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Risk factors for the development of Thunderstorm-associated asthma among indigenous Ghanaians: A matched case-control study

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ABSTRACT

Objectives: Epidemic Thunderstorm asthma (TA) is a serious public health threat with a potential to overwhelm health systems. Being the first documented incidence in Ghana, we sought to determine whether the chronic respiratory risk factors for the development of TA as identified in other countries were similar or different from that in Ghana.

Study design: A matched case-control study involving 41 cases and 82 controls was conducted in two conveniently selected health facilities in the Ashanti Region of Ghana.

Methods: Data were collected from pre-existing patient records and included general demography, a history of allergies and a history of asthma. A chi-square and multiple logistic regression analysis were conducted to identify risk factors for the development of TA.

Results: Overall, 53.7 % of the TA cases and 7.3 % of controls had a previous history of asthma (AOR = 4.53 p = 0.064, 95 % CI = 0.918–22.365). Also, 29.3 % of the cases and 1.2 % of the controls had a previous history of allergies (AOR = 12.48 p = 0.05, 95 % CI = 0.919–169.305).

Conclusions: A previous history of allergy was a significant risk factor for TA. A previous history of asthma though associated with TA, was not a significant risk factor for its development. The recognition and awareness of risk factors for TA, by clinicians and health managers, is essential for health education, case management and preparation for the surge capacity occasioned by the event.

1. Introduction

Though a rare phenomenon, Epidemic Thunderstorm Asthma (TA) poses a significant public health threat, as it has historically claimed people's lives in the Western world and consequently overwhelmed healthcare systems [1]. A dozen incidents of TA have been reported over the past three decades in the UK, Iran, Asia, Canada and the Americas [2–4]. The most devastating event, however, was observed in Melbourne, Australia [5,6]. Out of the 3400 reported cases in this catastrophic event, ten [10] deaths were recorded [6]. In Africa, there are documented records of incidents of TA in South Africa [7]. However, after a thorough literature search on Google Scholar and PubMed, from 1980 to 2023 using keywords such as 'Thunderstorm Asthma' 'Thunderstorms' 'Asthma' and 'Ghana', we found no documented record of TA in Ghana.

TA is believed to occur as a result of a complex interaction between climatic (thunderstorm), environmental (high load of aeroallergens) and patient susceptibility factors [8]. Some studies have shown evidence of a previous history of allergenic rhinitis, previous history of asthma, prior sensitization to allergens and being outside during the episode [9] as patient risk factors for the development and severity of TA. In a study conducted by Dabrera et al. [10], nine (9) out of nineteen (19) individuals with TA had a history of hay fever. In contrast, in another study, findings showed that approximately 80 % of TA cases had persistent asthmatic symptoms with an inability to self-manage [8].

In Ghana, the first incident of Epidemic TA was investigated and reported in March 2022. Findings from the outbreak investigation revealed that 266 individuals had reported to the Emergency

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Departments (ED) of fifteen (15) health facilities in the Ashanti Region with cough, wheezes and difficulty breathing following a thunderstorm. There were no reports of cases of TA from the outpatient and in-patient services in these facilities. This study aimed to determine whether the chronic respiratory risk factors for the development of Thunderstorm Asthma identified in other countries were similar or different from those observed in this setting. We tested the hypothesis that a previous history of allergic rhinitis and a previous history of asthma were possible risk factors for the development of Thunderstorm-associated asthma among Ghanaians. Awareness of risk factors for TA is useful for medical surge capacity by health managers and clinicians. For a low-incidence disease such as TA, a case-control study remains a well-established and appropriate tool that can enable us to investigate patient risk factors for the disease.

2. Methods

2.1. Study design, sampling and sample size

The study was a matched case-control design with 41 cases and 82 controls. A ***case*** was defined as any patient who presented to the Emergency Department (ED) of the study sites with a diagnosis of 'thunderstorm asthma', 'acute asthma' 'asthma' or 'respiratory distress' between the 17th – 25th day of March 2022. Individuals with cardiovascular diseases or respiratory tract infections may present with similar symptoms as Thunderstorm Asthma. This could lead to errors in measurement of the outcome i.e. development of Thunderstorm Asthma leading to Information bias and affecting the validity of the findings of the study. Therefore, individuals with these conditions were excluded from the study.

Age (±5 years the age of a case) and sex-matched controls, two (2) for each case were purposively selected for this study. Matching on age and sex is commonly used in case-control studies because they are the commonest confounding variables; this is essential in improving statistical precision [11]. Controls were obtained from the ED records of the study facilities. The controls were admitted during the same period as cases but had not been diagnosed with Thunderstorm asthma or asthma.

