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Original research

Prevalence of asthma among African children and adolescents: findings from the Chronic Respiratory Disease Observatory for Africa (CHEST-Africa)

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ABSTRACT

Introduction Asthma prevalence is rising in Africa; yet reliable and contemporary prevalence data are unavailable for many countries. Moreover, prevalence estimates are typically based on symptom questionnaires, which may lead to misclassification of disease burden. This study aims to determine the prevalence, severity and treatment of asthma among African children and adolescents from four African countries using both symptom-based and diagnostic testing.

Methods We conducted a cross-sectional, school-based study among children aged 6–7 years and adolescents aged 13–14 years using standardised questionnaires. Participants with self-reported asthma (wheeze in the last 12 months and/or ever asthma) underwent spirometry and fractional exhaled nitric oxide testing. Objectively confirmed asthma was defined as self-reported asthma with at least one consistent diagnostic test.

Results A total of 4477 participants' data (2108 children and 2369 adolescents) were analysed. The prevalence of current wheeze was 7.2% in children and 4.3% in adolescents, while self-reported asthma was 8.1% and 4.8% respectively. Over half of the children (54.7%) and adolescents (61.4%) with self-reported asthma reported severe symptoms and 22.4% and 20.2%, respectively, had a prior diagnosis. Objective testing supported asthma in 41.6% of children and 61.0% of adolescents with self-reported asthma. Fewer than 5% of those with self-reported asthma used inhaled corticosteroids.

Discussion There is substantial underdiagnosis and undertreatment of asthma among African children and adolescents, with high rates of severe symptoms. Incorporating objective testing refines prevalence estimates, underscoring the need to integrate these tests into clinical and epidemiological practice to improve diagnostic accuracy.

WHAT IS ALREADY KNOWN ON THE TOPIC

⇒ Asthma prevalence is rising in Africa, but most existing estimates rely only on symptom questionnaires that may misclassify disease.

WHAT THIS STUDY ADDS

- ⇒ In a school-based study of children and adolescents across four African countries, the prevalence of asthma ranged between 5% and 8%.
- ⇒ Objective testing supported asthma in only 41.6% of children and 61.0% of adolescents with self-reported disease based on a questionnaire.
- ⇒ Fewer than 25% had a prior diagnosis and fewer than 5% used inhaled corticosteroids despite high rates of severe symptoms.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Integrating spirometry and fractional exhaled nitric oxide into clinical and epidemiological practice is essential to refine asthma prevalence estimates, while urgent action is needed to close the substantial diagnostic and treatment gap in Africa.

INTRODUCTION

Asthma is the most common chronic respiratory disease in children and adolescents, causing substantial physical and socioeconomic burden to individuals, their families and the health system.^{1,2} The Global Asthma Network (GAN) studies highlight global differences in asthma prevalence and trends, noting a rise in low-income and middle-income countries.^{1,3}

In Africa, prevalence estimates indicate that the number of children with asthma has increased by 15 million between 1990 and 2010.⁴ In 2019, the

African region was reported to have the highest estimated prevalence of ‘current wheeze’ at 13.2% and ‘ever asthma’ at 11.3%, when compared with other regions globally.⁵

The GAN Phase I Study is one of the largest studies that has provided updated evidence of the global prevalence and burden of asthma among children and adolescents, using a standardised methodology and case definition based on symptoms.^{1 6} However, only four African countries (Nigeria, South Africa, Cameroon and Sudan) were included in this study and no objective testing was conducted. The heterogeneous nature of asthma, with different phenotypes, coupled with the non-specific and overlapping symptoms it shares with other childhood conditions, contributes to underdiagnosis and overdiagnosis. Incorporating objective diagnostic testing into the assessment process can help provide more reliable estimates.⁷ The European Respiratory Society (ERS) recommends inclusion of spirometry and fractional exhaled nitric oxide (FeNO) in the asthma diagnostic algorithm of children and adolescents, balancing sensitivity and specificity for diagnostic accuracy for asthma.⁸ The Achieving Control of Asthma in Children and Adolescents in Africa (ACACIA) Study, which was recently conducted across six African cities, found that about half of the adolescents who were identified as having asthma through a screening questionnaire were confirmed by a positive diagnostic test.⁹ The findings further highlighted that approximately 70% of adolescents who reported asthma symptoms, but had not received a formal diagnosis, demonstrated a positive result on objective diagnostic testing, underscoring high rates of underdiagnosed asthma.⁹ Diagnostic testing therefore showed high value in uncovering previously unrecognised asthma, reducing the likelihood of misdiagnosis and yielding a more accurate understanding of both the burden and characterisation of asthma.

The multicountry Chronic Respiratory Disease Observatory for Africa Cross-sectional Study was designed to extend the estimates of asthma prevalence based on real data to more African countries and to do this based on both symptoms and diagnostic testing.¹⁰ Here we provide estimates of asthma prevalence, severity and treatment among African children and adolescents.

METHODS

Study design and setting

This cross-sectional study surveyed children (6–7 years) and adolescents (13–14 years) attending urban schools in Kumasi (Ghana), Kampala (Uganda), Lubumbashi (Democratic Republic of the Congo) and Kano (Nigeria) (figure 1). These cities were chosen to address gaps in current data by age group or location. For instance, previous international studies covered Ibadan in Nigeria and different age groups in Kumasi and Kampala. The selected sites also benefit from established collaborative networks, including investigators trained through the American Thoracic Society (ATS) Methods in Epidemiological Clinical and Operations Research Africa programme.¹¹ Working with these investigators supports data quality, protocol adherence and sustainability of the observatory.

PARTICIPANT SELECTION

Participants (children and adolescents attending school) were selected from private and public primary and secondary schools in urban areas. The city education boards provided lists of schools, from which 10–20 per site were randomly selected, except in Ghana, where the University primary school was purposefully included. If a selected school declined or no longer existed, another was randomly chosen. See online supplemental



Figure 1 Map of Africa showing participating cities and age groups. DRC, Democratic Republic of the Congo.

box S1 for further details of school selection. After approval from administrators, participants were chosen consecutively from class registers to meet sample size requirements.

SAMPLE SIZE

A minimum sample size required per site was 1000 based on the approach taken by the GAN phase I study,¹² allowing for testing multiple hypotheses.

