggers, and effective home symptom management strategies [48]. Community leaders should demonstrate their readiness to collaborate with the healthcare sector to achieve this goal through resource mobilization for treatment and health initiatives. This synergy creates a supportive environment for asthma management programs [53].

Conclusion

In conclusion, inadequate management of asthma in Africa presents a substantial challenge, characterized by disparities in healthcare infrastructure, limited access to medical resources, and a shortage of trained professionals. A comprehensive and collaborative approach is crucial, requiring tailored funding strategies for the diverse African context. Collaboration among funders, governments, public health organizations, NGOs, and communities is essential for addressing this health crisis by improving infrastructure, accessing resources, and training healthcare providers. It is expedient for policymakers and decision-makers in Africa to take proactive steps to enhance asthma management. We advocate developing national and regional evidence-based management guidelines and plans suited to local situations. Ensuring the availability and affordability of WHO essential medicines and diagnostic tools is critical for providing effective asthma care to all age groups.

Community-based asthma education programs can also help improve management outcomes. Furthermore, reorienting health systems to include asthma care in primary care and investing in human resource capacity are critical measures. While budget restrictions create substantial hurdles, it is critical to recognize the potential benefit of applying evidence-based solutions, such as those proposed by GINA, to reduce preventable asthma morbidity and mortality. For better disease prognosis, collaborative efforts to implement research and policy recommendations are imperative. By uniting these endeavors, Africa can overcome the challenges associated with asthma management.

Abbreviations

GINA	Global Initiative for Asthma
CRDs	Chronic respiratory diseases
ISAAC	International Study of Asthma and Allergies in Childhood
WHO	World Health Organization
LMICs	Low- and middle-income countries
DALYs	Disability-adjusted life years
HCPs	Healthcare professionals
ICSs	Inhaled corticosteroids
COPD	Chronic obstructive pulmonary disease
SABAs	Short-acting β -agonists
SSA	Sub-Saharan Africa
NDs	Noncommunicable diseases
WHO-PEN	World Health Organization Package of Essential Noncommunicable Diseases
PACK	Practical Approach to Care Kit
ACACIA	Achieving Control of Asthma in Children In Africa
MART	Maintenance and reliever therapy
PATS MECOR	PATS Methods in Epidemiological, Clinical, and Operational Research

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Ethics approval and consent to participate

Approval from the ethical committee was not applicable.

Competing interests

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Author details

¹Department of Medical Laboratory Science, Joseph Ayo Babalola University, Ikeji Arakeji, Osun State, Nigeria. ²Faculty of Laboratory Hygiene and Epidemiology, University of Thessaly, Volos, Greece. ³School of Nursing and Midwifery, University for Development Studies, Tamale, Ghana. ⁴Department of Microbiology, Joseph Ayo Babalola University, Ikeji Arakeji, Osun State, Nigeria. ⁵Seventh Day Adventist Hospital, Agona-Asamang, Ghana. ⁶Department of Medical Laboratory Science, University College Hospital, Ibadan, Oyo State, Nigeria. ⁷Department of Research, Medical Research Circle (MedReC), Bukavu, Democratic Republic of Congo. ⁸Department of Internal Medicine, Asokoro District Hospital, Abuja, Nigeria. ⁹Department of Medical Laboratory Science, Osun State College of Health Technology, Ilesa, Nigeria. ¹⁰Department

of Global Health and Development, London School of Hygiene and Tropical Medicine, London, UK.