2.2. Study sites

The study took place in two health facilities; Komfo Anokye Teaching Hospital, a tertiary Government hospital and County Hospital, a private primary health facility in the Ashanti Region. These facilities are resident in the Kumasi Metropolitan Assembly, located in the rainforest region.

2.3. Data collection and study instrument

Risk factor variables were extracted from pre-existing records. The data collected included: Age, Sex (male, female), Residence, Occupation, Symptoms history, history of asthma (yes, no) and history of allergy (yes, no). Individuals with a history of allergies included those with symptoms of allergic rhinitis, atopy or hay fever, whether or not they had been formally diagnosed by a physician, before March 2022. The same data variables were obtained for controls.

2.4. Statistical analysis

The data collected was cleaned in an Excel spreadsheet. This involved identifying incomplete, inaccurate and duplicate data in the database and deleting or replacing them. Statistical analysis using a chi-square test was achieved with SPSS version 25 while a Multiple logistic regression analysis (LRA) was done with Stata version 17. For the case and control groups, the frequency distribution, chi-square value and p-values of each risk factor variable were calculated. This was useful in establishing the association between the independent (a previous history of allergic rhinitis and a previous history of asthma) and dependent variables (development of TA).

A multiple logistic regression model was used to identify chronic respiratory risk factors for Thunderstorm asthma. The variables '*History of Asthma* (yes/no)' and '*History of allergy* (yes/no)' were included in the multiple logistic regression analysis, controlling for age and gender. Confounders may be identified from the literature [12]. From literature review, there was an association between age and sex and the independent variables (history of asthma and history of allergies) and an association between 'age and sex' and the dependent variable 'Thunderstorm Asthma' [4,5,13]. It can thus be hypothesized that age and sex are potential confounders.

Univariate LRA items with p-value <0.05 between cases and controls in the chi-square test were included in the multiple logistic regression analysis models. The crude odds ratio and adjusted odds ratio were calculated.

Table 1
Summary measures of exposure variables by outcome variable.

Variable	Thunderstorm Asthma		Chi-square	p-value
	No	Yes		
Sex				
Male	31(37.8)	21(51.2)	1.503	0.220
Female	51(62.1)	20(48.8)		
Age (mean ± SD)	**46.34 ± 20.73**	41.29 ± **15.83**		
≤20 years	7(70)	3(30)	5.759	0.124
21–40 years	31(64.6)	17(35.4)		
41–60 years	22(56.4)	17(43.6)		
>60 years	22(84.6)	4(15.4)		
Previous History of Allergy				
No	81(98.8)	17(41.4)	29.644	0.000
Yes	1(1.2)	12(29.3)		
Previous History of Asthma				
No	76(92.7)	15(36.6)	35.682	0.000
Yes	6(7.3)	22(53.7)		
Missing data				
History of allergy	0	12		
History of asthma	0	4		

**Missing data: There was no information on a previous history of allergy for 12 TA cases. Similarly, no information could be obtained on whether or not there was a previous history of asthma for 4 TA cases.

3. Results

3.1. Subject characteristics

A total of 41 cases and 82 controls were recruited for the study. All 41 Thunderstorm asthma cases met the eligibility criteria and were categorized as such. A total of 82 matched controls were recruited from the same facilities as the cases. Overall, 58 % were females and 42 % were males. The mean age of the Thunderstorm asthma cases was 41 years and that of the controls was 46 years. Overall, 39 % which represents the majority of the study participants were between 20 and 40 years of age. Further demographic details have been provided in Table 1.

Table 1 shows summary measures for demographic and risk factor variables; and a bivariate analysis of the association between the independent variables (age, sex, previous history of asthma, previous history of allergies) and the dependent variable, Thunderstorm Asthma.

3.2. Bivariate analysis

The chi-square value and p-value for each risk factor have been shown in Table 1.

While 53.7 % of Thunderstorm asthma cases, had a previous history of asthma, only 7.3 % of the controls did (X^2=*35.68, p=0.000*).

A lower proportion of the cases, 29.3 % had a previous history of allergies. However, a much lower proportion of the control reported a

Table 2
Risk factors associated with Thunderstorm asthma in Ghana.

	Without Confounders				Controlling for the Effect of Confounders			
variables	Un-adjusted, OR	Std. Err.	z-score	P-value	Adjusted OR	Std. Err.	z-score	P-value
History of Allergy	10.813	13.702	1.880	0.060	12.475	16.599	1.900	0.058
No								
Yes								
History of Asthma	5.366	4.064	2.220	0.027	4.532	3.691	1.860	0.064
No								
Yes								
Y-Intercept	0.117	0.052	−4.800	0.000	0.970	0.806	−0.040	0.971

Odds Ratio significant at 0.05 (5 %).

previous history of allergies i.e., 1.2 % (X^2= *29.644, p=0.00)*

3.3. Multiple logistic regression analysis

The results of the multivariable analysis are presented in Table 2. Thunderstorm asthma cases were five (5) times more likely to have a previous history of asthma compared to controls. After adjusting for age and sex, the OR was statistically insignificant (AOR = 4.53, 95 % CI: 0.918–22.365).

