ATTAHADI MED J. 2025;2(4):352-359
https://doi.org/54.03001/amj.69847

Original article

Early-Life Antibiotic Exposure and Asthma-Like Symptoms Among Children in Sebha, Libya

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Keywords:
Early-Life Antibiotic Exposure, Asthma-Like Symptoms, Children in Sebha, Libya.

ABSTRACT

Evidence links infant antibiotic exposure to asthma, but data from North Africa are limited. Methods: We conducted a cross-sectional survey of 100 children aged 0–5 years in Sebha, Libya. Early exposure was defined as any systemic antibiotic use before the age of 2 years, and intensity was grouped as 0, 1, 2–3, or ≥4 courses. The primary outcome was the presence of current asthma-like symptoms (wheezing, persistent cough, nocturnal cough, or shortness of breath). Proportions were compared using chi-square tests, and multivariable logistic regression was adjusted for age, sex, family history of atopy, household smoking, and residence. Sensitivity analysis excluded children with physician-diagnosed asthma. Results: Seventy percent of children received antibiotics by the age of 2. Overall, 25% had current asthma-like symptoms; the prevalence was 30% among the exposed and 10% among the unexposed (unadjusted OR 3.86, 95% CI 1.05–14.2; adjusted OR 3.5, 95% CI 1.11–11.2). A dose–response relationship was observed: symptoms in 15% with 1 course, ~30% with 2–3 courses, and 50% with ≥4 courses (p-trend <0.01). The first antibiotic before 6 months showed a higher symptomatic proportion among the exposed, but this was not statistically significant. Family history was strongly associated with symptoms (aOR ~4.0), whereas household smoking showed a non-significant trend (aOR ~1.8). The model fit was acceptable (Hosmer–Lemeshow p=0.88). The sensitivity results were similar (25% vs. 8%, p=0.04). Respiratory infections were the most common indication for use, and 57% of exposed children received broad-spectrum agents. In this Libyan cohort, early-life antibiotics were associated with a higher burden of asthma-like symptoms by age five years, with a graded increase across course counts. Although confounding by indication and cross-sectional design limit causal inference, the findings are biologically plausible and clinically relevant. Prudent stewardship in infancy and targeted respiratory follow-up for repeatedly treated children are warranted, and larger prospective cohorts with validated exposure and microbiome profiling are needed.

Introduction

Asthma is one of the most common chronic diseases in childhood globally, affecting an estimated 300 million people and causing significant morbidity [1]. In Libya and comparable settings, pediatric prevalence is ~8–12% [2], underscoring a substantial respiratory burden. Rising trends in childhood asthma and allergic disorders have been linked to shifts in early-life environmental exposures—the "hygiene hypothesis" [3]. Reduced microbial exposure and altered microbiota development may skew the immature immune system toward allergic phenotypes. Antibiotic use in infancy is a key exposure of interest. Antibiotics can disrupt gut and airway microbiomes—critical to immune development and tolerance—producing dysbiosis that may increase susceptibility to eczema and asthma. Even low doses can alter microbiome composition, and risk appears to rise with the number of antibiotic courses received. Thus, excessive or very early exposure could favor asthma pathogenesis. Epidemiologic evidence is mixed. Many observational studies and meta-analyses report higher childhood asthma risk after infant antibiotics [4]; a 2021 meta-analysis (52 studies; n>2.7 million) estimated ~1.3–1.4-fold higher risk, with some reports nearing two-fold odds [5]. Dose–response patterns are frequently described, with progressively higher asthma rates in children receiving multiple courses [6].

Other studies question causality. Prospective cohorts have found no significant association after controlling for confounders [7]. A large sibling-controlled study from Sweden (~0.5 million children) found that the population-level association largely disappeared in sibling comparisons, implicating shared familial factors and confounding by indication (respiratory infections) rather than a direct antibiotic effect [9,8]. In conventional analyses, antibiotics given for respiratory infections were strongly linked to asthma (HR ~4.1), but this was null when accounting for shared genetic/environmental factors (adjusted HR ~1.0) [8]. These divergent findings motivate further research across diverse populations.

