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Frequency and pattern of skin-prick aero-allergic sensitization among children with asthma in Lagos, Nigeria

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Abstract: *Background:* Among children with asthma, aero-allergen sensitisation (AS) results in poorer outcomes, necessitating allergen control. However, the spectrum of AS in childhood asthma in Nigeria is not well-known. We describe the prevalence and pattern of skin-prick AS among children with asthma seen at the paediatric allergy clinic of the Lagos State University Teaching Hospital, Ikeja, Lagos, Nigeria.

Methods/Material: Retrospective review of routinely-collected data of asthmatic children who had skin -prick test (SPT) at the Paediatric Allergy clinic, conducted with a 9-allergen-extracts kit comprising house-dust mite (HDM) [subtypes: *Dermatophagoides pteronysinnus* (*Der p*), *Dermatophagoides farina* (*Der f*), *Blomia tropicalis* (*Blo t*)]; Cockroach, *Aspergillus fumigatus*, cat, dog, *Alternaria alternata* and grass-mix. AS was defined as wheal diameter ≥ 3 mm above saline control (0 mm), with histamine wheal ≥ 3 mm (after 15-minute observation), to at least one antigen.

Results: Between January 2019 and May 2021, fifty-eight children (60.3% boys) aged 2-17 years [median (range; IQR)= 7.0 (2.0, 17.0; 5.0)] had SPT. AS was present in 86.2% (n=50/58), comprising allergy to: HDM [82.1% (n=46/56) (*Der f*-67.9%; *Blo t*: 64.3%; *Der p* : 51.8%]; cockroach (39.3%, 22/56); moulds (*Aspergillus*- 3.6%, 2/56; *Alternaria*-1.8%, 1/55) and pet (cat-1.8%, 1/56; dog-1.8%, 1/56). About two-thirds (65.5%, 38/58) were polysensitised but there was no cross-sensitisation between HDM and cockroach allergy [*kappa* (95% CI)= -0.004(-0.18, 0.17)].

Conclusions: AS, especially to HDM and cockroach, was common among asthmatic children; a previously-unreported high prevalence of *Blomia tropicalis* allergy was notable. HDM and cockroach control may be important in our patients.

Keywords: Skin prick test, asthma, allergic sensitisation, atopy, sub-Saharan Africa

Introduction

Asthma, a heterogeneous chronic inflammatory airway disease, is one of the commonest chronic childhood disorders worldwide.[1,2] The prevalence of asthma and other clinical allergies like allergic rhino-conjunctivitis (AR) is increasing in Africa and Nigeria, with Lagos having the highest national prevalence.[1,3] The co-existence of asthma with other allergies like AR is associated with poorer asthma outcomes.[3,4] Identifying and managing such co-morbidities improves asthma outcomes.[4,5] Although about 72-86% of asthmatic children attending outpatient clinics in Nigeria have allergic co-morbidities,[5–9] these allergies may correlate poorly with objectively-assessed allergen sensitisation (AS), or atopy, which is the abnormal immunologic, often IgE-mediated, reaction to environmental allergens such as foods or aero-allergens.[2,10] AS, especially to more than one allergen (polysensitisation), is independently associated with the incidence, persistence and impaired control of asthma.[4,11–15] Thus, the characterisation of inciting allergens, through skin-prick testing (SPT) or serum immunoglobulin E assay, may guide allergen mitigation for optimal asthma management.[2,16] SPT is a sensitive and specific test of IgE-mediated immediate hypersensitivity to specific allergens based on cutaneous reactivity to standardized allergen extracts;[17] it has a sensitivity and specificity of about 77 and 97%, respectively,[18] and it is sometimes superior to specific IgE assay.[19] Routine allergy testing is largely missing in routine asthma care in Nigeria, partly because of the cost of allergy testing and inadequate expertise.[9,20] Thus, the knowledge of factors associated with AS may help identify subsets of asthmatic children who may benefit most from SPT.[9]

Moreover, the few published reports of AS among Nigerian children with asthma were mostly conducted many years ago.[13,14,21] We thus aimed to describe the frequency, pattern (types) and predictors of AS among children with asthma in our clinic. This knowledge may guide the provision of locally-contextualised allergological services like the appropriate choice of allergen panel and immunotherapy in the face of the increasing local prevalence of allergic diseases.[3,22,23]

Materials and Methods

Ethical considerations

The study was approved by the Health Research Ethics Committee, Lagos State University Teaching Hospital, as part of a larger study on *Gaps in Asthma Care* in our unit, with the overall aim of optimising asthma care (LREC/06/10/1487). Routine clinical pre-procedural informed consent was obtained from parents/guardians and assent was obtained from the children after explaining the procedure.

