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RESEARCH ARTICLE

Asthma control and management among schoolchildren in urban Uganda: results from a cross-sectional study [version 1; peer review: 1 approved, 2 approved with reservations]

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Abstract

Background: Children from low- and middle-income countries have poor asthma control, mainly because of poor management. The extent of this problem in Uganda is not well known, but such information would be useful to guide policy and practice. We therefore conducted a cross-sectional study among schoolchildren with asthma in urban Uganda, to assess the level of asthma control and management.

Methods: Schoolchildren aged 5-17 years were enrolled, asthma was diagnosed by the study medical team. Asthma control was assessed using the Asthma Control Test and the childhood Asthma Control Test. Data on previous asthma management was obtained using interviewer-led questionnaires. Data were analysed using multiple linear and multiple logistic regression.

Results: We enrolled 561 children with asthma, of whom only 56% had ever had an asthma diagnosis. We categorised asthma as well-controlled (55.5%), partly-controlled (29.5%) and poorly-controlled (15.0%). Poor asthma control was associated with increasing age (adjusted regression coefficient [95% confidence interval], p-value: -1.07 [-1.20, -0.94], p<0.0001), concurrent allergic rhinitis (-1.33 [-2.28, -0.38], p=0.006), and city residence in early life (-1.99 [-3.69, -0.29], p=0.06). Regular use of inhaled asthma medication in the last 12 months was very low; 18.1% for salbutamol and 6.7% for inhaled corticosteroids. The main barriers to inhaled asthma medication use were lack of prescription (47.6%) and inaccurate diagnosis (38.8%). Increased inhaler use was associated with tertiary education of the fathers (adjusted odds ratio [95% confidence interval], p-value: 5.19 [2.39-11.28], p<0.0001), city residence in early life (4.66 [1.79-12.43], 0.002) and an asthma diagnosis prior to enrolment (11.39 [6.35-20.43], p<0.0001).

Conclusions: This study confirms that children with asthma in Uganda

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Reviewer Status ❓ ❓ ✅

	Invited Reviewers		
	1	**2**	**3**
version 1 05 Nov 2019	❓ report	❓ report	✅ report

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generally have inadequate asthma control, which is attributable to poor asthma management. This could be improved through re-training of medical workers and patient education, and by increasing availability and affordability of essential asthma medications.

Keywords
Asthma control, asthma management, schoolchildren, Uganda, salbutamol, inhaled corticosteroids, Asthma Control Test

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Author roles: Mpairwe H: Conceptualization, Data Curation, Formal Analysis, Funding Acquisition, Investigation, Methodology, Project Administration, Resources, Supervision, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; **Tumwesige P**: Investigation, Project Administration, Writing – Review & Editing; **Namutebi M**: Investigation, Project Administration, Writing – Review & Editing; **Nnaluwooza M**: Investigation, Writing – Review & Editing; **Katongole T**: Investigation, Writing – Review & Editing; **Tumusiime J**: Investigation, Writing – Review & Editing; **Apule B**: Investigation, Writing – Review & Editing; **Onen C**: Investigation, Writing – Review & Editing; **Mukasa M**: Investigation, Writing – Review & Editing; **Kahwa J**: Data Curation, Writing – Review & Editing; **Webb EL**: Formal Analysis, Methodology, Validation, Visualization, Writing – Review & Editing; **Pearce N**: Conceptualization, Methodology, Resources, Supervision, Writing – Review & Editing; **Elliott AM**: Conceptualization, Funding Acquisition, Resources, Supervision, Writing – Review & Editing

How to cite this article: Mpairwe H, Tumwesige P, Namutebi M *et al.* **Asthma control and management among schoolchildren in urban Uganda: results from a cross-sectional study [version 1; peer review: 1 approved, 2 approved with reservations]** Wellcome Open Research 2019, **4**:168 https://doi.org/10.12688/wellcomeopenres.15460.1

First published: 05 Nov 2019, **4**:168 https://doi.org/10.12688/wellcomeopenres.15460.1

Background

Poor asthma control among children in low- and middle-income countries (LMICs) is believed to be relatively common, and mainly because of poor asthma management. Studies have shown increased asthma severity among children in LMICs compared to children in high income countries (HICs)[1]. The health systems in most LMICs are not well adapted to the management of chronic conditions[2]. In several LMICs, essential asthma medications, such as inhaled bronchodilators (salbutamol) and inhaled corticosteroids, are not on the country's essential drugs lists[3] and are not easily available[4]. This leads to poor asthma control, higher rates of asthma attacks and higher mortality[5].

The level of asthma control and management among children from the general population has not been investigated in Uganda, and there have been few investigations in other low income countries. This information is important in informing policy on the extent of the problem, and in identifying areas where improvements could be made cost-effectively. We therefore conducted a cross-sectional study among schoolchildren in urban Uganda with asthma, to assess their levels of asthma control and previous management.

Methods

Study design

This cross-sectional study included all schoolchildren with asthma who participated in a large case-control study whose aim was to investigate the risk factors for asthma[6]. We report using the STROBE guidelines[7].