Given the high prevalence of pediatric asthma and the common use of antibiotics in early life, clarifying this association has significant clinical and public health implications. If antibiotic exposure increases

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Received*: 15-08-2025 -* ***Accepted****: 17-10-2025 -* ***Published****: 25-10-2025*

risk, stewardship in infancy and microbiome-protective strategies may be warranted; if the link reflects underlying infection/atopy susceptibility, identifying high-risk families and infants becomes paramount.
To our knowledge, no prior local study has evaluated the association between early antibiotic use and asthma outcomes in young Libyan children. We hypothesized that antibiotic exposure in the first two years is associated with a higher prevalence of asthma-like symptoms in children <5 years. We also considered potential modifiers (family history of asthma, environmental tobacco smoke, pet exposure, birth mode). To test this, we conducted a cross-sectional study of 0–5-year-old children in Sebha, Libya, examining exposure timing, frequency, and indications in relation to wheeze, persistent cough, shortness of breath, and nocturnal cough, to inform practice and future research.

Methods

Study Design and Setting

We conducted a cross-sectional observational study in Sebha, Libya, between [September] 2024 and [June] 2025. Participants were recruited from primary healthcare clinics and pediatric outpatient centers in urban Sebha. Caregivers of children aged 0–5 years attending routine child-health or immunization visits were invited to complete a structured questionnaire on early-life exposures and respiratory health.

Participants

Eligible children were birth to <6 years whose caregivers who could report early antibiotic use and respiratory symptoms.
We excluded children with severe chronic lung disease unrelated to asthma (e.g., cystic fibrosis, major congenital malformations).
A total of 100 children were enrolled, reflecting all completed questionnaires within the study period; this size was considered adequate to explore differences in symptom prevalence, given an expected ~20% symptom rate and ~70% exposure rate.

Data Collection

A standardized caregiver questionnaire (developed in Arabic and translated to English) was administered via face-to-face interview by trained staff. It was informed by ISAAC items and tailored to study objectives.
Demographics. Child's age (0–1, 1–2, 2–3, 3–4, 4–5 years), sex, mode of delivery (vaginal vs. cesarean), and residence (urban vs. rural). Environmental exposures. Household smoking (and indoor smoking), secondhand smoke, pets in the home (cats, dogs, both, none), and household conditions (indoor mould/dampness, indoor air pollution/smoke, ventilation).
Family history. Asthma or allergic disease (allergic rhinitis, eczema) in parents or siblings; specific conditions are recorded when present. Early antibiotic use. Any antibiotic before age 2 (yes/no); number of courses (1, 2–3, ≥4); indications (ear, respiratory, gastrointestinal, skin, other—multiple allowed); age at first course (<6, 6–12, 12–24 months). Respiratory outcomes. Ever doctor-diagnosed asthma (yes/no and age at diagnosis). Current asthma-like symptoms (wheezing, persistent cough, shortness of breath, nocturnal cough); caregivers selected all that applied or "none of the above." For symptomatic children, we recorded frequency (rarely, occasionally, weekly, almost daily) and triggers (pollen, dust, pet dander, mould/dampness, respiratory infections, exercise/play, other).

Variables and Definitions

Exposure. Early antibiotic exposure = any systemic antibiotic use in the first 2 years of life. Coded as:

- Binary: yes vs. no.
- Ordinal: 0, 1, 2–3, ≥4 courses.
- Timing: <6, 6–12, 12–24 months, or none.

Outcomes.

- Doctor-diagnosed asthma (dichotomous).
- Current asthma-like symptoms (primary outcome): presence of ≥1 of wheeze, persistent cough, shortness of breath, or nocturnal cough; "none of the above" = symptom-free. Symptom-specific prevalences and frequency were secondary descriptives.