Study design and population

This is a retrospective review of the data of all children with asthma who had SPT at the paediatric allergy clinic since January 2019 (routine allergy testing was not available in the clinic before this time). The children had been previously diagnosed with asthma and were on routine outpatient asthma follow-up. The clinic diagnoses asthma using the clinical diagnostic criteria of the Global Initiative of Asthma (GINA) consisting of the presence of episodic or variable wheeze, cough, chest tightness and breathlessness; this is sometimes supplemented with lung function testing with peak flow meter or spirometry when available.[2]

Skin prick procedure

Before SPT, we routinely use a purpose-designed form to obtain the following data from parents/guardians and the child's medical records: demographic (age, sex), socio-economic (parental occupation and education) and clinical data (family history of allergy). The lead author, a consultant allergologist, conducted standardised SPT[10] according to the guidelines of the Australasian Society of Clinical Immunology & Allergy (ASCIA),[17] using a commercial allergen tool-kit consisting of nine standardised aqueous allergen extract and two control solutions (histamine and saline) supplied in multi-use dropper bottles (ALK-Abello™, Spain). The extracts comprised house-dust mite (HDM), namely *Dermatophagoides pteronysinnus* (*Der p*), *Dermatophagoidesfarinae* (*Der f*) and *Blomia tropicalis* (*Blo t*); cockroach; cat, dog, *Aspergillus fumigatus*, *Alternaria alternata*; and grass mix. During SPT, the forearm is placed on a table to expose the skin of the volar surface, mid-way between wrist and elbow. This area was cleaned with alcohol wipe. Positions for the different extracts and control solutions were marked and numbered on the skin with a non-permanent pen. A drop of each solution was placed at these points, avoiding admixture. A sterile lancet was then used to gently prick on the skin through the middle of each drop of fluid, driving it between epidermis and non-vascular upper dermis. The drops of fluid were swiped off from the skin and the child asked to wait for 15 minutes at the end of which the prick sites were examined for wheals. The circumference of each wheal area was measured with a ruler in millimetres. A positive SPT was defined as a wheal area more than 3mm greater than the control (which should be 0 mm), with histamine wheal of at least 3mm.

Data management

Data were analysed with JASP Statistics™ version 0.16.4 (University of Amsterdam, The Netherlands; https://jasp-stats.org). We computed socioeconomic status (SES) using a recently validated scale by Ibadin &Akpede[24] (revised from an older scale by Oyedeji[25]). The scale derives an averaged numerical score of 1-6 aggregated from both parents' education and occupation; then further classified as *high* (1 and 2), *middle* (3 and 4) and *low* socioeconomic class (5 and 6). The distribution of continuous variables was assessed with Shapiro-Wilk test and visual inspection of graphical plots. Categorical variables were summarised with counts (n), percentages (%) and 95% CI, while continuous variables were summarised with median, interquartile range (IQR) and range. Continuous and categorical variables were compared between subgroups using Mann-Whitney U-test and Fisher's exact tests, respectively. Statistical significance was assessed as p value < 0.05 while effect sizes were assessed with crude odds ratio (OR) with 95% CI. Cohen's kappa test of agreement was used to assess the concordance (cross-reactivity/cross-sensitisation) between HDM and cockroach allergies, and among HDM subtypes. Kappa values (κ) 0.0-0.2, 0.21-0.39, 0.40-0.59, 0.60-0.79, 0.80-0.90 and > 0.90 were respectively assumed equivalent to *no*, *minimal*, *weak*, *moderate*, *strong* and *excellent* concordance.[26]

Results

Overall, 58 children with asthma (35 boys, 60.3%) had SPT from January 2019 to May 2021. Two children had used anti-histamine within the preceding two days but their data is included herein; one was sensitised while the other was not.

Socio-demographic and socio-economic characteristics

The age range was 2-17 years, with median (range; IQR) age among girls, boys and the total sample being 8.0 (2.0, 15.0; 6.0), 6.0 (3.0, 17.0; 5.0) and 7.0 (2.0, 17.0; 5.0) years, respectively, with no significant sex difference (Mann-Whitney W=434.5, P = 0.614). Most of

them (49/58; 87.5%) belonged to middle-class families; 12.5% (7/58) and 3.7% (2/58) were of upper and lower SES, respectively.