Table 1 Definitions of terms used to describe asthma symptoms	
Term	Definition
Current wheeze	A positive response to ‘have you (has this child) had wheezing or whistling in the chest in the past 12 months?’
Asthma ever	A positive response to the question ‘have you (has this child) ever had asthma?’
Self-reported asthma*	A positive response to ‘current wheeze’ and/or ‘asthma ever’
Objectively confirmed asthma	Self-reported asthma with any positive diagnostic test
Severe asthma symptoms	Self-reported asthma with four or more attacks of wheeze or one or more nights per week with sleep disturbance from wheeze or wheeze affecting their speech or four or more urgent visits to the doctors for wheeze or one or more emergency room visits for wheeze or one or more hospitalisations for asthma in the preceding 12 months
Doctor-diagnosed asthma	Self-reported asthma with a positive response to the question ‘was your asthma diagnosed by a doctor?’
Exercise wheeze	A positive response to the question ‘in the past 12 months, have you (has this child’s) chest sounded wheezy during or after exercise?’
Night cough	A positive response to the question ‘in the past 12 months have you (has this child) had a dry cough at night, apart from associated with a cold or chest infection?’
*These participants were eligible for diagnostic testing.	

ELIGIBILITY CRITERIA

All children and adolescents within the designated age groups (6–7 years and 13–14 years) were considered eligible to participate provided that informed consent was obtained from a parent or guardian and assent from the participant. All eligible and consenting participants from each selected school were recruited. Individuals with chest wall deformity, on active tuberculosis treatment or those who had other contraindications to performing spirometry or FeNO tests based on the ATS/ERS guidelines were excluded.^{13 14} Tests were deferred for 2 weeks for participants with upper respiratory tract infection.

Screening for asthma

We used GAN-adapted questionnaires for ages 6–7 years and 13–14 years to screen for asthma symptoms, previous diagnosis, and healthcare resource and medication use.¹² The questionnaires were translated into Twi (Ghana) and Hausa (Nigeria) through standard forward and backward translations, while the existing French version was adapted for the Democratic Republic of the Congo.

Parents of children aged 6–7 years filled out the demographic and asthma screening sections of the GAN Questionnaire on paper.¹⁵ Questionnaires were either sent home with the children or handed to parents during drop-off or pick-up, depending on the local circumstances. The team checked all responses for accuracy, followed up with parents as needed and entered data into RedCap. Participants reporting 'wheeze in the last 12 months' or 'Asthma ever' were selected for further diagnostic testing with spirometry and FeNO.

Adolescents aged 13–14 years completed demographic and asthma screening sections of the GAN Questionnaire at school using RedCap on tablets. The tool automatically flagged positive asthma screens for diagnostic testing.

All the data were processed centrally in South Africa with quality checks. Weight and height were recorded for all the participants.

STUDY DEFINITIONS

We defined asthma symptoms as in table 1 using terms adapted from the GAN Phase I Study along with additional terms.¹²

Asthma diagnostic testing and interpretation

We used the ERS algorithm to guide diagnostic testing, performing FeNO, spirometry and bronchial reversibility tests as recommended.⁸ Trained research staff conducted these tests in schools for children and adolescents with self-reported asthma. Diagnostic test results were interpreted according to ERS guidelines for ages 5–16 years.⁸

FRACTIONAL EXHALED NITRIC OXIDE

FeNO was measured before spirometry with the Spiro-sure FenomPro breath analyser, following ATS standards.¹⁶ According to ERS guidelines, FeNO ≥ 25 ppb supports an asthma diagnosis, although a value <25 ppb does not rule out asthma.⁸