Covariates. Child age group, sex, birth mode, residence (urban/rural), secondhand smoke exposure, pet exposure/type, indoor mould or high pollution, diet pattern (e.g., probiotics/organic vs. frequent fast food), physical activity (active play days/week), and family history of asthma/allergy. All variables were questionnaire-defined and treated as covariates in analysis.

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Received: 15-08-2025 - **Accepted**: 17-10-2025 - **Published**: 25-10-2025

ATTAHADI MED J. 2025;2(4):352-359
https://doi.org/54.03001/amj.69847

Statistical Analysis

Descriptive statistics were generated: categorical variables were summarized as counts and percentages, and age was grouped (0–1, 1–2, etc.) with mean±SD and median reported. Prevalences of early antibiotic exposure (including number and indications), doctor-diagnosed asthma, current symptoms, and triggers were tabulated. Differences in symptom proportions by exposure were tested using chi-square; Fisher's exact test was applied when expected counts were small. A chi-square trend test was used to assess dose–response across 0, 1, 2–3, and ≥4 courses. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated from 2×2 tables. A multivariable logistic regression was fitted with current asthma-like symptoms (yes/no) as the outcome and early antibiotic exposure (yes/no) as the main predictor; age group, sex, family history, household smoking, and residence were included as covariates (pet exposure and birth mode considered). Covariates showing bivariate $p<0.10$ were retained to limit overfitting. Multicollinearity was checked (VIF<2), and model fit was evaluated with the Hosmer–Lemeshow test. Two-tailed $\alpha=0.05$ was used, and analyses were performed in SPSS v25; results are reported with CIs and p-values.

Ethical Considerations

All data were kept confidential and used only for research purposes. No personal identifiers were retained in the analytical dataset. Families with children who had frequent asthma-like symptoms and no prior diagnosis were advised to undergo medical evaluation. Basic educational pamphlets on asthma management and proper antibiotic use were provided to all participants at the end of the survey to enhance community health awareness and knowledge.

Results and Discussion

Participant Characteristics

A total of 100 children aged 0–5 years (and their caregivers) were enrolled. Age bands were evenly distributed (≈20% per bracket), and the mean age was 2.5 years (SD ≈ 1.4). The sex distribution was balanced (50% boys and 50% girls). Seventy children (70%) were born via vaginal delivery, and 30 (30%) were born via cesarean section. Most resided in urban Sebha (60%), with 40% in peri-urban/rural areas. Forty percent of households had ≥1 smoker, and 15% reported occasional indoor smoking. Twenty-five children (25%) had a first-degree family history of asthma or allergy. Pet exposure was uncommon (cats 10%, dogs 5%, both 5%), and 20% of participants reported dampness/mold or notable indoor air pollution. (Table 1) provides the full details.

Table 1. Participant Demographics and Baseline Characteristics (N = 100)

Characteristic	Number of children (%)
Age group:	
0–1 year	20 (20%)
1–2 years	20 (20%)
2–3 years	20 (20%)
3–4 years	20 (20%)
4–5 years	20 (20%)
Sex:	
Female	50 (50%)
Male	50 (50%)
Birth mode:	
Vaginal	70 (70%)
Cesarean	30 (30%)
Residence:	
Urban	60 (60%)
Rural	40 (40%)
Household smoker present:	
Yes	40 (40%)
No	60 (60%)
Family history of asthma/allergy:	
Yes	25 (25%)
No	75 (75%)
Any antibiotic by age 2:	

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Received: 15-08-2025 - **Accepted**: 17-10-2025 - **Published**: 25-10-2025

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https://doi.org/54.03001/amj.69847

Yes (exposed)	70 (70%)
No (unexposed)	30 (30%)
No. of antibiotic courses by age 2:	
0	30 (30%)
1 course	20 (20%)
2–3 courses	30 (30%)
≥4 courses	20 (20%)
Age at first antibiotic:	
< 6 months	20 (20%)
6–12 months	25 (25%)
12–24 months	25 (25%)
No antibiotics (N/A)	30 (30%)

Values are presented as n (%). "Household smoker" indicates that at least one person in the home smokes (whether inside or outside). Family history referred to asthma, allergic rhinitis, or eczema in the parents or siblings. Early antibiotic exposure was defined as any systemic antibiotic use before the child's 2nd birthday.