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References

- Against IU, Disease L. The Global Asthma Report Asthma affects today and the. 2011. 76 p. Available from: www.globalasthmareport.org.
- Webley WC, Hahn DL. Infection-mediated asthma: etiology, mechanisms and treatment options, with focus on Chlamydia pneumoniae and macrolides. *Respir Res.* 2017;18(1):98. Available from: <https://doi.org/10.1186/s12931-017-0584-z>.
- Cukic V, Lovre V, Dragisic D, Ustamujic A. Asthma and Chronic Obstructive Pulmonary Disease (COPD) and #8211; Differences and Similarities. *Mater Socio Medica.* 2012;24(2):100. Available from: <http://www.scopemed.org/fulltextpdf.php?mno=20020>.
- World Health Organization. Asthma. Available from: <https://www.who.int/news-room/fact-sheets/detail/asthma>.
- Anandan C, Nurmatov U, Van Schayck OCP, Sheikh A. Is the prevalence of asthma declining? Systematic review of epidemiological studies. *Allergy.* 2010;65(2):152–67. Available from: <https://doi.org/10.1111/j.1398-9995.2009.02244.x>.
- Bousquet J, Mantzouranis E, Cruz AA, Ait-Khaled N, Baena-Cagnani CE, Bleecker ER, et al. Uniform definition of asthma severity, control, and exacerbations: document presented for the World Health Organization Consultation on Severe Asthma. *J Allergy Clin Immunol.* 2010;126(5):926–38. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0091674910011267>.
- van Gemert F, van der Molen T, Jones R, Chavannes N. The impact of asthma and COPD in sub-Saharan Africa. *Prim Care Respir J.* 2011;20(3):240–8. Available from: <https://www.nature.com/articles/pcrj201127>.
- Robinson CL, Baumann LM, Romero K, Combe JM, Gomez A, Gilman RH, et al. Effect of urbanization on asthma, allergy and airways inflammation in a developing country setting. *Thorax.* 2011;66(12):1051–7. Available from: <https://doi.org/10.1136/thx.2011.158956>.
- Mackay D, Haw S, Ayres JG, Fischbacher C, Pell JP. Smoke-free legislation and hospitalizations for childhood asthma. *N Engl J Med.* 2010;363(12):1139–45. Available from: <https://doi.org/10.1056/NEJMa1002861>.
- The Global Asthma Report 2022. *Int J Tuberc Lung Dis.* 2022;26(1):1–104. Available from: <https://doi.org/10.5588/ijtld.22.1010>.
- Meghji J, Mortimer K, Agusti A, Allwood BW, Asher I, Bateman ED, et al. Improving lung health in low-income and middle-income countries: from challenges to solutions. *Lancet.* 2021;397(10277):928–40. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S014067362100458X>.
- Zanobetti A, Ryan PH, Coull B, Brokamp C, Datta S, Blossom J, et al. Childhood asthma incidence, early and persistent wheeze, and neighborhood socioeconomic factors in the ECHO/CREW consortium. *JAMA Pediatr.* 2022;176(8):759. Available from: <https://jamanetwork.com/journals/jamapediatrics/fullarticle/2792664>.
- Haakenstad A, Coates M, Marx A, Bukhman G, Verguet S. Disaggregating catastrophic health expenditure by disease area: cross-country estimates based on the World Health Surveys. *BMC Med.* 2019;17(1):36. Available from: <https://doi.org/10.1186/s12916-019-1266-0>.
- Naidoo KL, Dladla S, Mphahlele RE, Mosler G, Muyemayema S, Ssemata AS, et al. Barriers to childhood asthma care in sub-Saharan Africa: a multicountry qualitative study with children and their caregivers. *BMJ Open.* 2023;13(9):e070784. Available from: <https://bmjopen.bmj.com/lookup/doi/https://doi.org/10.1136/bmjopen-2022-070784>.
- Kirenga BJ, Chakaya J, Yimer G, Nyale G, Haile T, Muttamba W, et al. The burden of severe asthma in sub-Saharan Africa: findings from the African Severe Asthma Project. *J Allergy Clin Immunol Glob.* 2024;3(2):100209. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S2772829324000055>.
- Kwizera R, Musaazi J, Meya DB, Worodria W, Bwanga F, Kajumbula H, et al. Burden of fungal asthma in Africa: a systematic review and meta-analysis.