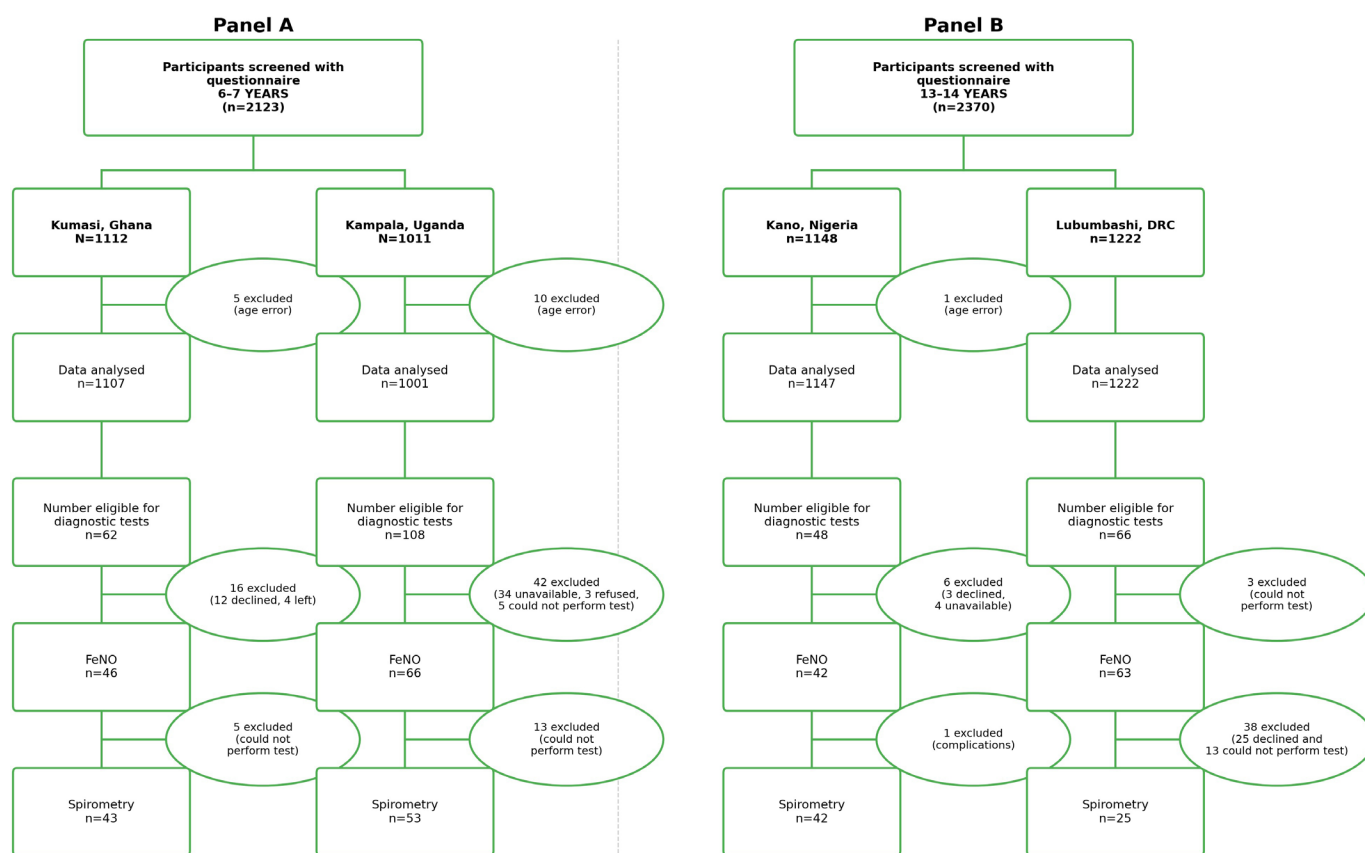


Figure 2 Study flow diagram. Panel A shows recruitment of participants aged 6–7 years. Panel B shows recruitment of participants aged 13–14 years. FeNO, fractional exhaled nitric oxide.

SPIROMETRY

Spirometry was done using the Vyaire Vyintus Pneumo spirometers following the ATS/ERS 2019 standards.¹³ Daily calibration checks were performed on all spirometers. Spirometry was repeated 15–30 min after administering 400 µg of inhaled salbutamol for reversibility testing, regardless of initial test results.

Quality assurance for spirometry tests was performed using ArtiQ.QC software, which follows ATS/ERS acceptability standards. The software assesses data quality by evaluating both numerical criteria and the curve's visual shape through deep-learning artificial intelligence.¹⁷ Only tests meeting acceptability criteria and quality grades A–C (forced expiratory volume in the first second (FEV₁) and forced vital capacity (FVC) repeatability ≤200 mL) were analysed.

According to ERS guidelines, a positive asthma test is FEV₁/FVC <80% or below the lower limit of normal (LLN), FEV₁ <80% or below LLN, or bronchodilator reversibility with FEV₁ increase ≥12% and/or ≥200 mL after bronchodilator.⁸ However, normal spirometry or reversibility test results do not exclude asthma.

ETHICAL CONSIDERATIONS

Site investigators followed local protocol to contact and access schools. Test results were provided to participants, and those screening positive for asthma without physician treatment were referred to hospitals.

STATISTICAL ANALYSIS

Data were analysed using Statistical Package for Social Sciences (SPSS) V.30. Categorical variables were expressed as percentages and continuous variables as mean±SD or median and IQR based on the distribution of the data. The χ^2 test and Student's t-test were used for associations and a value of $p < 0.05$ was considered statistically significant.

We estimated the prevalence (95% CI) of current wheeze, ever asthma, self-reported asthma, exercise wheeze and night cough as proportions of the participants, without weighting. To account for clustering within schools (design effect) we calculated prevalence and the CIs using survey-adjusted (complex

samples) methods, taking city as stratum and school as primary sampling unit with a with-variance sample estimator.

Objectively confirmed asthma prevalence was calculated using a two-stage computation approach because not all eligible participants completed good quality objective tests. First, the proportion of children eligible for diagnostic testing was calculated. Second, among those who completed good quality testing, the proportion with at least one positive objective test (spirometry or FeNO) was determined. The estimated population prevalence of objectively confirmed asthma was derived by multiplying the proportion eligible for testing by the proportion with positive objective tests. This assumes that tested participants are representative of all eligible children and adolescents. To address uncertainties based on this assumption, we performed sensitivity analyses by computing a conservative lower-bound estimate assuming that all eligible untested and poor-quality test participants were negative, and an upper-bound estimate assuming that the proportion of positive tests among untested or poor quality test was the same as among those who completed testing. Missing diagnostic test results were not imputed because missingness was not completely at random and there were no validated predictors sufficient to support reliable imputation. We calculated these prevalence estimates for objectively confirmed asthma manually based on observed proportions.

RESULTS

Between November 2023 and November 2024, we recruited 4493 participants from 57 schools in four African countries. Data were analysed for 4477 individuals (2108 children, 2369 adolescents), 2101 (46.9%) were male and 284 were eligible for asthma testing (figure 2 shows the study flow diagram). Median (IQR) weight and height were 23.6 (20.0–25.9) kg and 1.2 (1.2–1.3) m, respectively, among the participants aged 6–7 years and 35.0 (31.0–40.0) kg and 1.5 (1.4–1.6) m, respectively, among the participants aged 13–14 years (table 1).

Self-reported asthma prevalence

The prevalences of current wheeze, ever asthma, exercise wheeze and night cough among children were 7.2% (152/2108),

Table 2 Prevalence of self-reported asthma symptoms among all study participants

Age group	Country	Current wheeze	Asthma ever	Self-reported asthma	Severe asthma symptoms	Doctor-diagnosed asthma
6–7 years		Total n=2108	Total n=2108	Total n=2108	Total n=2108	Total n=2108
	Kumasi, Ghana	53 (4.8 (3.6–6.3))	25 (2.3 (1.3–3.8))	62 (5.6 (4.2–7.4))	29 (2.6 (1.7–4.0))	19 (1.0 (1.7–2.9))
	Kampala, Uganda	99 (9.9 (6.2–15.5))	26 (2.6 (1.2–5.5))	108 (10.8 (6.5–117.5))	64 (6.4 (3.2–12.4))	19 (1.9 (0.6–6.1))
	Combined sites	152 (7.2 (4.7–10.8))	51 (2.4 (1.5–3.9))	170 (8.1 (5.3–12.1))	93 (4.4 (2.4–7.9))	38 (1.8 (0.9–3.5))
13–14 years		Total n=2269	Total n=2369	Total n=2369	Total n=2369	Total n=2369
	Lubumbashi, Democratic Republic of the Congo	60 (4.9 (3.1–7.8))	11 (0.9 (0.4–2.9))	66 (5.4 (3.5–8.3))	37 (3.0 (1.7–5.2))	7 (0.6 (0.2–1.3))
	Kano, Nigeria	42 (3.7 (2.5–5.4))	25 (2.2 (1.2–4.1))	48 (4.2 (2.8–6.3))	33 (2.9 (1.8–4.6))	16 (1.4 (0.7–2.9))
	Combined sites	102 (4.3 (3.1–5.7))	36 (1.5 (0.9–2.5))	114 (4.8 (3.5–6.5))	70 (3.0 (2.1–4.2))	23 (1.0 (0.5–1.8))