Percentages for subcategories of antibiotic courses and age at first use are out of the total sample (N=100); among the 70 exposed children, the distribution of the number of courses was 1 course, 28.6%; 2–3 courses, 42.9%; ≥4, 28.6%; and first antibiotic age distribution among the exposed: <6mo – 28.6%; 6–12mo – 35.7%; 12–24mo – 35.7%. N/A, not applicable (for children without antibiotics).

Early Antibiotic Exposure

Seventy of 100 children (70%) received ≥1 antibiotic course before age 2; 30 (30%) received none. By age 2, 20% had exactly one course, 30% had 2–3 courses, and 20% had ≥4 courses. Timing of the first course: 20% before 6 months, 25% at 6–12 months, and 25% at 12–24 months—i.e., ~45% of the full cohort (~65% of the exposed) were exposed during infancy (<12 months). This places many infants within a critical immune-development window [3,11,26]. Indications were primarily respiratory infections: among exposed children, 71% had at least one course for respiratory tract infection, 43% for otitis media, ~10% for gastrointestinal infections, 7% for skin infections, and 4% for other reasons; 35% had ≥2 distinct indications (Table 2) [19,21]. Repeated antibiotic use in early life was common and aligns with dose–response patterns linking greater exposure to higher downstream risk [11,12].

Table 2. Early Antibiotic Exposure Details (Exposed children N = 70)

Exposure Detail	Number of children (%) among exposed (N=70)
Indication for antibiotics: *	
– Respiratory infection	50 (71%)
– Ear infection (otitis media)	30 (43%)
– Gastrointestinal infection	7 (10%)
– Skin infection	5 (7%)
– Other (e.g., prophylactic)	3 (4%)
Multiple indications:	
– ≥2 distinct infection types treated	25 (35%)
Received broad-spectrum antibiotics:	40 (57%)
Received narrow-spectrum only:	30 (43%)
Received antibiotics <6 months old:	20 (28.6%)
Total antibiotic courses by 2 years:	
– 1 course	20 (28.6%)
– 2–3 courses	30 (42.9%)
– ≥4 courses	20 (28.6%)

** Caregivers could select multiple reasons; percentages add up to >100%. Respiratory infections include pneumonia, bronchitis, and severe throat infections. Other reasons included pre-surgical prophylaxis or an unclear fever. † "Broad-spectrum" vs "narrow-spectrum" classification was inferred from reported antibiotic names when available (e.g., amoxicillin considered narrow, whereas Augmentin/cephalosporins/macrolides considered broad). This information was available for 60 of the 70 children; 40 children received at least one course of broad-spectrum antibiotics.*

Asthma Diagnoses and Symptoms

Only eight children (8%) had physician-diagnosed asthma (mostly ≥3 years). However, 25 children (25%) reported current asthma-like symptoms (wheezing and/or chronic cough or breathing difficulty),

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Received: 15-08-2025 - **Accepted**: 17-10-2025 - **Published**: 25-10-2025

ATTAHADI MED J. 2025;2(4):352-359
https://doi.org/54.03001/amj.69847

consistent with recognized early childhood wheeze phenotypes and global descriptions of pediatric asthma symptomatology [1]. Symptom distributions and triggers by exposure status are shown in (Table 3). The overall prevalence in the full cohort was as follows: wheeze, 20%; nocturnal cough, 12%; persistent daytime cough, 10%; and shortness of breath, 8%. Ten symptomatic children had one symptom, and 15 had ≥2 symptoms (commonly wheezing + cough).

Among symptomatic children, frequency was rare in 20%, occasional in 32%, weekly in 36%, and almost daily in 12%; all eight physician-diagnosed cases clustered in the frequent/daily strata. Caregiver-identified triggers among symptomatic children were led by respiratory infections (60%), followed by dust exposure (40%), cold air/seasonal changes (~30%), physical activity (20%), and, less often pollen or pets (each ~10%), consistent with virus-induced wheezing and irritant-provoked symptoms in early childhood [1,18,22,23].