- Barac A, editor. PLoS One. 2019;14(5):e0216568. Available from: <https://doi.org/10.1371/journal.pone.0216568>.
17. Adeloye D, Chan KY, Rudan I, Campbell H. An estimate of asthma prevalence in Africa: a systematic analysis. *Croat Med J*. 2013;54(6):519–31. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3893990/>.
 18. Mortimer K, Nantanda R, Meghji J, Vanker A, Bush A, Ndimande N, et al. Africa's respiratory "Big Five." *J Pan African Thorac Soc [Internet]*. 2021 May 25;2:64. Available from: <https://patsjournal.org/african-respiratory-big-five/>.
 19. Kirenga BJ, de Jong C, Mugenyi L, Katagira W, Muhofa A, Kanya MR, et al. Rates of asthma exacerbations and mortality and associated factors in Uganda: a 2-year prospective cohort study. *Thorax*. 2018;73(10):983–5. Available from: <https://doi.org/10.1136/thoraxjnl-2017-211157>.
 20. Nantanda R, Tumwine JK, Ndeezzi G, Ostergaard MS. Asthma and pneumonia among children less than five years with acute respiratory symptoms in Mulago Hospital, Uganda: evidence of under-diagnosis of asthma. *Schildgen O, editor. PLoS One*. 2013;8(11):e81562. Available from: <https://doi.org/10.1371/journal.pone.0081562>.
 21. Masekela R, Gray CL, Green RJ, Manjra AI, Kritzinger FE, Levin M, et al. The increasing burden of asthma in South African children: a call to action. *South African Med J*. 2018;108(7):537. Available from: <http://www.samj.org.za/index.php/samj/article/view/12337>.
 22. Mash B, Rhode H, Pather M, Ainslie G, Iruosen E, Bheekie A, et al. Quality of asthma care: Western Cape province, South Africa. *S Afr Med J*. 2009;99(12):892–6. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/20460001>.
 23. Alansari D, Mirza TA. Assessment of asthma control among asthmatic patients at primary healthcare centers in Makkah, Saudi Arabia. *Cureus [Internet]*. 2020 Oct 23; Available from: <https://www.cureus.com/articles/29339-assessment-of-asthma-control-among-asthmatic-patients-at-primary-healthcare-centers-in-makkah-saudi-arabia>.
 24. Zeitouni M, Al-Moamary M, Coussa M, Riachy M, Mahboub B, AlHuraish F, et al. Challenges and recommendations for the management of asthma in the Middle East and Africa. *Ann Thorac Med*. 2022;17(2):71. Available from: <http://www.thoracicmedicine.org/text.asp?2022/17/2/71/343442>.
 25. Beaglehole R, Bonita R, Horton R, Adams C, Alleyne G, Asaria P, et al. Priority actions for the noncommunicable disease crisis. *Lancet*. 2011;377(9775):1438–47. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0140673611603930>.
 26. Azevedo MJ. The state of health system(s) in Africa: challenges and opportunities. In 2017. p. 1–73. Available from: https://doi.org/10.1007/978-3-319-32564-4_1.
 27. GINA. Global strategy for asthma management and prevention. *Glob Initiast Asthma*. 2019;1–201. Available from: www.ginasthma.org.
 28. O' Kane R. Why asthma still kills. *Ulster Med J*. 2017;86(1):44. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/28298715>.
 29. O'Byrne PM, Jenkins C, Bateman ED. The paradoxes of asthma management: time for a new approach? *Eur Respir J*. 2017;50(3):1701103. Available from: <https://doi.org/10.1183/13993003.01103-2017>.
 30. Kostakou, Kaniaris, Filiou, Vasileiadis, Katsaounou, Tzortzaki, et al. Acute severe asthma in adolescent and adult patients: current perspectives on assessment and management. *J Clin Med*. 2019;8(9):1283. Available from: <https://www.mdpi.com/2077-0383/8/9/1283>.
 31. Babar ZUD, Lessing C, Mace C, Bissell K. The availability, pricing and affordability of three essential asthma medicines in 52 low- and middle-income countries. *Pharmacoconomics*. 2013;31(11):1063–82. Available from: <https://doi.org/10.1007/s40273-013-0095-9>.
 32. Cameron A, Ewen M, Ross-Degnan D, Ball D, Laing R. Medicine prices, availability, and affordability in 36 developing and middle-income countries: a secondary analysis. *Lancet*. 2009;373(9659):240–9. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0140673608617626>.
 33. Mendis S. The availability and affordability of selected essential medicines for chronic diseases in six low- and middle-income countries. *Bull World Health Organ*. 2007;85(4):279–88. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2636320/pdf/06-033647.pdf>.
 34. Kibirige D, Kampiire L, Atuhe D, Mwibaze R, Katagira W, Muttamba W, et al. Access to affordable medicines and diagnostic tests for asthma and COPD in sub-Saharan Africa: the Ugandan perspective. *BMC Pulm Med*. 2017;17(1):179. Available from: <https://doi.org/10.1186/s12890-017-0527-y>.