Prevalence presented as n (% (95% CI)). 95% CIs are survey-adjusted for school-level clustering (city as stratum, school as primary sampling unit. Design effects size estimates for the 6–7 years old age group were as follows: current wheeze (6.6), asthma ever (2.8), self-reported asthma (7.4), severe asthma (8.1) and diagnosed asthma (4.0). Design effect size estimates for the 13–14 years old age group were as follows: current wheeze (2.5), asthma ever (2.3), self-reported asthma (2.6), severe asthma (2.3) and diagnosed asthma (2.0).

Table 3 Characteristics of children and adolescents with self-reported asthma

Variables	6–7 years N (%)			13–14 years N (%)		
	Kumasi, Ghana, n=62	Kampala, Uganda, n=108	Total in the age group, n=170	Lubumbashi, Democratic Republic of the Congo, n=66	Kano, Nigeria, n=48	Total in the age group, n=114
Sex (%)						
Female	29 (46.8)	53 (49.1)	82 (48.2)	37 (56.1)	31 (64.6)	68 (59.6)
Male	33 (53.2)	29 (46.8)	88 (51.8)	29 (43.9)	17 (35.4)	46 (40.4)
Current wheeze (wheeze in the last 12 months) (%)	53 (85.5)	99 (91.2)	152 (89.4)	60 (90.9)	42 (87.5)	102 (89.5)
Ever asthma (%)	25 (40.3)	26 (24.1)	50 (30.0)	11 (16.7)	25 (52.1)	36 (36.1)
Exercise wheeze (%)	18 (29.0)	48 (44.4)	66 (38.8)	52 (78.8)	38 (79.2)	90 (78.9)
Night cough (%)	39 (62.9)	66 (61.7)	105 (62.1)	51 (77.3)	27 (56.3)	78 (68.4)
Number of wheezing attacks in the last 12 months						
None	10 (16.1)	16 (16.8)	26 (15.3)	11 (16.7)	7 (14.6)	18 (15.8)
1–3	39 (62.9)	62 (57.4)	101 (59.4)	40 (60.6)	23 (47.9)	63 (55.3)
4–12	12 (19.4)	25 (23.1)	37 (21.7)	11 (16.7)	17 (35.4)	28 (24.6)
>12	1 (1.6)	5 (4.6)	6 (3.5)	4 (6.1)	1 (2.1)	5 (4.4)
Episodes of sleep disturbed by wheezing in the last 12 months						
None	25 (40.3)	36 (33.3)	61 (35.9)	43 (65.2)	22 (45.8)	65 (57.0)
<1/week	26 (41.9)	44 (40.7)	70 (41.2)	20 (30.3)	11 (22.9)	31 (27.2)
≥1/week	11 (17.7)	28 (25.9)	39 (22.9)	3 (4.5)	15 (31.3)	18 (15.8)
Wheeze severe to ever limit speech in the last 12 months (%)	15 (24.2)	25 (23.1)	40 (23.5)	20 (30.3)	29 (60.4)	49 (43.0)
Number of urgent doctor's visit for asthma in the last 12 months						
None	48 (77.4)	94 (87.0)	142 (83.5)	43 (65.2)	26 (54.2)	69 (60.5)
1–3	12 (19.4)	10 (9.3)	22 (12.9)	22 (33.3)	20 (41.7)	42 (36.8)
4–12	2 (3.2)	3 (2.8)	5 (2.9)	0	2 (4.2)	2 (1.8)
≥12	0	1 (0.9)	1 (0.6)	1 (1.5)	0	1 (0.9)
Number of emergency room visits for asthma in the last 12 months						
None	54 (87.1)	96 (88.9)	150 (88.2)	51 (77.3)	41 (85.4)	92 (80.7)
1–3	6 (9.7)	10 (9.3)	16 (9.4)	14 (21.2)	6 (12.5)	20 (17.5)
4–12	2 (3.2)	2 (1.9)	4 (2.4)	1 (1.5)	0	1 (0.9)
≥12	0	0	0	0	1 (2.1)	1 (0.9)
Number of hospitalisations for asthma in the last 12 months						
None	56 (90.3)	98 (90.7)	154 (90.6)	57 (86.4)	40 (83.6)	97 (85.1)
1	4 (6.5)	4 (3.7)	8 (4.7)	7 (10.6)	3 (6.3)	10 (8.8)
2	2 (3.2)	3 (2.8)	5 (2.9)	0	3 (6.3)	3 (2.6)
≥2	0	3 (2.8)	3 (1.8)	2 (3.0)	2 (4.2)	4 (3.5)
Number of days missed school for asthma in last 12 months						
None	56 (90.3)	98 (90.7)	154 (90.6)	40 (60.6)	25 (52.1)	65 (57.0)
1–3	3 (4.8)	4 (3.7)	7 (4.1)	20 (30.3)	9 (18.8)	29 (25.4)
4–12	2 (3.2)	5 (4.6)	7 (4.1)	5 (7.6)	10 (20.8)	15 (13.2)
≥12	1 (1.6)	1 (0.9)	2 (1.2)	1 (1.5)	4 (8.3)	5 (4.4)
Severe asthma symptoms	29 (46.8)	64 (59.3)	93 (54.7)	37 (56.1)	33 (68.8)	70 (61.4)
Doctor-diagnosed asthma	19 (30.6)	19 (17.6)	38 (22.4)	7 (10.6)	16 (33.3)	23 (20.2)
Severe asthma diagnosed by a doctor (%)*	9/29 (31.0)	14/64 (21.9)	23/93 (24.7)	4/37 (10.8)	12/33 (36.4)	16/70 (22.9)
Severe asthma not diagnosed by a doctor (%)*	20/29 (69.0)	50/64 (78.1)	70/93 (75.3)	33/37 (89.2)	21/33 (63.6)	54/70 (77.1)