Frequency and pattern of clinical allergy and skin-prick aero-allergen sensitisation

Sensitisation (positive SPT to at least one allergen) occurred in 86.2% (n=50/58; 95% CI= 74.6, 93.9) of them, with about two-thirds (65.5%; 38/58) polysensitised (Table 1). Figure 1 shows that the sensitisations were house-dust mites allergy [82.1% (n=46/56; 95% CI=69.6, 91.1), comprising *Dermatophagoides farina* (67.9%; 95% CI= 54.0, 79.7), *Blomia tropicalis* (64.3%, 95% CI= 50.4, 76.6) and *Dermatophagoides pteronysinnus* (51.8%, 95% CI=38.0, 65.3)]; cockroach allergy (39.3%, 95% CI=26.5, 53.2); moulds allergy, comprising *Aspergillus fumigatus* (3.6%, 95% CI=0.4, 12.3) and *Alternaria alternata* (1.8%, 95% CI=0.0, 9.7)]; pet allergy, comprising cat 1.8% (95% CI=0.0, 9.6) and dog allergies (1.8%, 95% CI=0.0, 9.6)]. None of the children had grass (pollen) allergy (0%).

Table 1: Frequency of allergen sensitisation

Sensitization frequency		Frequency N (%)	95% CI
*Sensitization**			
	Yes	50 (86.2)	74.6, 93.9
	No	8 (13.8)	6.1, 25.4
Number of aero-allergens†			
	0	8 (13.8)	6.1, 25.4
	1	12 (20.7)	11.2, 33.4
	2	11 (19.0)	9.9, 31.4
	3	14 (24.1)	13.9, 37.2
	4	11 (19.0)	9.9,31.4
	5	2 (3.4)	0.4, 11.9

*Sensitization to at least one aero-allergen
† Monosensitisation is sensitisation to one aero-allergen while polysensitisation is sensitisation to two or more aero-allergens
Abbreviations: N, number of patients; CI, confidence intervals

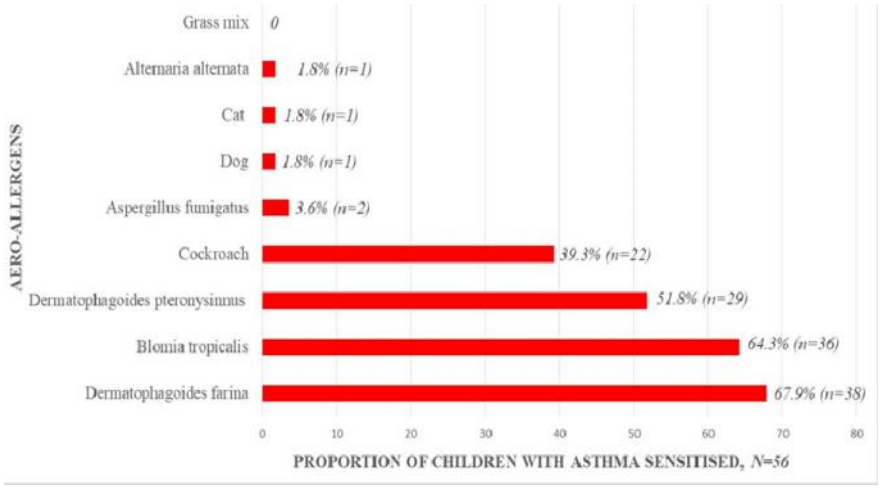
Socio-demographic determinants of aero-allergen sensitisation pattern

Neither allergen sensitisation (AS) nor polysensitisation was significantly associated with any of the socio-demographic factors (Table 2 and 3, respectively). However, compared with younger children (< 7 years), older children (≥ 7 years) had about 4-fold increased odds of allergen sensitisation [OR (95% CI) = 3.82 (0.70, 20.80), P=0.138] (Table 2) and 3-fold increased odds of polysensitisation [OR (95% CI) =2.85 (0.92, 8.78), P=0.097; Table 3]. Similarly, boys had a 3-fold higher odds of AS (OR (95% CI)= 2.96 (0.63, 13.87), P = 0.244; Table 2) and a 2-fold higher odds of polysensitisation (OR (95% CI)=1.92 (0.64, 5.80), P=0.271; Table 3), compared to female sex, while upper socioeconomic status (SES) was associated with a 3-fold higher odds of AS compared to middle SES [OR (95% CI)= 3.07 (0.16, 59.07), P=0.577] (Table 2).

Cross-sensitisation among allergens

Cross-tabulations show that 81.8 % (18/22) of children with cockroach allergy also had HDM allergy while 39.1 % (18/46) of those with HDM allergy also had cockroach allergy but there was no concordance between HDM and cockroach allergies [kappa (95% CI) = -0.004 (-0.18, 0.17)]. Among the subtypes of HDM allergy, 89.7% (26/29) of children with Der f allergy also had Der p allergy while 68.4% (26/38) of those with Der f had Der p allergy and there was weak concordance between the two allergies (kappa= 0.46 (0.24, 0.68). Also, 86.2% (25/29) of those with Der p had Blo t allergy, while 69.4% (25/36) of those with Blo t allergy had Der p allergy and the concordance between Der p and Blo t allergies was 0.46 (0.23, 0.68); 76.3% (29/38) of those with Der f had Blo t allergy while 80.6% (29/36) of those with Blo t allergy also had Der f allergy and the concordance was weak (κ = 0.36 (0.11, 0.62).