The odds of having a previous history of allergies were ten (10) times higher among cases than controls and statistically significant after adjusting for age and sex (AOR = 12.48, 95 % CI: 0.919–169.305).

Table 2 shows results from a multiple logistic regression analysis of the relationship between the risk factor variables and the outcome. This is necessary for determining the exposure variables which are significant risk factors for the disease.

4. Discussion

This study focused on chronic respiratory risk factors necessary for the development of Thunderstorm Asthma. The proportion of males among the cases was comparable with females. Therefore no gender predilection for Thunderstorm asthma existed as observed in some studies [4]. In terms of age distribution, the majority of the cases were between 20 and 60 years. This age distribution is similar to findings from studies such as [1,5] and deviates from the typical U-shaped pattern where more younger and elderly people are affected by diseases [2,5]. It has been hypothesized that this age distribution corresponds with that of allergic rhinitis [5]. Other factors such as the fact that individuals within this age bracket are more active and are likely to be outdoors at the time of the event might also account for this observation.

A higher proportion of individuals with TA had a previous history of asthma than those without TA. A history of asthma was also significantly associated with Thunderstorm asthma ($X^2 = 35.68$, p = 0.00). However, this was not maintained after controlling for confounders at a *p-value* of 0.064 (AOR = 4.53, 95 % CI: 0.918–22.365). A previous history of asthma was therefore not found to be a statistically significant risk factor for the development of TA. The importance of a previous history of asthma may be, as [1,4,8] attributed, to show how severe their experience of TA may be. When compared to the fact that the majority of the TA cases had a previous history of asthma, provides enough justification for why these individuals with existing asthma may have severe enough symptoms to report to the health facility. When extrapolated, we can infer that true cases of TA may be more than what is reported, as a majority of the population who have no history of asthma may have minor symptoms not warranting hospital admission.

Several descriptive studies of Thunderstorm asthma have identified that affected patients may not previously have suffered from asthma yet are likely to have hay fever or allergic rhinitis [9,10]. In this study, a lower proportion of those who developed TA had a previous history of allergic rhinitis. There was however a statistically strong association between previous history of allergy and TA (X^2 = 29.6, p = 0.000), which was maintained after controlling for confounders at a *p-value* of 0.058 (AOR = 12.48, 95 % CI: 0.919–169.305). This finding should however be interpreted with caution owing to its wide confidence interval.

Generally, a previous history of asthma and a previous history of allergy were significantly associated with Thunderstorm Asthma as observed in some studies. However, a previous history of allergy was a significant risk factor for the disease.

This study has some limitations. Though the use of pre-existing data minimizes information bias, it is associated with missing data, affecting the internal validity of the results. Also, in a matched case-control study design, matching introduces bias which can be minimized by controlling for matching factors in the analysis [11]. We controlled for the matching factors, age and sex to minimize this bias. Lastly, though hospital controls are very suitable and convenient for a study such as this, the results obtained may not be generalizable to the entire population. In the same vein, the choice of two health facilities among the fifteen [(15)] affected by the outbreak, affects the generalizability of the results. To minimize this, we chose facilities that are likely to cater to the needs of people at all levels of the health system i.e., public and private, primary and tertiary levels.

5. Conclusion

In this study, we conclude that a previous history of asthma is not a risk factor for developing Thunderstorm asthma. A previous history of allergies, however, may be a significant risk factor for the development of TA. The findings of this study are necessary for prompt awareness and recognition of factors necessary for the development and/or severity of TA.

While identification of risk factors is essential for health education for those who can develop TA, it is useful for preparedness and clinician sensitization for those who may develop severe disease. We recommend future research on the influence of chronic non-respiratory diseases such as Hypertension and Diabetes on the development of TA when environmental conditions are satisfied.

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Ethics statement

Ethical approval was obtained from the Institutional Review Board of the Komfo Anokye Teaching Hospital (Ref no: *KATH IRB/AP/144/22*) and permission to carry on with the survey was obtained from the respective health facilities.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence

the work reported in this paper.

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Abbreviations

TA	Thunderstorm Asthma
KATH	Komfo Anokye Teaching Hospital
OR	Odds Ratio
AOR	Adjusted odds ratio
p-value	probability value

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