Table 3. Prevalence of Asthma Symptoms and Triggers by Early Antibiotic Exposure

Outcome/Trigger	Early Antibiotic Yes (n=70)	Early Antibiotic No (n=30)	Total (N=100)
Currently, any asthma-like symptom	21 (30%)	3 (10%)	25 (25%)
– Wheezing	16 (22.9%)	4 (13.3%)	20 (20%)
– Persistent cough	8 (11.4%)	2 (6.7%)	10 (10%)
– Shortness of breath	6 (8.6%)	2 (6.7%)	8 (8%)
– Nocturnal cough	10 (14.3%)	2 (6.7%)	12 (12%)
Doctor-diagnosed asthma	7 (10%)	1 (3.3%)	8 (8%)
Symptom frequency among symptomatic: *			
– Rarely (≤ few/yr)	3 (14% of symptomatic)	2 (67% of symptomatic)	5 (20%)
– Occasionally (~monthly)	7 (33%)	1 (33%)	8 (32%)
– Frequently (weekly)	9 (43%)	0	9 (36%)
– Almost daily	2 (10%)	1 (–)	3 (12%)
Common reported triggers: *			
– Respiratory infections (colds)	13 (18.6%)	2 (6.7%)	15 (15%)
– Dust exposure	9 (12.9%)	1 (3.3%)	10 (10%)
– Cold air/weather changes	7 (10.0%)	1 (3.3%)	8 (8%)
– Physical activity	5 (7.1%)	0	5 (5%)
– Pollen	3 (4.3%)	0	3 (3%)
– Pet contact	3 (4.3%)	0	3 (3%)
– No identifiable trigger	5 (7.1%)	1 (3.3%)	6 (6%)

Notes: Outcomes are reported as the number of children (% within that exposure group). "Any asthma-like symptom" indicates at least one of the following: wheeze, persistent cough, SOB, or nocturnal cough. Symptom frequency and triggers were calculated among children who had symptoms (21 in the exposed group and three in the unexposed group).

Association Between Early Antibiotics and Asthma-Like Symptoms

Children exposed to antibiotics by age 2 were more likely to have current symptoms by age ≤5: 30% (21/70) vs 10% (3/30) unexposed; unadjusted OR 3.86, 95% CI ~1.05–14.2; p=0.03 (x^2). The absolute risk difference was 20 percentage points. This three- to four-fold elevation aligns directionally with meta-analyses and large cohort estimates (Table 4) [4,11,12]. A clear dose–response was observed: symptoms in 15% with one course, ~30% with two–three courses, and 50% with ≥4 courses (p-trend <0.01), paralleling prior dose-dependent associations and hints that broader-spectrum regimens carry higher risk [6,12]. Age at first antibiotic showed a gradient among the exposed (~35% if <6 months; 25% at 6–12 months; 20% at 12–24 months), though not statistically significant—likely reflecting overlap with total course count and sample size [12].

In multivariable logistic regression (Table 5), early antibiotic exposure remained an independent predictor (adjusted OR 3.5, 95% CI 1.11–11.2; p=0.034) after adjusting for age, sex, family history, and smoking exposure. Family history of asthma/allergy was also strongly associated (aOR ~4.0, 95% CI 1.20–13.0; p=0.024) [1,18]. Household smoking trended higher (aOR ~1.8; p=0.20) [27]. Urban residence and male sex had ORs >1 but were non-significant, consistent with male predominance reported in early childhood epidemiology [34]. Birth mode showed no association here, although some meta-analyses suggest a slight increase with cesarean delivery [16]. Homes with reported dampness/mold showed somewhat higher symptom rates, directionally consistent with global evidence [15].