Fig 1: Frequency and types of skin-prick aero-allergen sensitisation



The commonest form of aero-allergen sensitisation were allergies to house-dust mites (*Dermatophagoides farina*, *Blomia tropicalis* and *Dermatophagoides pteronysinnus*). None of the children had pollen (grass mix allergy).

Table 2: Socio-demographic determinants of allergen sensitisation

Factors	Allergen sensitization* Yes N (%)	No N (%)	Total N (%)	OR (95% CI)	Fisher's exact value (95% CI)	*P*
Age (years)						
≥ 7	28 (93.3)	2 (6.7)	30 (00.0)	3.82(0.70, 20.80)	3.73(0.59, 41.38)	0.138
< 7	22 (78.6)	6 (21.4)	28 (100.0)			
Total	50 (86.2)	8 (13.8)	58 (100.0)			
Sex						
M	32 (91.4)	3 (8.6)	35 (100.0)	2.96 (0.63, 13.87)	2.91 (0.50, 20.93)	0.244
F	18 (78.3)	5 (21.7)	23 (100.0)			
Total	50 (86.2)	8 (13.8)	58 (100.0)			
Family history of allergy[†]						
Yes	32 (84.2)	6 (15.8)	38 (100.0)	0.36 (0.04, 3.22)	0.36 (0.01, 3.41)	0.66
No	15 (93.7)	1 (6.2)	16 (100.0)			
Total	47 (87.0)	7 (13.0)	54 (100.0)			
Socioeconomic status[‡]						
Upper	7 (100.0)	0 (0.00)	7 (100.0)	3.07 (0.16, 59.07)	∞ (0.23, ∞)	0.577
Middle	41 (83.7)	8 (16.3)	49 (100.0)			
Total	48 (85.7)	8 (14.3)	56 (100.0)			

*Allergen sensitization: 'yes' implies sensitization to at least one aero-allergen
[†]Family history of allergy: history of any of asthma, allergic rhinitis, allergic conjunctivitis, atopic dermatitis or food allergy in parents or siblings
[‡]Socioeconomic status (SES) was derived with a validated scale by Ibadin &Akpede[24] comprising aggregated and averaged scores of parents' highest formal education and occupation which is then classified as low, middle and high SES corresponding to scores of 5-6, 3-4 and 1-2, respectively.
Abbreviations: OR, unadjusted odds ratio derived from a 2 x 2 contingency tables with variables dichotomized where appropriate; CI, confidence intervals

Table 3: Socio-demographic determinants of polysensitisation

Factors	Number of allergens* ≥ 2	< 2	Total	OR (95% CI)	Fisher's exact values (95% CI)	*P*
Age, years						
>= 7	23 (76.7)	7 (23.3)	30 (100.0)	2.85 (0.92, 8.78)	2.8 (0.81, 10.39)	0.097
< 7	15 (53.6)	13 (46.4)	28 (100.0)			
Sex						
M	25 (71.4)	10 (28.6)	35 (100.0)	1.92 (0.64, 5.80)	1.9 (0.55, 6.66)	0.271
F	13(56.5)	10 (43.5)	23 (100.0)			
Family history of allergy[†]						
Yes	22 (57.9)	16 (42.1)	38	0.2 (0.04, 0.99)	0.2 (0.02, 1.08)	0.057
No	14 (87.5)	2 (12.5)	16 (100.0)			
Socioeconomic status[‡]						
Upper	5 (71.4)	2 (28.6)	7 (100.0)	1.45 (0.26, 8.27)	1.44 (0.21, 16.62)	1
Middle	31 (63.3)	18 (36.7)	49 (100.0)			

*Number of allergens: ≥ 2 allergens implies polysensitisation while < 2 implies mono- or non-sensitisation;
†Family history of allergy: history of any of asthma, allergic rhinitis, allergic conjunctivitis, atopic dermatitis or food allergy in parents or siblings;
‡Socioeconomic status (SES) was derived with a validated scale by Ibadin &Akpede(22) comprising aggregated and averaged scores of parents' highest formal education and occupation which is then classified as low, middle and high SES corresponding to scores of 5-6, 3-4 and 1-2, respectively.
Abbreviations: OR, unadjusted odds ratio derived from a 2 x 2 contingency tables with variables dichotomized where appropriate; CI, confidence intervals

Discussion

In this essentially exploratory retrospective descriptive report on the frequency, pattern and social-economic determinants of AS among these predominantly middle-income urban-dwelling asthmatic children who had SPT in our clinic, we observed that AS was common, occurring in about 8 of 10 children with asthma, with HDM and cockroach allergies being the commonest. Perhaps because of the small sample size, none of the socio-demographic factors explored significantly predicted AS in this study, although older children (> 7 years) and male sex showed a consistent pattern of increased odds with both AS and polysensitisation. There was no evidence of cross-sensitisation between cockroach and

HDM allergy.