Continued

Table 3 Continued

Variables	6–7 years N (%)			13–14 years N (%)		
	Kumasi, Ghana, n=62	Kampala, Uganda, n=108	Total in the age group, n=170	Lubumbashi, Democratic Republic of the Congo, n=66	Kano, Nigeria, n=48	Total in the age group, n=114
Use of asthma action plan (%)	5 (8.1)	13 (12.0)	18 (10.6)	2 (3.0)	15 (31.3%)	17 (14.9)
*% of participants with severe asthma						

2.4% (51/2108), 6.3% (132/2108) and 19.6% (413/2108), respectively. Among adolescents, these prevalences were 4.3% (102/2369), 1.5% (36/2369), 12.3% (291/2369) and 13.9% (330/2369) (table 2 and online supplemental table S1 of the online supplement). Current wheeze was more frequent in boys compared with girls within the 6–7 years age group and was nearly twice as prevalent in Uganda as in Ghana. Conversely, among adolescents, the prevalence was higher in girls than in boys (online supplemental table S2 of the online supplement).

Self-reported asthma prevalence was 8.1% (170/2108) among the 6–7 years old age group overall, (5.6% (62/1107) in Ghana and 10.8% (108/1001) in Uganda. Among the 13–14 years age group it was 4.8% (114/2369) overall, (5.4% (66/1222) in the Democratic Republic of the Congo and 4.2% (48/1147) in Nigeria, with a similar sex distribution as current wheeze across both the age groups (online supplemental table S2). Severe asthma symptoms and doctor-diagnosed asthma were reported by 4.4% (93/2108) and 1.8% (38/2108) of the children, respectively, and 3.0% (70/2369) and 1.0% (23/2369) of the adolescents, respectively (table 2).

Characteristics of participants with self-reported asthma

Among children and adolescents with self-reported asthma, 51.8% (88/170) and 40.4% (46/114), respectively, were male (table 3). Approximately 90% had current wheeze and most adolescents (78.9%) experienced exercise wheeze. Nearly 75% of the participants in both groups had at least one wheezing episode in the past year. Approximately 40% of the adolescents had at least one urgent doctor's visit, 20% visited the emergency room, 15% were hospitalised for asthma and nearly half missed at least 1 day of school due to asthma (table 3).

Severe asthma symptoms were present in 54.7% (93/170) of the children and 61.4% (70/114) of the adolescents. Of these participants with severe asthma symptoms, 24.7% (23/93) of the children and 22.9% (16/70) of the adolescents had a doctor's diagnosis, leaving the majority (75.3% and 77.1%, respectively) undiagnosed (table 3). Only 15% of participants with self-reported asthma had a written asthma action plan.

Medication use in children and adolescents with self-reported asthma

Fewer than a quarter of the children and adolescents with self-reported asthma used inhaled medication (table 4). Under 5% used inhaled corticosteroids (ICS). Inhaled salbutamol was the most frequently used medication (8.8%).

Diagnostic test findings

Of 170 children eligible for testing, 112 (65.8%) had valid FeNO measurements with a median of 17 ppb (IQR 11–29). Among these, 29.5% (33/112) had a FeNO value ≥ 25 ppb. Asthma was previously diagnosed in 25/112 (22.3%) and 8/25 (32%) had FeNO > 25 ppb and 25/87 (28.7%) with undiagnosed asthma had FeNO > 25 ppb. Severe asthma symptoms were reported by 56/112 (50%) with 21/56 (37.5%) showing FeNO ≥ 25 ppb (table 5).

Of 170 eligible children, 96 (56.5%) underwent spirometry tests and 68/96 (70.8%) tests were of good quality, with 23/68 (33.8%) confirming asthma (21 had airflow limitation and 9 reversibility). Of the 68 good tests 12 (17.6%) had a previous asthma diagnosis and 5/12 (41.7%) had asthma confirmed by spirometry and 18/56 (32.1%) previously undiagnosed had

Table 4 Use of asthma medications in children and adolescents with asthma symptoms

Variables	6–7 years			13–14 years		
	Kumasi, Ghana, n=62	Kampala, Uganda, n=108	Total n=170	Lubumbashi, Democratic Republic of the Congo, n=66	Kano, Nigeria, n=48	Total n=114
Inhaled medicines (%)	13 (21.0)	10 (9.3)	23 (13.5)	9 (13.6)	8 (16.7)	17 (14.9)
ICS	2 (3.2)	1 (0.9)	3 (1.8)	0	0	0
ICS+LABA	5 (8.1)	1 (0.9)	6 (3.5)	0	0	0
SABA inhaler	13 (21.0)	2 (1.9)	15 (8.8)	0	0	0
Tablets (%)	14 (22.6)	15 (13.9)	29 (17.1)	11 (16.7)	20 (41.7)	31 (27.2)
Salbutamol tablets	6 (9.7)	6 (5.6)	12 (7.1)	2 (3.0)	4 (8.3)	6 (5.3)
Oral steroid	3 (4.8)	9 (8.3)	12 (7.1)	1 (1.5)	0	1 (0.9)
Leukotriene receptor antagonist	6 (9.7)	6 (5.6)	12 (7.1)	0	0	0
Others	3 (4.8)	0	3 (1.8)	5 (7.6)	10 (20.8)	15 (13.2)
None of the adolescents specified the type of inhaled medicine used.						
ICS, inhaled corticosteroid; LABA, long-acting β_2 agonist; SABA, short-acting β_2 agonist.						