 35. Binegdie AB, Meme H, El Sony A, Haile T, Osman R, Miheso B, et al. Chronic respiratory disease in adult outpatients in three African countries: a cross-sectional study. *Int J Tuberc Lung Dis*. 2022;26(1):18–25. Available from: <https://doi.org/10.5588/ijtld.21.0362>.
 36. Ozoh OB, Ayuk AC, Ukwaja KN, Desalu OO, Olufemi O, Aderibigbe SA, et al. Asthma management and control in Nigeria: the asthma insight and reality Nigeria (AIRNIG) study. *Expert Rev Respir Med*. 2019;13(9):917–27. Available from: <https://doi.org/10.1080/17476348.2019.1651201>.
 37. Asher I, Haahtela T, Selroos O, Ellwood P, Ellwood E. Global Asthma Network survey suggests more national asthma strategies could reduce burden of asthma. *Allergol Immunopathol (Madr)*. 2017;45(2):105–14. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0301054616301665>.
 38. Castillo JR, Peters SP, Busse WW. Asthma exacerbations: pathogenesis, prevention, and treatment. *J Allergy Clin Immunol Pract*. 2017;5(4):918–27. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S2213219817303598>.
 39. MSF. Clinical guidelines, diagnosis and treatment manual. 2013. p. 189–91. <https://medicalguidelines.msf.org/en/viewport/CG/english/clinical-guidelines-16686604.html>. ISBN 978-2-37585-253-8.
 40. Jindal SK, Aggarwal AN, Chaudhry K, Chhabra SK, D'Souza GA, Gupta D, et al. A multicentric study on epidemiology of chronic obstructive pulmonary disease and its relationship with tobacco smoking and environmental tobacco smoke exposure. *Indian J Chest Dis Allied Sci*. 2006;48(1):23–9. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/16482948>.
 41. Tarraf H, Al-Jahdali H, Al Qaseer AH, Gjurovic A, Haouichat H, Khassawneh B, et al. Asthma control in adults in the Middle East and North Africa: results from the ESMAA study. *Respir Med*. 2018;138:64–73. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0954611118300957>.
 42. Barne M. Gaps in asthma diagnosis and treatment in low- and middle-income countries. *Front Allergy*. 2023;4. Available from: <https://doi.org/10.3389/falgy.2023.1240259/full>.
 43. Rylance S, Chinoko B, Mnesa B, Jewell C, Grigg J, Mortimer K. An enhanced care package to improve asthma management in Malawian children: a randomized controlled trial. *Thorax*. 2021;76(5):434–40. Available from: <https://doi.org/10.1136/thoraxjnl-2020-216065>.
 44. World Health Organization (WHO). World Health Organization. Package of essential noncommunicable (PEN) disease intervention for primary health care. 2020. 1–37 p. Available from: <https://iris.paho.org/handle/10665.2/52998>.
 45. Musafiri S, Joos G, Van Meerbeeck JP. Asthma, atopy and COPD in sub-Saharan countries: the challenges. *East Afr J Public Health*. 2011;8(2):161–3. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/22066305>.
 46. Bahadori. A systematic review of economic evaluations of therapy in asthma. *J Asthma Allergy*. 2010;33. Available from: <http://www.dovepress.com/a-systematic-review-of-economic-evaluations-of-therapy-in-asthma-peer-reviewed-article-JAA>.
 47. Bousquet J, Mohammad Y, Bedbrook A, To T, McGihon R, Bárbara C, et al. Country activities of Global Alliance against Chronic Respiratory Diseases (GARD): focus presentations at the 11th GARD General Meeting, Brussels. *J Thorac Dis*. 2018;10(12):7064–72. Available from: <http://jtd.amegroups.com/article/view/26227/19494>.
 48. Mortimer K, Reddel HK, Pitrez PM, Bateman ED. Asthma management in low and middle income countries: case for change. *Eur Respir J*. 2022;60(3):2103179. Available from: <http://erj.ersjournals.com/lookup/doi/https://doi.org/10.1183/13993003.03179-2021>.
 49. Siduna W, Bradley H, Laing R. A comparative analysis of asthma treatment guidelines and essential medicine lists in sub-Saharan Africa. *Int J Tuberc Lung Dis*. 2020;24(12):1294–8. Available from: <https://doi.org/10.5588/ijtld.20.0172>.
 50. Mosler G, Oyenuga V, Addo-Yobo E, Adeyeye OO, Masekela R, Mujuru HA, et al. Achieving Control of Asthma in Children in Africa (ACACIA): protocol of an observational study of children's lung health in six sub-Saharan African countries. *BMJ Open*. 2020;10(3):e035885. Available from: <https://doi.org/10.1136/bmjopen-2019-035885>.
 51. Ahmad S, Ismail AI, Zim MAM, Ismail NE. Assessment of self-stigma, self-esteem, and asthma control: a preliminary cross-sectional study among adult asthmatic patients in Selangor, Malaysia. *Front Public Heal*. 2020;7. Available from: <https://doi.org/10.3389/fpubh.2019.00420/full>.