Study population, recruitment and consent

We recruited schoolchildren, 5–17 years, from primary and secondary schools in an urban area of Wakiso District, in central Uganda. At each school, all children were pre-screened for breathing problems by the study nurses; this involved requesting all children with any current breathing problems to register with the study team or the class teacher. Children with any self-reported breathing problems were provided with cards inviting their parents or guardians for a parents' meeting. During the meeting, the study team explained what the study was about, talked about asthma in general and responded to any questions or concerns that the parents raised. Parents or guardians interested in their child participating in the study provided written informed consent for participation in the study and publication of anonymised study findings. The consent process was conducted in either English or Luganda (the main local language). Children eight years or older provided written informed assent. Study enrolment was between May 2015 and July 2017.

Ethical approval

The study was approved by the Uganda Virus Research Institute Research and Ethics Committee (reference number: GC/127/14/09/481), and the Uganda National Council for Science and Technology (reference number: HS 1707).

Asthma diagnosis

All study procedures were conducted at the school premises, to minimise interruption of the pupils' studies. We screened for asthma with the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire[8]. Children with wheezing in the last 12 months were further assessed by the study medical or clinical officers, including a detailed medical and treatment history reported by parents or adolescents and clinical assessments including spirometry. Asthma diagnosis was mostly clinical, as a history of recurrent symptoms of wheezing, chest tightness, shortness of breath and cough (that is mostly dry, worse at night and in the morning). In addition, we assessed for forced expiratory volume in the first second (FEV_1) and considered values <80% of the expected values for age, sex, height and race abnormal. However, this contributed to, but was not a requirement for, the asthma diagnosis. We enquired, from the parents or the adolescents, about medical history of a prior physician asthma diagnosis and good response to asthma medication. For children whose asthma diagnosis was not straightforward, two clinicians reviewed that participant and if they disagreed, that participant was excluded from the study. Children who did not report asthma symptoms in the last 12 months were also excluded from this study.

We collected data on asthma symptoms in the last four weeks using the childhood Asthma Control Test (c-ACT)[9] for children less than 12 years, and the Asthma Control Test (ACT) for children 13 years and older[10]. We enquired about asthma medications that the children had ever used in the past, as well as medications that they had used regularly because of asthma symptoms in the last 12 months. Questionnaires[11] were interviewer-led and were answered by either the adolescents or by the parents/guardians for the younger children.

The clinical assessments included spirometry using a handheld device (Micro 1 Diagnostic Spirometer, CareFusion, Chatham Marine, United Kingdom); skin prick tests (SPT) with seven allergen extracts (*Dermatophagoides* mix [*D. farinae* and *D. pteronyssminus*], *Blomia tropicalis*, *Blattella germanica*, peanut, cat, pollen mix [weeds], and mould mix [*Aspergillus* mix], with negative saline and positive histamine controls [ALK Abello, Hoersholm, Denmark]), using standard procedures described previously[12]. This involved pricking through droplets of the allergens on the volar aspect of the participant's arm with a skin lancet; the size of the wheal was measured after 15 minutes. Fractional exhaled nitric oxide (FENO) was measured using a handheld device (NoBreath® from Bedfonf Scientific, Maidstone, United Kingdom).

Data management and statistical methods

Data were collected using pre-coded questionnaires[11] and double entered into OpenClinica open source software version 3.1.4 (OpenClinica LLC and collaborators, Waltham, MA, USA), and analysed in STATA, version 15 (StataCorp, Texas, USA).

For analyses where the outcome was asthma control scores as a continuous variable, the independent t-test or one-way ANOVA were used for univariate analysis, and multiple linear regression was used to control for confounders. For binary outcomes, we used standard chi square tests and multiple logistic regression. We built the final multiple regression

models by adding one potential confounder at a time and examined the change in the main effect estimate; factors that were closely related (such as father's and mother's education level, or area of residence at birth and in the first five years) were not included in the same model to avoid multicollinearity[13]. We did not impute for missing data.

Results

Characteristics of study participants

We enrolled 562 children with asthma from 55 schools, but one child was excluded from the current analysis because of incomplete data. Detailed participant flow diagram is published[6]. At enrolment, only four children had wheezing symptoms; and of 477 (85%) children who successfully underwent spirometry, only three had forced expiratory volume in the first second (FEV$_1$) values less than 80% of predicted values[14]. The mean age was 11.4 years (range 5–17 years), 52.8% were girls and 47.3% and 37.9% had fathers and mothers with tertiary education, respectively (Table 1). Based on the ISAAC questionnaire, 28.7% children reported four or more wheezing attacks in the last 12 months; 71.9% reported that their chest sounded wheezy during or after exercise in the last 12 months; 74.0% reported a dry cough at night in the last 12 months that was not associated with a common cold or chest infection; however, only 55.9% had ever had an asthma diagnosis (Table 1).

Factors associated with asthma control

Total scores from the ACT and c-ACT were generated for each child, using the standard cut-off points of >19 for well-controlled, 15–19 for partly controlled, and <15 for poorly controlled asthma. Asthma control categories were 55.5% well-controlled, 29.5% partly controlled and 15.0% poorly controlled (Table 1).