Table 5 Diagnostic tests findings

Variables	6–7 years N (%)	13–14 years N (%)
Median FeNO (IQR) in ppb	17 (11–29)	23 (14–36)
Positive FeNO ≥ 25 ppb (%)	33/112 (29.5)	49/105 (46.7)
Severe asthma with positive FeNO (%)	21/56 (37.5)	28/64 (43.8)
Diagnosed asthma with positive FeNO (%)	8/25 (32.0)	10/20 (50.0)
Undiagnosed asthma with positive FeNO (%)	25/87 (28.7)	46/85 (54.1)
Median FEV ₁ z-Score (IQR)	−0.80 (−1.6 to −0.3)	−1.76 (−2.49 to −0.67)
Median FEV ₁ /FVC z-Score (IQR)	−0.6 (−1.40 to 0.06)	−0.17 (0.46 to 0.99)
Positive spirometry* (%)	23/68 (33.8)	19/37 (51.4)
Severe asthma with positive spirometry	10/36 (27.8)	12/21 (57.1)
Diagnosed asthma with positive spirometry	5/12 (41.7)	3/10 (30.0)
Undiagnosed asthma with positive spirometry	18/56 (32.1)	16/27 (59.3)
Positive for any diagnostic tests (FeNO or spirometry)	47/113 (41.6)	64/105 (61.0)
Severe asthma with any positive test	26/57 (45.6)	33/64 (51.6)
Diagnosed asthma with any positive test	9/25 (36.0)	12/20 (60.0)
Undiagnosed asthma with any positive test	38/88 (43.2)	45/85 (52.9)
Positive FeNO ≥ 25 ppb. *Positive spirometry = FEV ₁ /FVC ratio $< 80\%$ or LLN or FEV ₁ $< 80\%$ or LLN or a positive bronchodilator reversibility with increase in FEV ₁ $\geq 12\%$ and/or ≥ 200 mL postbronchodilator. FeNO, fractional exhaled nitric oxide; FEV ₁ , forced expiratory volume in the first second; FVC, forced vital capacity; LLN, lower limit of normal.		

confirmatory spirometry. Among 36/68 (52.9%) with severe asthma symptoms, 10/36 (27.2%) had a confirmatory test (table 5).

Overall, 113 children had reliable FeNO and/or spirometry test results and 41.6% (47/113) had asthma confirmed on at least one test.

Of 114 eligible adolescents, 105 (92.1%) provided valid FeNO data with a median of 23 (IQR 14–36) ppb and 49 (46.7%) had levels ≥ 25 ppb. Asthma was previously diagnosed in 20/105 (19.0%), half (10/20) of whom had FeNO ≥ 25 ppb and 46/85 (54.1%) previously undiagnosed had FeNO ≥ 25 ppb. Severe asthma symptoms were reported by 64/105 (61.0%) with 43.8% (28/64) having FeNO ≥ 25 ppb (table 5).

Of 114 eligible adolescents, 67 (58.8%) underwent spirometry and 37/67 (55.2%) tests were of good quality with 19 (51.4%) confirming asthma based on airflow limitation only. Of the 10/37 (27.0%) with a previous diagnosis of asthma, 3/10

(30.0%) had a confirmatory result and 16/27 (59.3%) previously undiagnosed had a confirmatory result. Severe asthma symptoms were reported by 21/37 (56.8%) with 12/21 (57.1%) having a confirmatory test (table 5).

Overall, 61% of the 105 adolescents with reliable FeNO or spirometry results had asthma confirmed by either test (table 5). See online supplemental table S3 in the online supplement for the results of asthma diagnostic tests categorised by age group and city. There was no significant relationship between confirmatory asthma diagnostic tests using FeNO or spirometry and asthma severity or previous diagnosis across both age groups (data not shown). Comparison of participants with good quality diagnostic tests and those without is shown in the Online supplemental table 4. The only significant difference was that a higher proportion of children completed good quality spirometry tests in Uganda compared with Ghana.

Estimated prevalence of confirmed asthma based on positive diagnostic tests

The estimated prevalence of objectively confirmed asthma among participants aged 6–7 years was 3.4% with sensitivity analyses indicating a range from 2.2% to 3.4%. Among adolescents, the prevalence was 2.9%, with sensitivity analyses ranging from 2.7% to 3.0% (table 6).

DISCUSSION

We found that children aged 6–7 years had a prevalence of current wheeze of 7.2%, self-reported asthma of 8.1%, severe asthma of 4.4% and confirmed asthma of 3.4%. The respective prevalence estimates in adolescents aged 13–14 years were 4.3%, 4.8%, 3.0% and 2.9%. There was some variation across cities in both age groups. Similar to the GAN Phase I Study, there was a higher proportion of male children and female adolescents affected by asthma.¹ Fewer than a quarter of all children and adolescents with self-reported asthma had a doctor's diagnosis, about 50% experienced severe symptoms and 40% of adolescents missed at least one school day in the preceding year due to asthma. Three quarters with severe asthma remained undiagnosed. Asthma was confirmed in 42% of children and 60% of adolescents with self-reported asthma providing an estimated prevalence of confirmed asthma of 3.4% and 2.9%, respectively. Most participants with self-reported asthma did not receive regular ICS treatment, a key component of asthma management.

The prevalence of current wheeze among children in this study is consistent with the 10% global estimate from the GAN Phase I Study, but higher than 2.7% average from the Asthma Insight and Reality (AIR) Survey in Nigeria across five cities.^{3 18} Among adolescents, our prevalence estimate was lower than the global

Table 6 Estimated prevalence of confirmed asthma based on positive diagnostic tests

Variable	6–7 years			13–14 years		
	Kumasi, Ghana	Kampala, Uganda	Total	Lubumbashi, Democratic Republic of the Congo	Kano, Nigeria	Total
Eligible for testing	62/1107 (5.6%)	108/1001 (10.8%)	170/2108 (8.1%)	66/1222 (5.4%)	48/1147 (4.2%)	114/2369 (4.8%)
Positive diagnostic test*	20/46 (43.5%)	27/67 (40.3%)	47/113 (41.6%)	32/63 (50.8)	25/42 (59.5%)	64/105 (61.0%)
Estimated 'confirmed asthma' prevalence	2.4% (1.8%–2.4%)†	4.4% (2.7%–4.4%)†	3.4% (2.2%–3.4%)†	2.7% (2.6%–2.8%)†	2.5% (2.2%–2.5%)†	2.9% (2.7%–3.0%)†
*Proportion of positive good quality diagnostic tests †Upper and lower bound estimates						

and African estimates from the GAN Study (5.7% in Khartoum, 10.6% in Ibadan and 21.3% in Cape Town) and slightly below the 5.5% reported in the AIR Nigeria Study.^{3 18} However, our prevalence estimate in Kano (3.7%) is comparable to the 3.5% previously reported in the AIR Nigeria Study, while findings in the Democratic Republic of the Congo are lower than the 7.5% reported in Kinshasa in the International Study of Asthma and Allergies in Children phase III.¹⁹

Regional disparities in asthma prevalence across Africa reflect a combination of genetic, climatic, urbanisation and environmental factors, operating both between and within countries. For example, Lagos (south-west) is characterised by high traffic density and particulate air pollution, which has been associated with higher asthma prevalence, whereas Kano (north-west) reports lower prevalence alongside different environmental exposures, including seasonal dust and carbon monoxide.^{18 20 21} These variations highlight the need for context-specific data to guide resource allocation, inform targeted interventions and optimise healthcare delivery.