Frequency of allergen sensitisation

Our results suggests that AS may be very common among children with asthma in our clinic, with a frequency of 82%. We found no similar clinic-based reports in Nigeria for immediate comparison as previous studies were community-based[13,14] or were in adult populations.[27] Earlier clinic-based studies of AS among asthmatic adults in Nigeria reported similarly high prevalence of 65-92%.[27–29] Compared to clinic-based studies like ours, most paediatric community-based studies often report lower AS prevalence. For example, in 1999, a community-based study by Faniran*et al*[13] showed AS prevalence of 28% among school children in Lagos.[13] Similarly, a more recent school-based study at Kaduna which tested only for HDM (*Der p* and *Der f* allergy) reported an overall prevalence of 10.4%. Also, Arrais*et al*,[30] in a study of Angolan school children aged 5-14 years reported the prevalence of AS to be 8%. In contrast, a school-based study by Oluwole *et al*[14] reported a much higher prevalence of 73% about a decade ago among Nigerian asthmatic adolescents at Ibadan, Nigeria. However, 60% of the non-asthmatic group also had AS, suggesting that AS was also common in the general population.

Pattern of sensitised allergens

In agreement with global data,[31] HDM allergy was the commonest AS, followed by cockroach allergy. In contrast, Oluwole *et al'*[14] reported cockroach allergy (58%) predominance over HDM (52%) and grass mix (43%) among children with asthma in Ibadan a decade ago. These variations among Nigerian studies may reflect true geographical difference in allergen profile but could also be due to the use of different sets of allergen panel comprising limited spectrum of allergens. Secular trend from changing geo-political and environmental factors may also contribute to these variations.

A strength of our study was the inclusion of *Blomia tropicalis* (*Blo t*) in our panel, which is often missing in AS studies in Nigeria and Africa.[13,14,21,32] While the *Dermatophagoides* are global in distribution, *Blo t* is found more in tropical and sub-tropical regions.[33,34] Thus, it was the second commonest allergen in our study (64.3%). In a two-centre clinic-based study among children with asthma and AR in South Africa, the prevalence of *Blo t* was 52% in the northern coastal region of KwaZulu-Natal while it was only 3% in the less humid Johannesburg. Lagos shares a similarly coastal humid characteristics with KZN possibly favouring the high prevalence of *Blo t*. We may thus hypothesise that in a large country like Nigeria with wide an inter-regional weather disparity, the distribution of *Blo t* may vary within the country. This has implication for the local choice of SPT panels and immunotherapy.

Allergy to cockroaches' saliva, faeces or remains is a major allergenic driver of asthma especially in low-income urban communities.[13,35] Cockroach allergy is associated with current wheeze among Nigerian children with asthma, especially in rural communities.[14] Our report suggests that cockroach allergy is also common among urban-dwelling children with asthma. We observed less frequent allergy to moulds and pets. A systematic review showed that, compared to exposure to indoor bacterial or viral allergens, exposure to indoor moulds such as *Aspergillus* and *Alternaria* was associated with strong risk of respiratory morbidity, wheezing and AR.[12] Thus, household mould control may be important in affected children. In contrast to an earlier Nigerian report,[14] none of our patients had allergy to grass-mix, perhaps due to the characteristic short pollen-season in Nigeria or to non-representation of the dominant local aero-pollens in our foreign-prepared allergen extracts. Thankfully, the characterization of local aero-pollens is being addressed.[22,23]

Although positive SPT may correlate poorly with clinical allergies, the knowledge of the presence and pattern of AS among children with asthma is important for optimal management.[2,16] HDM and cockroach control measures may be important in our patients. While cockroaches can be controlled with insecticides, traps and other measures, such strategies-including the use of anti-mite mattresses- have limited effectiveness for the control of HDM because of their ubiquitous nature. Thus, where there is evidence of significant impact of HDM allergy on asthma control, immunotherapy may be the most practicable option.[2,16,32]