We assessed factors associated with asthma control, based on ACT and c-ACT test scores (low scores indicate poorer asthma control). We found that older children were more likely to have lower asthma control scores (adjusted coefficient [95% confidence interval], p-value: -1.07 [-1.20, -0.94], p<0.0001); children who reported regular vigorous physical activity three or more times a week (WHO recommendation[15]) had higher scores (0.84 [0.01, 1.67], p=0.05); children with concurrent allergic rhinitis had lower scores (-1.33 [-2.28, -0.38], p=0.006); children who reported receiving antimalarial medication twice or more in the last 12 months had lower scores (-1.38 [-2.31, -0.45], p=0.007); and children who spent most of their first five years in the city had lower scores (-1.99 [-3.69, -0.29], p=0.06) (Table 2). However, SPT and FENO were not significantly associated with asthma control.

Reported medications previously used for asthma

Only 26.8% (148/553) children reported having ever used inhaled asthma medications, and 29.7% (164/553) reported having ever used herbal remedies for asthma management. Participants reported that the medications they used regularly (for asthma symptoms) in the last 12 months were steroid tablets (particularly prednisolone, 27.0%), salbutamol inhaler

Table 1. Characteristics of the Ugandan schoolchildren with asthma (N=561).

Characteristic	n	%
Age (years) mean, range (m=1)	11.4	5 - 17
Sex		
Boys	265	47.2
Girls	296	52.8
Father's highest education level attained (m=5)		
None/Primary	99	17.8
Secondary	194	34.9
Tertiary	263	47.3
Mother's highest education level attained (m=7)		
None/Primary	159	28.7
Secondary	185	33.4
Tertiary	210	37.9
Number of wheezing attacks in the last 12 months[‡] (m=4)		
One	150	26.9
2–3	247	44.4
4 or more	160	28.7
Ever had asthma diagnosis (m=8)[‡]		
Yes	309	55.9
Chest sounded wheezy during or after exercise (m=9)[‡]		
Yes	397	71.9
Had dry cough at night not associated with a cold, 'flu' or chest infection (m=8)[‡]		
Yes	409	74.0
Asthma control in the last four weeks, based on ACT and cACT scores (m=8)		
Well controlled (scores >19)	307	55.5
Partly controlled (scores 15–19)	163	29.5
Poorly controlled (scores <15)	83	15.0

N, number; m, missing; [‡]Based on the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire; ACT, Asthma Control Test; cACT, childhood Asthma Control Test.

(18.1%), salbutamol tablets (17.4%), inhaled corticosteroids (6.7%), antihistamines (particularly cetirizine, 6.2%), aminophylline tablets or injections (5%), unspecified cough remedies (4.6%), antibiotics (2.8%), other unspecified tablets (2.6%), herbal remedies (2.5%), and nebulised salbutamol (1%).

We looked at the correlation between asthma control in the last four weeks and type of asthma medication used in the last 12 months. This was to assess the proportion of children currently with poor asthma control who had received the correct asthma treatment at any point in the last 12 months. We found that among 83 children currently with poorly controlled asthma, only 19 (20.9%) and six (7.2%) had used

Table 2. Factors associated with asthma control test scores among Ugandan schoolchildren.

Participants' characteristics	Asthma control test scores[#] N=553			
	Univariate analysis		Multivariate analysis[‡]	
	Mean (SD)	p-value	Adjusted mean difference (95% CI)	p-value
Age [m=1]				
5–12 years (n=338)	27.32 (3.80)		ref	
13–17 years (214)	18.37 (4.60)	<0.0001	-1.07 (-1.20, -0.94)	<0.0001
Sex				
Male (261)	25.18 (5.46)		ref	
Female (292)	22.68 (6.23)	<0.0001	-0.54 (-1.34, 0.26)	0.18
Regular physical exercise as recommended by WHO				
No (251)	21.91 (6.08)		ref	
Yes (302)	25.49 (5.44)	<0.0001	0.84 (0.01, 1.67)	0.05
Concurrent allergic rhinitis [m=1]				
No (434)	24.40 (5.97)		ref	
Yes (118)	21.88 (5.77)	0.0001	-1.33 (-2.28, -0.38)	0.006
Received antimalarial treatment in the last 12 months [m=1]				
None (208)	24.45 (5.89)		ref	
Once (169)	24.56 (5.76)		-0.15 (-1.08, 0.78)	
Twice or more (175)	22.48 (6.19)	0.001	-1.38 (-2.31, -0.45)	0.007
Area of residence in first five years of life				
Rural (71)	23.62 (5.18)		ref	
Town (433)	24.18 (6.09)		-0.60 (-1.77, 0.57)	
City (49)	21.37 (5.86)	0.007	-1.99 (-3.69, -0.29)	0.06
Skin prick test responses [m=9]				
Negative (<3mm) (244)	24.00		ref	
Positive (≥3mm) (300)	23.75	0.63	-0.51 (-1.31, 0.29)	0.21
Fractional exhaled nitric oxide levels [m=13]				
Normal (<35ppb) (335)	23.91		ref	
Elevated(≥35ppb) (195)	23.62	0.59	0.42 (-0.39, 1.24)	0.31

N, number; SD, standard deviation; CI, confidence interval; ref, reference; m, missing; WHO, World Health Organisation; ppb, parts per billion.