Asthma prevalence estimates were lower when based on objective testing compared with questionnaire-defined self-reported asthma, particularly among children aged 6–7 years, where fewer than half had confirmatory test results. Similar findings were reported from the ACACIA Study, where only about half of the adolescents screening positive by questionnaire were confirmed by testing, highlighting the limitations of questionnaire-based methods. This disparity raises important considerations for clinical practice, public health and future research. While a negative test does not exclude asthma, reliance on questionnaires alone may overestimate prevalence, especially in children where conditions such as lower respiratory tract infections can mimic asthma symptoms. Recall bias and variable interpretation of symptoms like wheeze may further contribute to misclassification. These findings underscore the importance of incorporating objective diagnostic testing into both epidemiological research and routine clinical practice to enhance diagnostic accuracy and support effective public health planning. Considering the limited access to these resources in Africa, a stepwise approach that involves symptom screening, clinical evaluation and diagnostic testing when indicated is a pragmatic approach towards incorporation. Meanwhile, ensuring broader access to diagnostic resources continues to be an essential objective in Africa.²²

Asthma underdiagnosis remains a major challenge in Africa, as reflected by the high proportion of undiagnosed participants with positive diagnostic tests in this study. This underscores the importance of incorporating objective testing into routine evaluation of respiratory symptoms. A pragmatic strategy may combine initial questionnaire screening with targeted diagnostic testing to improve case detection while limiting unnecessary investigations. Strengthening school-based programmes, including teacher education and screening, could further enhance early diagnosis and reduce stigma.^{23 24} Beyond diagnosis, improving access to affordable inhaled therapies is critical, given persistent gaps in availability across the region.^{25 26} The 2025 United Nations high-level declaration on NCDs, which prioritises access to essential inhaled medicines, provides an important policy framework to support these efforts.²⁷

The high burden of severe asthma symptoms and school absenteeism observed in this study is consistent with findings from the ACACIA Study, where approximately half of the participants with self-reported asthma had severe symptoms.⁹ This high burden likely reflects substantial underdiagnosis and undertreatment, particularly limited use of ICS in our study. More so, fewer than one in four participants had a written asthma action

plan, indicating gaps in implementation of guideline-based care by healthcare workers.^{28 29} As asthma action plans are central to self-management and enhancing asthma control, strengthening healthcare provider education is essential. Given workforce constraints in most parts of Africa, task shifting offers a pragmatic approach to expand service delivery.^{30 31} In parallel, community-based education is needed to improve symptom recognition, care-seeking and treatment adherence, while addressing stigma associated with asthma and inhaler use.³²

Consistent with the ACACIA Study, FeNO testing had higher acceptance and completion rates than spirometry.⁹ This likely reflects its simplicity and shorter administration time, supporting its potential as a scalable screening tool in school settings. However, cost remains a key barrier to widespread implementation in African contexts.

A key limitation in our study was incomplete objective diagnostic testing among eligible participants, raising the possibility of verification bias, as those who completed testing may differ systematically from those who did not. For example, symptom severity may have influenced participation, potentially affecting diagnostic yield and prevalence estimates. To address this, we applied a two-stage estimation approach with sensitivity analyses using conservative and less conservative assumptions for untested participants. We did not perform multiple imputation, as missing diagnostic data were unlikely to be missing at random and imputation could bias estimates. Instead, we report a range of plausible prevalence values to reflect uncertainty. Additional limitations include inability of adolescents to specify inhaler type, limiting assessment of treatment patterns, and potential recall bias in symptom reporting. Also, this study was conducted in four urban cities among children attending schools, and our finding may not be generalisable to rural areas, out of school children and other African cities.

There are also notable strengths in this study which include the use of a standardised methodology across a large multicountry school-based population enhancing comparability. Importantly, integrating diagnostic testing alongside questionnaire data provided more robust prevalence estimates and demonstrates the feasibility and scalability of implementing such approaches into school-based asthma programmes in African settings.

In conclusion, this study demonstrates a substantial burden of self-reported asthma among African children, characterised by severe symptoms and frequent underdiagnosis. Integrating diagnostic testing provides a more robust estimate of asthma prevalence which is about 40%–60% of that reported based on the questionnaire. This integrated approach helps to reduce both underdiagnosis and overdiagnosis, guiding future studies. However, limited access to these diagnostic tests remains a major challenge in many African settings. Our findings underscore the importance of context-specific evaluations and interventions such as school-based programmes and education for healthcare providers and the wider community to support better asthma recognition, diagnosis and treatment. Expanding access to diagnostic testing and essential inhaled medicines is crucial to reducing the impact of asthma in Africa.