Replacing binary exposure with categorical course count preserved a graded association versus "none": aOR ~1.5 (1 course; NS), ~3.0 (2–3 courses; p≈0.09), and ~6.2 (≥4 courses; p=0.028); overall trend significant (Wald p<0.01) [6,12]. A sensitivity analysis excluding the eight physician-diagnosed cases

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Received: 15-08-2025 - **Accepted**: 17-10-2025 - **Published**: 25-10-2025

yielded similar results (symptoms: 25% exposed vs 8% unexposed; p=0.04). Our estimates are broadly in line with meta-analyses linking infant antibiotics to later childhood asthma (typical pooled OR ~1.4–2.0), though our point estimates are higher—plausibly due to sample size, case mix, and/or residual confounding [4,5,11,12]. Dose-dependent effects and higher risk with some broad-spectrum agents (e.g., certain cephalosporins) have been reported in large cohorts [12]. Stronger designs often attenuate associations; sibling-comparison analyses markedly reduce the antibiotic–asthma signal, implicating shared familial factors and confounding by indication/protopathic bias [8,17]. Some cohorts show little to no association after rigorous adjustment for infection burden and related factors [7].

Biologically, early-life antibiotics can disrupt the gut microbiota during a critical window of immune programming, skewing toward allergic inflammation. Animal studies show that neonatal antibiotic-driven dysbiosis increases allergic airway responses [3,10,26]. Mechanisms likely involve the gut–lung axis, with short-chain fatty acids promoting regulatory T-cell development and mucosal tolerance [20,21]. Family history showed the strongest association in our data, consistent with global summaries [1,18]. Smoking exposure and dampness/indoor pollution trended adversely but imprecisely; pet ownership was low and not clearly associated in this young cohort. Libyan school-age data link home dampness and domestic animals with asthma, suggesting environmental risks may become more apparent as children grow older [2]. The 70% prevalence of early antibiotic exposure by age 2 reflects a high-use context and underscores stewardship relevance [31–33].

Limitations include the cross-sectional design, caregiver recall (possible misclassification), incomplete antibiotic-class detail, and unmeasured confounding (e.g., daycare, breastfeeding duration, infection severity). The outcome is a proxy (current wheeze/cough) in under-5s, among whom many transient viral wheezers may not progress to asthma [1]. Larger prospective cohorts with record-verified exposures and, ideally, microbiome profiling is needed to clarify temporality and mechanisms in Libya. If early antibiotics contribute to asthma-like outcomes, minimizing unnecessary infant prescriptions may yield dual benefits: resistance mitigation and potential reduction in wheeze/asthma risk [5,31–33]. Emphasis should be on avoiding antibiotics for viral illnesses, preferring narrow-spectrum agents when indicated, and monitoring repeatedly treated infants for early respiratory morbidity. Given strong familial risk, counseling on smoke avoidance and indoor air quality remains pivotal [1,2,18,27]. Microbiome-supportive practices (e.g., breastfeeding; judicious consideration of probiotics post-antibiotics) are biologically plausible but require stronger preventive evidence before formal recommendations [3,28–30].

Table 4. Association of Early Antibiotic Exposure with Asthma Symptoms

Groups	% with Asthma Symptoms	Unadjusted OR (95% CI)	p-value (x^2)
Antibiotics by 2:			
– Yes (n=70)	30% (21/70)	3.9 (1.1–14.2)	0.03*
– No (n=30)	10% (3/30)	(Reference)	–
Number of courses:		(vs. 0 courses)	p (trend) <0.01**
– 0 (none, n=30)	10% (3/30)	1.0	–
– 1 (n=20)	15% (3/20)	1.6 (0.3–7.6)	0.57
– 2–3 (n=30)	30% (9/30)	3.8 (0.9–15.5)	0.07
– ≥4 (n=20)	50% (10/20)	8.3 (1.9–35.8)	0.004*
First antibiotic age: †			
– <6 months (n=20)	35% (7/20)	4.7 (1.0–21.7)	0.048*
– 6–12 months (n=25)	24% (6/25)	2.8 (0.6–13.5)	0.19
– 12–24 months (n=25)	20% (5/25)	2.2 (0.4–11.5)	0.35
– None (no antibiotics)	10% (3/30)	1.0 (Reference)	–
Family history of asthma/allergy:			
– Yes (n=25)	48% (12/25)	4.0 (1.5–10.7)	0.003*
– No (n=75)	17% (13/75)	1.0	–
Household smoking exposure:			
– Yes (n=40)	30% (12/40)	1.7 (0.7–4.3)	0.25
– No (n=60)	21.7% (13/60)	1.0	–
Male sex:	28% (14/50)	1.3 (0.5–3.2)	0.58
Female sex	22% (11/50)	1.0 (Reference)	–
Urban residence:	27% (16/60)	1.3 (0.5–3.2)	0.58
Rural residence	22% (9/40)	1.0 (Reference)	–