Socio-economic predictors of allergen sensitisation

Strachan's hygiene hypothesis[36] has traditionally been used to explain the link between AS and socioeconomic status: children born into affluence are more likely to live and grow in hygienic environment with less exposures to microbial antigens compared to those in rural settings with higher microbial loads. It was believed that the former encouraged T-helper 2 pathway with consequent increased tendency towards allergic conditions. However, it is now argued that exposure to diverse microbes, rather than to infectious agents, is the driver of reduced allergenic tendency among persons of lower socioeconomic status.[21,37] Zuani*et al*,[21] in a recent community-based study of school-children in northern Nigeria, reported that HDM sensitisation was associated with urbanisation and SES. They found HDM allergy prevalence of 15.6% and 2.8% among urban-dwelling and rural-dwelling children, respectively; among the urban-dwelling pupils, the frequency of HDM allergy increased with increasing socioeconomic status- 27.4%, 13.1% and 8.1% in the high, middle and low socioeconomic sub-groups, respectively. Our data may also suggest a similar pattern: whereas 84% of those of middle class were sensitised, all (100%) of the seven children of high SES were sensitised, with three-fold higher odds of AS; albeit the association was not statistically significant presumably due to the small sample size. Similarly, boys and older children (> 7 years) were both associated

with 2- to 3-fold increased odds of AS and polysensitisation, despite not reaching statistical significance. The association of increased odds of older age with AS and polysensitisation may be concerning because atopy and polysensitisation at older age increases the risk of asthma persistence and poorer outcomes.[11,15] This may justify early institution of allergen mitigation measures such as mite and cockroach control.[2,16] However, these supposed association of AS/polysensitisation with these social factors need further elucidation with larger sample sizes.

Cross-sensitisation among aero-allergens

Cross-sensitisation (or cross-reactivity) among allergens such as HDM and cockroach is attributed to ubiquitous protein pan-allergens like tropomyosins found in crustaceans, molluscs and insects like HDM and cockroaches.[38] However, we found no evidence of cross-sensitisation between HDM and cockroach. In persons where there are significant cross-reactivity due to true antigenic homology or cross-antigenic contamination at preparation or procedure, it is more clinically difficult to delineate which of the cross-reacting allergens is responsible for symptoms, thus necessitating further tests like allergen-specific IgE assays to delineate the culprit allergen.[31] Our study suggests that we could have confidence that an individual with sensitisation to both HDM and cockroach is truly allergic to both antigens, and not just due to cross-sensitisation. In contrast to our finding, Kulalert *et al*[31] reported significant moderate concordance [$\kappa = 0.53$ (95%CI: 0.42, 0.64)] between HDM and cockroach allergy in children with AR and asthma. They also found moderate concordance between cats and dog allergy ($\kappa = 0.41$ (95% CI: 0.30 to 0.52); however, the small prevalence of pet allergies in our sample precludes assessment of this in our sample.

Limitations

Apart from its small sample size and retrospective nature, our findings should be regarded with caution because of other limitations: the sample was not randomly selected to represent the population of children with asthma in our clinic and thus may not provide a true prevalence. Nonetheless, the burden documented agrees with similar studies in Nigeria and elsewhere. We did not have a control group to account for a possibly high prevalence of AS in the general population.[14] We also had a limited spectrum of allergens in our battery and did not explore relationship of AS with asthma control or severity. Also, we did not explore the modifiable early-life risk factors such as mode of birth or non-exclusive breastfeeding.

Conclusion and recommendations

AS was common among children with asthma in our clinic, the commonest being HDM and cockroach allergy with no significant cross-sensitisation; the previously-unreported high frequency of *Blomia tropicalis* was a unique finding in our study. The absence of allergy to grass-mix possibly reflects non-representation of local grass pollens in the panel used and short pollen season in our environment. The observed statistically non-significant but potential association between AS and each of age, sex and socioeconomic status need further exploration in larger sized, representative and geographically-diverse prospectively-sample populations of children with asthma. Meanwhile, our findings may be useful for local and national baseline allergen profiling and optimizing allergological services like immunotherapy.

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References

1. 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*.
2. Global Initiative for Asthma (GINA). Global strategy for asthma management and prevention, updated 2023 [Internet]. 2023. Available from: ginasthma.org
3. Ozoh OB, Aderibigbe SA, Ayuk AC, Desalu OO, Oridota OE, Olufemi O, et al. The prevalence of asthma and allergic rhinitis in Nigeria: A nationwide survey among children, adolescents and adults. PLoS One [Internet]. 2019 Sep;14(9):e0222281. Available from: http://dx.plos.org/10.1371/journal.pone.0222281
4. Mphahlele RE, Kitchin O, Masekela R. Barriers and determinants of asthma control in children and adolescents in Africa: a systematic review. BMJ Open [Internet]. 2021 Oct [cited 2022 Sep 5];11 (10):e053100. Available from: http://dx.doi.org/10.1136/bmjopen-2021-053100