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REFERENCES

- García-Marcos L, Asher MI, Pearce N, *et al*. The burden of asthma, hay fever and eczema in children in 25 countries: GAN Phase I study. *Eur Respir J* 2022;60:2102866.
- World Health Organisation. Asthma. Available: <https://www.who.int/news-room/fact-sheets/detail/asthma> [accessed 3 Jun 2024]
- Asher MI, Rutter CE, Bissell K, *et al*. Worldwide trends in the burden of asthma symptoms in school-aged children: Global Asthma Network Phase I cross-sectional study. *The Lancet* 2021;398:1569–80.
- Adeloye D, Chan KY, Rudan I, *et al*. An estimate of asthma prevalence in Africa: a systematic analysis. *Croat Med J* 2013;54:519–31.
- Song P, Adeloye D, Salim H, *et al*. Global, regional, and national prevalence of asthma in 2019: a systematic analysis and modelling study. *J Glob Health* 2022;12:04052.
- García-Marcos L, Chiang C-Y, Asher MI, *et al*. Asthma management and control in children, adolescents, and adults in 25 countries: a Global Asthma Network Phase I cross-sectional study. *Lancet Glob Health* 2023;11:e218–28.
- Aaron SD, Boulet LP, Reddel HK, *et al*. Underdiagnosis and Overdiagnosis of Asthma. *Am J Respir Crit Care Med* 2018;198:1012–20.
- Gaillard EA, Kuehni CE, Turner S, *et al*. European Respiratory Society clinical practice guidelines for the diagnosis of asthma in children aged 5–16 years. *Eur Respir J* 2021;58:2004173.
- Oyenuga VO, Mosler G, Addo-Yobo E, *et al*. Asthma symptoms, severity, and control with and without a clinical diagnosis of asthma in early adolescence in sub-Saharan Africa: a multi-country, school-based, cross-sectional study. *The Lancet Child & Adolescent Health* 2024;8:859–71.
- Ozoh OB, Ndimande N, Amaral AFS, *et al*. Chronic respiratory disease observatory for Africa (CHEST-Africa): study protocol for the prevalence, determinants and economic impacts of asthma and COPD in Africa. *BMJ Open Respir Res* 2024;11:e002416.
- Gordon S, Buist S, Ardrey J, *et al*. The birth and life of the Pan African Thoracic Society Methods in Epidemiologic, Clinical and Operations Research (PATS MECOR) program: celebrating 15 years. *JPATS* 2022;3:3–5.
- Ellwood P, Asher MI, Billo NE, *et al*. The Global Asthma Network rationale and methods for Phase I global surveillance: prevalence, severity, management and risk factors. *Eur Respir J* 2017;49:1601605.
- Graham BL, Steenbruggen I, Miller MR, *et al*. Standardization of Spirometry 2019 Update. An Official American Thoracic Society and European Respiratory Society Technical Statement. *Am J Respir Crit Care Med* 2019;200:e70–88.
- Dweik RA, Boggs PB, Erzurum SC, *et al*. An official ATS clinical practice guideline: interpretation of exhaled nitric oxide levels (FENO) for clinical applications. *Am J Respir Crit Care Med* 2011;184:602–15.
- Global Asthma network. Study instrument for 6/7 year olds. 2016. Available: <https://globalasthmanetwork.org/publications/manual/study6.php> [Accessed 14 Feb 2025].
- Khatri SB, Iaccarino JM, Barochia A, *et al*. Use of Fractional Exhaled Nitric Oxide to Guide the Treatment of Asthma: An Official American Thoracic Society Clinical Practice Guideline. *Am J Respir Crit Care Med* 2021;204:e97–109.
- Topole E, Biondaro S, Montagna I, *et al*. ArtiQ.qc facilitates spirometry quality control in asthma and copd clinical trials. ERS International Congress 2021 abstracts; September 5, 2021
- Ozoh OB, Aderibigbe SA, Ayuk AC, *et al*. The prevalence of asthma and allergic rhinitis in Nigeria: A nationwide survey among children, adolescents and adults. *PLoS One* 2019;14:e0222281.
- Ait-Khaled N, Odhiambo J, Pearce N, *et al*. Prevalence of symptoms of asthma, rhinitis and eczema in 13- to 14-year-old children in Africa: the International Study of Asthma and Allergies in Childhood Phase III. *Allergy* 2007;62:247–58.
- Croitoru L, Chang JC, Kelly A. The cost of air pollution in Lagos. Washington, DC; 2020. Available: <https://hdl.handle.net/10986/33038>
- Mahmud K, Mitra B, Uddin MS, *et al*. Temporal assessment of air quality in major cities in Nigeria using satellite data. *Atmospheric Environment: X* 2023;20:100227.
- Plum C, Stolbrink M, Zurba L, *et al*. Availability of diagnostic services and essential medicines for non-communicable respiratory diseases in African countries. *Int J Tuberc Lung Dis* 2021;25:120–5.

- 23 Chini L, Iannini R, Chianca M, *et al.* Happy air®, a successful school-based asthma educational and interventional program for primary school children. *J Asthma* 2011;48:419–26.
- 24 Naidoo KL, Dladla S, Mphahlele RE, *et al.* Barriers to childhood asthma care in sub-Saharan Africa: a multicountry qualitative study with children and their caregivers. *BMJ Open* 2023;13:e070784.
- 25 Ozoh OB, Eze JN, Garba BI, *et al.* Nationwide survey of the availability and affordability of asthma and COPD medicines in Nigeria. *Trop Med Int Health* 2021;26:54–65.
- 26 Stolbrink M, Ozoh OB, Halpin DMG, *et al.* Availability, cost and affordability of essential medicines for chronic respiratory diseases in low-income and middle-income countries: a cross-sectional study. *Thorax* 2024;79:676–9.
- 27 Political declaration of the fourth high-level meeting of the General Assembly on the prevention and control of noncommunicable diseases and the promotion of mental health and well-being. Available: <https://www.who.int/publications/m/item/political-declaration-of-the-fourth-high-level-meeting-of-the-general-assembly-on-the-prevention-and-control-of-noncommunicable-diseases-and-the-promotion-of-mental-health-and-well-being> [Accessed 25 Jan 2026].
- 28 Merghani MM, Mohammed RGA, Al-Sayaghi KM, *et al.* Asthma-related school absenteeism: Prevalence, disparities, and the need for comprehensive management: A systematic review and meta-analysis. *Dialogues Health* 2025;7:100239.
- 29 Adiele DK, Onyia JT, Mbanefo N, *et al.* Comparative Management of Childhood Asthma in Urban and Rural Settings in Sub-Saharan Africa. *Niger J Clin Pract* 2025;28:1163–9.
- 30 Rylance S, Chinoko B, Mnesa B, *et al.* An enhanced care package to improve asthma management in Malawian children: a randomised controlled trial. *Thorax* 2021;76:434–40.
- 31 Ozoh OB, Akinbolagbe Y, Tekobo A, *et al.* The feasibility and effect of a nurse-led, patient-centered asthma education program in a Nigerian context. *J Asthma* 2022;59:1670–9.
- 32 Mosler G, Nkhalamba LM, Mkutumula E, *et al.* Using theatre to transform understanding and attitudes about asthma in African adolescents. *Health Promot Int* 2025;40:daaf189.