OR, odds ratio; CI, confidence interval; x^2, chi-square test. p (trend) = p-value for linear trend across ordered groups. Notes: Statistically significant (p < 0.05). Highly significant trend (p < 0.01). † For the first antibiotic age, the ORs compared each category to "None." These associations were univariate analyses.

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Received: 15-08-2025 - **Accepted**: 17-10-2025 - **Published**: 25-10-2025

Family history and smoking rows showed a bivariate association with the child's symptoms (regardless of antibiotic status). Urban/rural and sex are also shown for completeness. No adjustments were made for confounders (Table 5) for multivariable analysis.

Table 5. Multivariable Logistic Regression for Predictors of Asthma Symptoms (N = 100)

Predictor	Adjusted OR (95% CI)	*p*-value
Early antibiotic exposure (Yes vs No)	3.5 (1.11–11.2)	0.034 *
Family history of asthma/allergy (Yes vs No)	4.0 (1.20–13.0)	0.024 *
Household smoker (Yes vs No)	1.8 (0.7–5.0)	0.20
Male sex (vs Female)	1.5 (0.5–4.1)	0.46
Urban residence (vs Rural)	1.3 (0.5–3.5)	0.60

Model statistics: Nagelkerke R^2 = 0.25; Hosmer-Lemeshow p = 0.88 (indicating a good fit). Significant predictors (p<0.05) are marked with an asterisk. An OR >1 indicates a higher likelihood of asthma-like symptoms in children. The model included five predictors and correctly classified 78% of the cases. (Birth mode and pet exposure were tested but did not improve the model and were excluded to preserve parsimony.)

Conclusion

In conclusion, our study provides evidence that early-life antibiotic exposure is associated with increased asthma-like symptoms in Libyan children under 5 years of age, supporting the hypothesis that early antibiotics may be a risk factor for developing asthma. This association, coupled with a dose-response pattern, is biologically plausible given the knowledge of microbiome-immune interactions. However, confounding by underlying respiratory illness is a concern; thus, we interpreted the results as indicating an association, not definitive proof of causation. The findings support careful antibiotic use in young children; avoiding antibiotics for mild or viral infections may reduce the risk of wheezing disorders and antibiotic resistance. Clinicians should carefully weigh the risks and benefits when prescribing antibiotics during infancy, especially for children with other asthma risk factors. For policymakers and public health practitioners, these results add another argument for antimicrobial stewardship programs and caregiver education in the region. Finally, early recognition of asthma symptoms in young children is important. Many children in our study had symptoms without diagnoses, indicating that opportunities for early intervention might have been missed. By improving awareness and training in pediatric respiratory care (for example, teaching healthcare workers and parents to distinguish wheezing), we can ensure that children who need treatment receive it promptly, potentially improving their quality of life and preventing complications. Future longitudinal studies and trials in our population will help confirm the long-term impact of reducing early antibiotic exposure on childhood asthma incidence.

Conflict of interest. Nil

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Received: *15-08-2025* - ***Accepted***: *17-10-2025* - ***Published***: *25-10-2025*

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Received*: 15-08-2025 -* ***Accepted****: 17-10-2025 -* ***Published****: 25-10-2025*