5. Ayuk A, Eze J, Edelu B, Oguonu T. The prevalence of allergic diseases among children with asthma: What is the impact on asthma control in South East Nigeria? *Niger J Clin Pract [Internet]. 2018;21 (5):632. Available from: http://www.njcponline.com/text.asp?2018/21/5/632/231894*
6. Ishaq FA, Garba BI, Jiya NM, Hamidu A. Assessment of asthma control and lung function in asthmatic children in Sokoto, North Western Nigeria. *J Pan African Thorac Soc. 2021;2(3):148–53.*
7. Garba BI, Sani UM, Isezuo KO, Waziri UM, Ugege MO, Adamu A, et al. Pattern of allergic co-morbidities in children with asthma in Sokoto, North Western Nigeria. *Int J Biomed Res. 2019;10 (10):e5282.*
8. Onubogu U, West B. The Pattern of Comorbidities of Childhood Asthma as Seen in the Rivers State University Teaching Hospital, Nigeria. *Open J Respir Dis [Internet]. 2021;11 (01):1–18. Available from: https://www.scirp.org/journal/doi.aspx?doi=10.4236/ojrd.2021.111001*
9. Odusote OA, Ubuane PO, Akinola IJ. Allergic co-morbidities in childhood asthma in Lagos, Nigeria. *Curr Allergy Clin Immunol J [Internet]. 2020 Feb 1;33(1):35. Available from: http://erj.ersjournals.com/cgi/doi/10.1183/09031936.00070309*
10. Australasian Society of Clinical Immunology & Allergy (ASCIA). Skin Prick Testing Guide for Diagnosis of Allergic Disease [Internet]. 2020 [cited 2020 Oct 13]. Available from: https://www.allergy.org.au/hp/papers/skin-prick-testing
11. Rubner FJ, Jackson DJ, Evans MD, Gangnon RE, Tisler CJ, Pappas TE, et al. Early life rhinovirus wheezing, allergic sensitization, and asthma risk at adolescence. *J Allergy Clin Immunol [Internet]. 2017;139 (2):501–7. Available from: http://dx.doi.org/10.1016/j.jaci.2016.03.049*
12. Fakunle AG, Jafta N, Naidoo RN, Smit LAM. Association of indoor microbial aerosols with respiratory symptoms among under-five children: a systematic review and meta-analysis. Environ Heal [Internet]. 2021 Jul 1;20(1):77. Available from: https://doi.org/10.1186/s12940-021-00759-2
13. Faniran AO, Peat JK, Woolcock AJ. Prevalence of atopy, asthma symptoms and diagnosis, and the management of asthma: comparison of an affluent and a non-affluent country. Thorax [Internet]. 1999 Jul 1 [cited 2021 Oct 13];54 (7):606–10. Available from: http://thorax.bmj.com/
14. Oluwole O, Arinola OG, Falade GA, Ige MO, Falusi GA, Olopade IO, et al. Allergy sensitization and asthma among 13-14 year old school children in Nigeria. *Afr Health Sci. 2013;13(1):144–53.*
15. Madulara GM, Andaya AG. Effects of Aeroallergen Sensitization on Symptom Severity, Pulmonary Function, and Bronchodilator Response in Children With Bronchial Asthma. *J Med Univ St Tomas [Internet]. 2022 Oct 31;6 (2):959–70. Available from: https://www.jmust.org/elib/journal/doi/10.35460/2546-1621.2019-0003/abstract*
16. Cloutier MM, Baptist AP, Blake K V., 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 [Internet]. 2020 Dec 1 [cited 2022 May 16];146(6):1217–70. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0091674920314044*
17. Australasian Society of Clinical Immunology & Allergy (ASCIA). Skin prick testing for the diagnosis of allergic disease: A manual for practitioners [Internet]. 2016 [cited 2020 Oct 13]. Available from: https://www.allergy.org.au/hp/papers/skin-prick-testing
18. Önell A, Whiteman A, Nordlund B, Baldracchini F, Mazzoleni G, Hedlin G, et al. Allergy testing in children with persistent asthma: comparison of four diagnostic methods. Allergy [Internet]. 2017 Apr;72(4):590–7. Available from: https://onlinelibrary.wiley.com/doi/10.1111/all.13047
19. Gureczny T, Heindl B, Klug L, Wantke F, Hemmer W, Wöhrl S. Allergy screening with extract-based skin prick tests demonstrates higher sensitivity over in vitro molecular allergy testing. Clin Transl Allergy [Internet]. 2023 Feb 5;13(2):1–9. Available from: https://onlinelibrary.wiley.com/doi/10.1002/clt2.12220