[#]Asthma control test scores are based on Asthma Control Test (ACT) and childhood Asthma Control Test (cACT); scores ranged from 8–34, low scores indicating poor asthma control and high scores indicating well controlled asthma.

[‡]Final linear regression model adjusted for age, sex, exercise as recommended by WHO, concomitant allergic rhinitis, antimalarial treatment, area of residence in early life and father's education level; (model constant =37.30, R^2=0.44, F-ratio [10, 537] =41.69, p<0.0001, N=548).

inhaled salbutamol and inhaled corticosteroids, respectively, in the last 12 months (Table 3). Instead, a larger proportion had regularly used salbutamol tablets (26.5%) and steroid tablets (28.9%). We observed that of the 307 children with *well-controlled* asthma, 153 (49.8%) reported not using salbutamol or steroids in any formulation (Table 3), suggesting that perhaps they had mild asthma.

Reported previous asthma assessments

We also enquired about previous asthma assessments and follow-up, and found that only 45 (8.2%) children had ever had a lung function test; only two (0.4%) had ever used a peak flow meter to monitor their asthma at home; 13.2% reported visiting a health facility to monitor their asthma; and only three (0.5%) had a personal written asthma action plan.

Table 3. Asthma control in last four weeks and regularly used asthma medications in the last 12 months (N=553).

Regular asthma medication in the last 12 months	Asthma control in the last four weeks (ACT and cACT scores)			
	Well controlled, n (%) (scores >19) N=307	Partly controlled, n (%) (scores 15–19) N=163	Poorly controlled, n (%) (scores <15) N=83	p-value
Salbutamol inhaler				
Yes (n=100)	51 (16.6)	30 (18.4)	19 (20.9)	0.42
Inhaled corticosteroids				
Yes (37)	22 (7.2)	9 (5.5)	6 (7.2)	0.78
Salbutamol tablets				
Yes (96)	45 (14.7)	29 (17.8)	22 (26.5)	0.04
Steroid tablets (mostly prednisolone)				
Yes (149)	86 (28.1)	39 (23.9)	24 (28.9)	0.57
Neither salbutamol nor steroids				
Yes (225)	153 (49.8)	50 (30.7)	22 (26.8)	<0.0001
Other medications[§]				
Yes (121)	68 (22.2)	32 (19.6)	21 (25.3)	0.59

ACT= Asthma Control Test; cACT=childhood Asthma Control Test; N=number; 2nd-4th columns show numbers (percentages).

[§]Other medications mainly included aminophylline (tablets or injection), antihistamines, antibiotics, various cough and herbal remedies. Only three reported nebulised salbutamol. None reported leukotriene modifiers (such as montelukast) or antimalarials.

Factors associated with having ever used inhaled asthma medication

We assessed factors associated with having ever used inhaled asthma medication, and found these were mother's and father's tertiary education (adjusted odds ratio [95% confidence interval]: 2.91 [1.61-5.25] and 5.19 [2.39-11.28], respectively); the child's area of residence in early life (city residence at birth, 4.66 [1.79-12.43] or in the first five years, 2.99 [1.11-8.05]); and having ever had an asthma diagnosis (11.39 [6.35-20.43]) (Table 4).

Barriers to inhaled asthma medication use

We investigated why 405 of 553 (73%) children enrolled in this study had never used inhaled asthma medications, which are the mainstay of treatment including mild asthma[16]. The reasons included that inhaled asthma medication had never been prescribed for them (47.6%, including children with a previous asthma diagnosis); no asthma diagnosis (38.8%); high cost of inhalers (4.5%); fear of side-effects of inhalers (4.5%); and alternative treatment with herbal or cough remedies (2.2%), or with salbutamol or steroid tablets (1.4%). Some children (1%) reported wrapping up in warm clothes or resting, without any medication.

Reported asthma triggers, and treatment offered

The children reported the following, non-mutually exclusive, triggers for asthma: cold air (89.1%), chest infections (84.0%), physical exercise (78.0%), dust (66.8%), fumes or air pollution (61.9%), emotional distress or excitement (21.6%), pollen or pets (6.5%).

All children were offered one course of asthma treatment according to the Global Initiative for Asthma (GINA) 2015 treatment guidelines[17]. This was determined by the study clinicians, using participants' detailed asthma symptoms reported on the Asthma Control Test (ACT) or childhood Asthma Control Test (cACT). According to the GINA 2015 guidelines, 279 (50.4%) children received step I [salbutamol inhaler as needed], 209 (37.8%) children step II [salbutamol inhaler as needed and low dose inhaled corticosteroids], 52 (9.4%) children step III [salbutamol inhaler as needed, and low dose inhaled corticosteroids and long acting beta$_2$-agonist], and 13 (2.4%) children step IV [salbutamol inhaler as needed, and medium dose inhaled corticosteroids and long acting beta$_2$-agonist]. None received step V treatment. Participants were then referred to one of the two asthma clinics in the study area for further management, according to their preference.