52. Price DB, Trudo F, Voorham J, Xu X, Kerkhof M, Ling Zhi Jie J, et al. Adverse outcomes from initiation of systemic corticosteroids for asthma: long-term observational study. *J Asthma Allergy*. 2018;11:193–204. Available from: <https://www.dovepress.com/adverse-outcomes-from-initiation-of-systemic-corticosteroids-for-asthm-peer-reviewed-article-JAA>.
53. Mortimer K, Masekela R, Ozoh OB, Bateman ED, Nantanda R, Yorgancioğlu AA, et al. The reality of managing asthma in sub-Saharan Africa – priorities and strategies for improving care. *J Pan African Thorac Soc*. 2022;3:105. Available from: <https://patsjournal.org/the-reality-of-managing-asthma-in-sub-saharan-africa-priorities-and-strategies-for-improving-care/>.
54. Baker JA, Houin PR. Comparison of national and global asthma management guiding documents. *Respir Care*. 2023;68(1):114–28. Available from: <https://doi.org/10.4187/respcare.10254>.
55. Reddel HK, Bacharier LB, Bateman ED, Brightling CE, Brusselle GG, Buhl R, et al. Global Initiative for Asthma Strategy 2021: executive summary and rationale for key changes. *Eur Respir J*. 2022;59(1):2102730. Available from: <https://doi.org/10.1183/13993003.02730-2021>.
56. Reddel HK, FitzGerald JM, Bateman ED, Bacharier LB, Becker A, Brusselle G, et al. GINA 2019: a fundamental change in asthma management. *Eur Respir J*. 2019;53(6):1901046. Available from: <https://doi.org/10.1183/13993003.01046-2019>.
57. Cloutier MM, Baptist AP, Blake KV, Brooks EG, Bryant-Stephens T, DiMango E, et al. 2020 focused updates to the asthma management guidelines: a report from the National Asthma Education and Prevention Program Coordinating Committee Expert Panel Working Group. *J Allergy Clin Immunol*. 2020;146(6):1217–70. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0091674920314044>.
58. Welsh EJ, Cates CJ. Formoterol versus short-acting beta-agonists as relief medication for adults and children with asthma. *Cochrane Database Syst Rev*. 2010;2013(5). Available from: <https://doi.org/10.1002/14651858.CD008418.pub2>.
59. Buels KS, Fryer AD. Muscarinic receptor antagonists: effects on pulmonary function. In 2012. p. 317–41. Available from: https://doi.org/10.1007/978-3-642-23274-9_14.
60. Lee LA, Bailes Z, Barnes N, Boulet LP, Edwards D, Fowler A, et al. Efficacy and safety of once-daily single-inhaler triple therapy (FF/UMEC/VI) versus FF/VI in patients with inadequately controlled asthma (CAPTAIN): a double-blind, randomized, phase 3A trial. *Lancet Respir Med* [Internet]. 2021 Jan;9(1):69–84. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S2213260020303891>.
61. Casale TB, Aalbers R, Bleecker ER, Meltzer EO, Zaremba-Pechmann L, de la Hoz A, et al. Tiotropium Respimat[®] add-on therapy to inhaled corticosteroids in patients with symptomatic asthma improves clinical outcomes regardless of baseline characteristics. *Respir Med*. 2019;158:97–109. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0954611119303014>.