20. Desalu OO, Onyedum CC, Iseh KR, Salawu FK, Salami AK. Asthma in Nigeria: Are the facilities and resources available to support internationally endorsed standards of care? Health Policy (New York) [Internet]. 2011 Mar;99 (3):250–4. Available from: http://www.embase.com/search/results?subaction= viewrecord&from= export&id= L51135810%5Cnhttp://dx.doi.org/10.1016/j.healthpol.2010.10.006%5Cnhttp://sfx.ub.rug.nl:9003/sfx_local?sid=EMBASE&issn=01688510&id=doi:10.1016/j.healthpol.2010.10.006&atitle=Asthma+in
21. Zuiani C, Arigliani M, Zubair R, Dogara LG, Castriotta L, Sunday AD, et al. The impact of urbanization and wealth on house dust mite sensitization in children from north-central Nigeria. *Ital J Pediatr [Internet]. 2022;48(1):4–7. Available from: https://doi.org/10.1186/s13052-022-01348-w*
22. Adeniyi TA, Adeonipekun PA, Olowokudejo JD, Akande I. Allergenicity of dominant aeropollen in Nigeria (Part I). *Curr Allergy Clin Immunol. 2017;30(4):264–9.*
23. Adeniyi TA, Adeonipekun PA, Olowokudejo JD, Akande I. Allergenicity of dominant aeropollen in Nigeria (Part II). *Curr Allergy Clin Immunol. 2018;31(3):178–83.*
24. Ibadin MO, Akpede GO. A revised scoring scheme for the classification of socioeconomic status in Nigeria. *Niger J Paediatr [Internet]. 2021 Feb 4 [cited 2021 Nov 30];48(1):26–33. Available from: http://dx.doi.org/10.4314/njp.v48i1.5*
25. Oyedeji EA. Socioeconomic and cultural background of hospitalized children in Ilesa. *Niger J Paediatr. 1985;12:111–7.*
26. McHugh ML. Interrater reliability: The kappa statistic. Biochem Medica [Internet]. 2012 Oct 15 [cited 2022 Nov 16];22(3):276–82. Available from: https://www.biochemia-medica.com/en/journal/22/10.11613/BM.2012.031
27. Oladeji SM, Nwawolo CC, Adewole OO, Fasunla AJ. Pattern of skin sensitivity to various aeroallergens in bronchial asthmatic patients in Lagos, Nigeria. *Afr J Med Med Sci. 2014;43(4):339–45.*
28. Ogunlade OA, Ige OM, Arinola OG, Onadeko BO. Allergen-specific immunoglobulin E (IgE) antibodies and skin test reactivity in patients with asthma in Nigeria. *J Clin Immunol Immunopathol Res. 2012;4(3):25–8.*
29. Bandele EO, Elegbeleye OO, Williams KO, Femi-Pearse D. An analysis of skin prick test reactions on asthmatics in Lagos. *J Natl Med Assoc. 1983;75(5):511–4.*
30. Arrais M, Lulua O, Quifica F, Rosado-Pinto J, Gama JMR, Brito M, et al. Sensitisation to aeroallergens in relation to asthma and other allergic diseases in Angolan children: a cross-sectional study. AllergolImmunopathol (Madr) [Internet]. 2020 May;48 (3):281–9. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0301054620300057
31. Kulalert P, Sritipsukho P, Nanthapisal S, Poachanukoon O. Concordance of skin test reactivity between indoor inhalant allergens among children with allergic respiratory disease. BMC Pediatr [Internet]. 2021 Dec 11 [cited 2021 Oct 13];21(1):338. Available from: https://doi.org/10.1186/s12887-021-02800-2
32. Jeevarathnum AC, van Niekerk A, Green RJ, Becker P, Masekela R. Prevalence of Blomia Tropicalis allergy in two regions of South Africa. South African Med J [Internet]. 2015;105(7):567–9. Available from: http://dx.doi.org/10.7196/SAMJNEW.7786
33. Cao H, Liu Z. Clinical significance of dust mite allergens. Mol Biol Rep [Internet]. 2020 Aug 1 [cited 2022 Nov 21];47 (8):6239–46. Available from: https://pubmed.ncbi.nlm.nih.gov/32803501/
34. Thomas WR. Geography of house dust mite allergens. *Asian Pacific J Allergy Immunol. 2010;28(4):211–24.*
35. Do DC, Zhao Y, Gao P. Cockroach allergen exposure and risk of asthma. Allergy [Internet]. 2016 Apr;71(4):463–74. Available from: https://onlinelibrary.wiley.com/doi/10.1111/all.12827
36. Strachan DP. Hay fever, hygiene, and household size. *Br Med J. 1989;299 (November):1259–60.*
37. Scudellari M. Cleaning up the hygiene hypothesis. Proc Natl Acad Sci [Internet]. 2017 Feb 14 [cited 2022 Nov 21];114 (7):1433–6. Available from: www.pnas.org/cgi/doi/10.1073/pnas.1700688114
38. Papia F, Bellia C, Uasuf CG. Tropomyosin: A panallergen that causes a worldwide allergic problem. Allergy Asthma Proc [Internet]. 2021 Sep 1;42 (5):e145–51. Available from: https://www.ingentaconnect.com/content/10.2500/aap.2021.42.210057