Discussion

We found that asthma control among Ugandan schoolchildren was poor, and this was mainly related to inadequate management. About half the children had either partly or poorly controlled asthma in the previous four weeks, 44% had asthma that had never been diagnosed, and only 7% had used the

Table 4. Factors associated with having ever used inhaled asthma medication.

Characteristic	Ever used inhaled treatment? (N=553)		Adj. OR (95% CI)[#]	p-value
	Yes n (%)	No n (%)		
Mother's education (m=6)				
None/primary (n=154)	24 (15.6)	130 (84.4)	1	
Secondary (183)	43 (23.5)	140 (76.5)	1.26 (0.68-2.35)	
Tertiary (210)	81 (38.6)	129 (61.4)	2.91 (1.61-5.25)	0.0002
P-value for trend			*p<0.0001*	
Father's education (m=4)				
None/primary (97)	10 (10.3)	87 (89.7)	1	
Secondary (189)	44 (23.3)	145 (76.7)	2.24 (1.00-5.02)	
Tertiary (263)	94 (35.7)	169 (64.3)	5.19 (2.39-11.28)	<0.0001
P-value for trend			*p<0.0001*	
Area of residence at the time of the child's birth				
Rural (74)	9 (12.2)	65 (87.8)	1	
Town (411)	106 (25.8)	305 (74.2)	1.93 (0.86-4.35)	
City (68)	33 (48.5)	35 (51.5)	4.66 (1.79-12.43)	0.002
P-value for trend			*P=0.001*	
Area of residence where child spent most of 0–5 years				
Rural (71)	10 (14.1)	61 (85.9)	1	
Town (433)	114 (26.3)	319 (73.7)	1.60 (0.73-3.50)	
City (49)	24 (49.0)	25 (51.0)	2.99 (1.11-8.05)	0.08
P-value for trend			*p=0.03*	
Ever had asthma diagnosis (m=7)				
No (241)	17 (7.0)	224 (93.0)	1	
Yes (305)	131 (42.9)	174 (57.1)	11.39 (6.35-20.43)	<0.0001

N, number; Adj.OR, adjusted odds ratio; CI, confidence interval; m, missing;

[#]Adjusted for child's age and sex, father's education, area residence at birth, asthma diagnosis ever, and asthma control.

recommended inhaled corticosteroids in the last 12 months. These findings confirm that children with asthma in Uganda have poor asthma management, which stems from systemic failures of the health system.

The level of asthma control we observed was similar to that reported in a study from Cameroon[18]. We found that poor asthma control was associated with three factors: increasing age, concurrent allergic rhinitis and city residence in early life. The association between concurrent allergic rhinitis and poor asthma control has been reported elsewhere[19]. The association between city residence in early life and poor asthma control was particularly interesting. Our earlier work found

that asthma risk among schoolchildren who resided in the city in their early years was three times higher than their classmates who resided in rural areas in early life[6]. This suggests that city residence in early life is associated with both increased asthma risk and asthma severity.

Children with poor asthma control were less likely to engage in regular physical exercise. For some children, this was their way of controlling asthma symptoms. Other studies have observed that children with asthma symptoms avoid activities or exercise[20,21]. What was intriguing was the finding that children with poor asthma control were more likely to have received several doses of antimalarial treatment in the last year, yet

antimalarials were not among medications that children reported using to control asthma symptoms. This is the first report of this kind. We did not ascertain whether these antimalarials were prescribed by medical workers or were self-administered. In Uganda, the antimalarials currently in use are artemisinin and its derivatives artesunate and artemether, which are either freely available from health service providers or easily available as over-the-counter medications (a positive laboratory test is not a requirement). It is important to investigate why poor asthma control was associated with increased use of antimalarials.

Asthma management in this urban area was very poor. Although inhaled medications (salbutamol and inhaled corticosteroids) are the main stay of asthma treatment[16], less than one-third of the children with asthma in this setting had ever been treated with any form of the recommended inhaled medication, and only 20% utilised inhaled salbutamol and 7% inhaled corticosteroids in the last 12 months. These percentages were no better for children with poor asthma control in the last four weeks. This suggests that the poor asthma control could be attributed to lack of correct asthma treatment. Instead, children with asthma were using inferior medications such as salbutamol tablets, which are known to cause numerous side-effects, and medications that have no role in asthma treatment, such as antihistamines, cough and herbal remedies. This was particularly disappointing because salbutamol and beclomethasone (an inhaled corticosteroid) inhalers are on the country's Essential Medicines and Health Supplies list (EMHSLU) and in the National Treatment Guidelines.