62. Leas BF, D'Anci KE, Apter AJ, Bryant-Stephens T, Lynch MP, Kaczmarek JL, et al. Effectiveness of indoor allergen reduction in asthma management: a systematic review. *J Allergy Clin Immunol*. 2018;141(5):1854–69. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0091674918302239>.
63. Schulten V, Trippl V, Aasbjerg K, Backer V, Lund G, Würtzen PA, et al. Distinct modulation of allergic T-cell responses by subcutaneous vs. sublingual allergen-specific immunotherapy. *Clin Exp Allergy*. 2016;46(3):439–48. Available from: <https://doi.org/10.1111/cea.12653>.
64. d'Hooghe JNS, ten Hacken NHT, Weersink EJM, Sterk PJ, Annema JT, Bonta PI. Emerging understanding of the mechanism of action of bronchial thermoplasty in asthma. *Pharmacol Ther*. 2018;181:101–7. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S016372581730195X>.
65. Almasi S, Shahbodaghi A, Asadi F. Efficacy of telemedicine for the management of asthma: a systematic review. *Tanaffos*. 2022;21(2):132–45. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/36879729>
66. Sobieraj DM, Weeda ER, Nguyen E, Coleman CI, White CM, Lazarus SC, et al. Association of inhaled corticosteroids and long-acting β -agonists as controller and quick relief therapy with exacerbations and symptom control in persistent asthma. *JAMA*. 2018;319(14):1485. Available from: <https://doi.org/10.1001/jama.2018.2769>.
67. Crossingham I, Turner S, Ramakrishnan S, Fries A, Gowell M, Yasmin F, et al. Combination fixed-dose beta agonist and steroid inhaler as required for adults or children with mild asthma. *Cochrane Database Syst Rev*. 2021;2021(5). Available from: <https://doi.org/10.1002/14651858.CD013518.pub2>.
68. Ndarukwa P, Chimbari MJ, Sibanda E. Protocol for a scoping review to evaluate the extent of utilization of healthcare services by asthma patients in sub-Saharan African countries. *BMJ Open*. 2021;11(8):e046294. Available from: <https://doi.org/10.1136/bmjopen-2020-046294>.
69. Holden K, Akintobi T, Hopkins J, Belton A, McGregor B, Blanks S, et al. Community engaged leadership to advance health equity and build healthier communities. *Soc Sci*. 2015;5(1):2. Available from: <http://www.mdpi.com/2076-0760/5/1/2>.
70. Comaru T, Pitrez PM, Friedrich FO, Silveira VD, Pinto LA. Free asthma medications reduces hospital admissions in Brazil (free asthma drugs reduces hospitalizations in Brazil). *Respir Med*. 2016;121:21–5. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S095461111630261X>.
71. Asher I, Bissell K, Chiang CY, El Sony A, Ellwood P, García-Marcos L, et al. Calling time on asthma deaths in tropical regions—how much longer must people wait for essential medicines? *Lancet Respir Med*. 2019;7(1):13–5. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S2213260018305137>.
72. Jia X, Zhou S, Luo D, Zhao X, Zhou Y, Cui Y. Effect of pharmacist led interventions on medication adherence and inhalation technique in adult patients with asthma or COPD: a systematic review and meta analysis. *J Clin Pharm Ther*. 2020;45(5):904–17. Available from: <https://doi.org/10.1111/jcpt.13126>.

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