Medical workers played an important role in the inadequate asthma management that we observed, from diagnosis and prescription to follow-up. Their inadequate prescription of inhaled asthma medications may have been related to the limited availability and affordability of inhaled asthma medications, as previously reported[22]. However, their lack of accurate prescriptions could also have been related to their general lack of knowledge on current asthma management guidelines, which emphasise inhaled rather than oral formulations of salbutamol and steroids. Accurate asthma diagnoses were not always made. We noted that children with a prior asthma diagnosis had increased chances of having received inhaled asthma treatment, and that parents with tertiary education and those in the city were able to seek appropriate treatment for their children's asthma. Therefore, there is an urgent need to re-train medical workers in asthma management in this setting, and to update the country's National Treatment Guidelines to reflect the internationally recognised GINA guidelines, in which salbutamol tablets have no role in asthma treatment.

We recognise three main limitations of this study. First, because of the cross-sectional design, there was no follow-up of participants and therefore, we were not able to assess asthma severity. Asthma severity depends on the level of treatment required to control symptoms and exacerbations. Secondly, this study was not designed to collect data from health workers; therefore, we did not establish why health workers did not routinely prescribe inhaled asthma medications. Thirdly, we included only children with a history of wheezing and other asthma symptoms in the last 12 months, which may have excluded children with well-controlled asthma. This potential selection bias is likely to have introduced only minor imprecision to our findings.

The strength of this study was the large number of children with asthma recruited from the general population, thereby increasing the generalisability of the study findings. Our results suggest that the poor asthma management observed could be improved by: re-training health workers in asthma diagnosis and management; increasing patient and public education about asthma; increasing the availability and affordability of inhaled asthma medication; and updating the essential drugs list and national treatment guidelines to include the basic inhaled asthma medications recommended by the GINA treatment guidelines. Given the increasing prevalence of asthma among children in urban areas in LMICs, policy makers must prioritise asthma management at all levels of the health system. Medical training in the country needs to adapt to the epidemiological transition towards non-communicable diseases.

Conclusion
This study confirms that several children in Uganda have inadequately controlled asthma, mostly because of lack of accurate diagnosis, treatment and follow-up.

Data availability
Underlying data
LSHTM Data Compass: SONA project - Asthma management data. https://doi.org/10.17037/DATA.00001358[14].

This project contains the following underlying data:
- SONA_management_data.csv (This dataset includes all the variables that were used in this analysis. This includes participant demographics, previous asthma treatment and management history, asthma control and assessments at enrolment)

- Codebook.html (codebook for asthma management dataset)

Extended data
LSHTM Data Compass: SONA project – Asthma management questionnaire: https://doi.org/10.17037/DATA.00001405[11].

This project contains the following extended data:
- Asthma management questions (questionnaire in PDF and Microsoft Word format)

Data are available under the terms of the Creative Commons Attribution 3.0 International license (CC-BY 3.0).

Acknowledgements

References

1. Lai CK, Beasley R, Crane J, *et al.*: **Global variation in the prevalence and severity of asthma symptoms: phase three of the International Study of Asthma and Allergies in Childhood (ISAAC).** *Thorax.* 2009; **64**(6): 476–83.
   PubMed Abstract | **Publisher Full Text**

2. Beran D, Zar HJ, Perrin C, *et al.*: **Burden of asthma and chronic obstructive pulmonary disease and access to essential medicines in low-income and middle-income countries.** *Lancet Respir Med.* 2015; **3**(2): 159–70.
   PubMed Abstract | **Publisher Full Text**

3. Bissell K, Ellwood P, Ellwood E: **Essential Medicines at the National Level: The Global Asthma Network's Essential Asthma Medicines Survey 2014.** *Int J Environ Res Public Health.* 2019; **16**(4): pii: E605.
   PubMed Abstract | **Publisher Full Text** | **Free Full Text**

4. Kibirige D, Sanya RE, Nantanda R, *et al.*: **Availability and affordability of medicines and diagnostic tests recommended for management of asthma and chronic obstructive pulmonary disease in sub-Saharan Africa: a systematic review.** *Allergy Asthma Clin Immunol.* 2019; **15**: 14.
   PubMed Abstract | **Publisher Full Text** | **Free Full Text**

5. Kirenga BJ, de Jong C, Mugenyi L, *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.
   PubMed Abstract | **Publisher Full Text**

6. Mpairwe H, Namutebi M, Nkurunungi G, *et al.*: **Risk factors for asthma among schoolchildren who participated in a case-control study in urban Uganda.** *bioRxiv.* 2019; 677799.
   Publisher Full Text

7. von Elm E, Altman DG, Egger M, *et al.*: **The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.** *Int J Surg.* 2014; **12**(12): 1495–9.
   PubMed Abstract | **Publisher Full Text**

8. Asher MI, Keil U, Anderson HR, *et al.*: **International Study of Asthma and Allergies in Childhood (ISAAC): rationale and methods.** *Eur Respir J.* 1995; **8**(3): 483–91.
   PubMed Abstract | **Publisher Full Text**

9. Liu AH, Zeiger R, Sorkness C, *et al.*: **Development and cross-sectional validation of the Childhood Asthma Control Test.** *J Allergy Clin Immunol.* 2007; **119**(4): 817–25.
   PubMed Abstract | **Publisher Full Text**

10. Nathan RA, Sorkness CA, Kosinski M, *et al.*: **Development of the asthma control test: a survey for assessing asthma control.** *J Allergy Clin Immunol.* 2004; **113**(1): 59–65.
    PubMed Abstract | **Publisher Full Text**

11. Mpairwe H, Webb E: **SONA project - Asthma management questionnaire.** [Data Collection]. London School of Hygiene & Tropical Medicine, London, United Kingdom. 2014.
    http://www.doi.org/10.17037/DATA.00001405

12. Mpairwe H, Muhangi L, Ndibazza J, *et al.*: **Skin prick test reactivity to common allergens among women in Entebbe, Uganda.** *Trans R Soc Trop Med Hyg.* 2008; **102**(4): 367–73.
    PubMed Abstract | **Publisher Full Text** | **Free Full Text**

13. Greenland S, Daniel R, Pearce N: **Outcome modelling strategies in epidemiology: traditional methods and basic alternatives.** *Int J Epidemiol.* 2016; **45**(2): 565–75.
    PubMed Abstract | **Publisher Full Text** | **Free Full Text**

14. Nyirenda M, Crampin AC, Mclean E, *et al.*: **Malawi Epidemiology and Intervention Research Unit Non-Communicable Disease Survey data, 2013-2017.** [Data Collection]. London School of Hygiene & Tropical Medicine, London, United Kingdom. 2019.
    http://www.doi.org/10.17037/DATA.00000961

15. World Health Organisation: **Information sheet: global recommendations on physical activity for health 5 - 17 years old.** 2011.
    Reference Source

16. Reddel HK, FitzGerald JM, Bateman ED, *et al.*: **GINA 2019: a fundamental change in asthma management: Treatment of asthma with short-acting bronchodilators alone is no longer recommended for adults and adolescents.** *Eur Respir J.* 2019; **53**(6): pii: 1901046.
    PubMed Abstract | **Publisher Full Text**

17. Reddel HK, Bateman ED, Becker A, *et al.*: **A summary of the new GINA strategy: a roadmap to asthma control.** *Eur Respir J.* 2015; **46**(3): 622–39.
    PubMed Abstract | **Publisher Full Text** | **Free Full Text**

18. Hugo MN, Walter PY, Maimouna M, *et al.*: **Assessment of asthma control using asthma control test in chest clinics in Cameroon: a cross-sectional study.** *Pan Afr Med J.* 2016; **23**: 70.
    PubMed Abstract | **Publisher Full Text** | **Free Full Text**

19. de Groot EP, Nijkamp A, Duiverman EJ, *et al.*: **Allergic rhinitis is associated with poor asthma control in children with asthma.** *Thorax.* 2012; **67**(7): 582–7.
    PubMed Abstract | **Publisher Full Text**

20. Jonsson M, Bergstrom A, Egmar AC, *et al.*: **Asthma during adolescence impairs health-related quality of life.** *J Allergy Clin Immunol Pract.* 2016; **4**(1): 144–6.e2.
    PubMed Abstract | **Publisher Full Text**

21. Lochte L, Nielsen KG, Petersen PE, *et al.*: **Childhood asthma and physical activity: a systematic review with meta-analysis and Graphic Appraisal Tool for Epidemiology assessment.** *BMC Pediatr.* 2016; **16**: 50.
    PubMed Abstract | **Publisher Full Text** | **Free Full Text**

22. Kibirige D, Kampiire L, Atuhe D, *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.
    PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Open Peer Review

Current Peer Review Status: ❓ ❓ ✔

Version 1

Reviewer Report 30 June 2020

https://doi.org/10.21956/wellcomeopenres.16907.r38829

✔ **Pierluigi Paggiaro**
Department of Surgery, Medicine, Molecular Biology and Critical Care, University of Pisa, Pisa, Italy

General comments

This paper reports an interesting survey performed in a large sample of children and adolescents in Uganda. The methodology used for selecting potential patients from a full sample of children at school is correct, and the authors were able to individuate a fairly large number of patients with suspected asthma, then confirmed with an appropriate assessment. In this way, the merit of this study was to have examined really patients with proven or very probable asthma. The results of the evaluation of these patients are in agreement with what was expected: poor asthma control, inappropriate previous diagnosis, very low use of anti-asthma drugs. Also the risk factors for poor asthma control are in line with previous known data (exposure to pollutants in inner city, patents' education level, previous asthma diagnosis).

The paper might be suitable, but it require a minor revision, mainly as regards some comments to be included in the discussion.

Specific comments

Few considerations may required to be mentioned and commented on in the discussion
1. The socio-economic level of the participants seems fairly high, considering that 40% about of the parents reported a tertiary level of education. If so, the really low rate of prescription for asthma is more astonishing. It might be interesting to compare the present data with other previous surveys performed in other countries or in more poor or rural populations, to see if the data are similar.

2. Although 50% about of these children were affected by mild asthma, and therefore recommended to use salbutamol only as needed, according to GINA guidelines until 2018, the use of ICS was really very low, and also in more symptomatic patients only salbutamol plus oral steroids (probably in a short-course way) were used. This was completely in disagreement with all asthma guidelines

3. As regards the reason of the very low use of ICS, only 7% attributed this to a high cost of the drug (considering also the medium-high income of the studied population), but almost 50% reported a

lack of prescription from their physician, also when asthma diagnosis was present. This suggest the need of a strong education plan of GPs, according to the implementation program of GINA.

4. What might be the reason for a so high use of salbutamol tablets ?

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Asthma, severe asthma, biomarkers

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 12 May 2020

https://doi.org/10.21956/wellcomeopenres.16907.r38389

?   **Inger Kull** (iD)

Institute of Environmental Medicine, Karolinska Institutet, Stockholm, Sweden

Thank you for the opportunity to review this paper aiming to asses the level of asthma control and management among children. Data arises from a cross sectional study among schoolchildren 5-17 years in Uganda. Asthma was measured by the validated asthma control test and the childhood Asthma control test. The study covers a topic of high clinical importance for asthma management.

Specific comments:
Abstract

Conclusion: Data from the current study do indicate that the inadequate asthma control among a high proportion of children is due to poor asthma management. But can we be sure? I recommend that the authors rephrase the conclusion slightly.

Background:
If possible, I suggest that you support the first statement in the section of background with a reference.

Method:
The participants in the present study were recruited from a large case-control study. I suggest that you present the original cohort in a short sentence.
The study population in the current consisted of 562 children from 55 schools. But how many were children were eligible at all schools? 562 children out of how many? n/N

Results:
Interesting and clearly presented.
A bit confusing the way the authors present the result," adjusted odds ratio (95% Confidence interval), P-value and then the result. I suggest that you delete p-value, to read adjusted odds ratio, xxxx (95% CI xxx-xxx) p-value xxxx.

An interesting result presented is that almost the same proportion reported ever used inhaled asthma medication and herbal remedies. Suggesting a gap between asthma guidelines and asthma management.

Discussion
In the first paragraph of the discussion I expect to find the main result (as in the present version) but also information on study design.

Conclusion:
I find the conclusion at the end of the section preferable. Slightly different from the abstract.

Minor comments:
Key words: Please put key words in alphabetical order
Abstract: A bit confusing the way the authors present the result," adjusted odds ratio (95% Confidence interval), P-value and then the result. I suggest that you delete p-value, to read adjusted odds ration, xxxx (95% CI xxx-xxx) p-value xxxx

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?

No source data required

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Asthma management, epidemiology

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 10 December 2019

https://doi.org/10.21956/wellcomeopenres.16907.r37209

? **Christopher Kuaban**
Faculty of Health Sciences, University of Bamenda, Bamenda, Cameroon

This is an interesting cross-sectional study whose objective was to assess the level of asthma control and management among school children aged 5 to 17 years with asthma in an urban area of Wakiso District in Uganda.

Comments:
- It is not quite clear in the methods what the definition used for designating a school child as asthmatic was. Was asthma defined using the ISAAC definition or it was "mostly clinical as a history of recurrent symptoms of wheezing, chest tightness, shortness of breath and cough that is mostly dry, worse at night and in the morning"? This should be made clear.

- By prescreening and screening for asthma only among children with "any current breathing problems", it can be assumed that there was some selection bias as children with well controlled asthma might not have indicated that they had any current breathing problem. In this case the study might have recruited mostly children whose asthma was not well controlled. This could therefore lead to an over-estimation of poorly managed asthma in this population.

- It is important to indicate how many children were prescreened for the selection of the 562 or 561 children included in the study.

- It is observed that the proportion of children who had ever had a diagnosis of asthma is practically same as that of children whose asthma was well controlled (respectively 55.9% and 55.5%). Could this not mean that the majority of children with poor asthma control was mostly made up of children whose asthma was only diagnosed due to or during the study?

- The authors state that they "looked at the correlation between asthma control in the last four weeks and type of asthma medication used in the last 12 months to assess the proportion of children currently with poor asthma control who have received the correct asthma treatment at any point in the last 12 months". The reason given for this analysis is not convincing as it is not clear how receiving correct medication at any point in the last 12 months can explain poor asthma control in the last four weeks. By the way, nowhere in the text is it mentioned that these children had persistent asthma to warrant that one should guess that they were prescribed daily maintenance therapy and that they might have abandoned treatment thereby causing poor control of their disease. This guess even cannot be true as "clinicians using participants' detailed asthma symptoms" prescribed to 279 (50.4%) children step 1 treatment (Salbutamol as needed). By the way, do we speak of asthma control when patients have a crisis from time to time? I believe asthma control using the scales the authors used is indicated essentially for evaluating control in patients with persistent asthma under medication.

- It would have been interesting to find out if poor asthma control was related to barriers to inhaled asthma medication use and reported asthma triggers and even treatment offered for these triggers rather than just give proportions of these factors found in the children. This is important because apart from medication, preventive measures should be included as a strategy in the management of these patients.

- The discussion and abstract have not been reviewed because they might have to be modified in light of the comments above.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
I cannot comment. A qualified statistician is required.

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Respiratory disorders

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.