ORIGINAL ARTICLE *UDK: 616.248-035.6(497.711)*
www.doi.org/10.67214/9qjasx95

CHANGES IN ASTHMA PREVALENCE, SYMPTOMS, AND ASSOCIATED RISK FACTORS AMONG ADOLESCENTS IN SKOPJE, 2016–2026

Kimovska Hristova M.[1], Vlaski E.[1], Cvejoska Cholakovska V.[1]

[1]*University Children's Hospital, Skopje, North Macedonia.*

Abstract

Background: Asthma is one of the most common chronic diseases in childhood, with considerable differences in prevalence and trends worldwide.

Objective: To assess asthma prevalence and changes over the 2016–2026 period among adolescents in Skopje, and to examine changes and associations with selected personal, family, behavioral, and environmental factors.

Materials and Methods: Data from two cross-sectional surveys conducted in Skopje in 2016 and 2026 were compared. Both surveys used the same standardized questionnaire on respiratory health and asthma. The analysis included 1,013 adolescents aged 12–15 years (690 in 2016 and 323 in 2026). Statistical analyses were performed using IBM SPSS Statistics version 25.0 and JASP version 0.98.1.

Results: The prevalence of doctor-diagnosed asthma was low (3.4%) and showed a slight increase, although the difference was not statistically significant. In contrast, several asthma-related symptoms increased significantly. Current wheeze increased from 5.5% to 9.9%, exercise-induced wheeze from 1.9% to 6.2%, and dry night cough from 9.6% to 20.7%. Measures of symptom severity also increased significantly. In the fully adjusted models, household dampness, maternal asthma, frequent fast-food consumption, paracetamol use, and truck traffic were positively associated with several asthma-related symptoms.

Conclusion: Asthma and asthma-related symptoms increased over the ten-year period, while underdiagnosis and inadequate treatment remained important concerns. The findings suggest a need for better education for healthcare professionals to improve asthma diagnosis and treatment, together with education of patients and parents on the regular and correct use of prescribed therapy.

Keywords: *asthma; adolescents; risk factors; trends; wheeze.*

Introduction

Asthma is one of the most common chronic diseases in childhood. It results from the interaction between genetic predisposition and environmental factors. It is a heterogeneous disease commonly characterized by chronic airway inflammation and persistent bronchial hyperresponsiveness to different stimuli. Clinically, asthma presents with wheeze, shortness of breath, chest tightness, and/or cough, which may vary in intensity, together with variable expiratory airflow limitation (1).

Large international epidemiological studies, particularly the International Study of Asthma and Allergies in Childhood (ISAAC), have revealed considerable geographical differences in the prevalence of asthma and asthma-related symptoms among adolescents and have enabled comparisons of trends across different populations. Globally, asthma prevalence is higher in economically developed countries, whereas more severe symptoms and underdiagnosis are more common in developing countries (2). Comparison of ISAAC Phase Three with Phase One demonstrated an increase in asthma prevalence in many low- and middle-income countries, while prevalence remained stable or decreased in many high-income countries (3,4). In North Macedonia, studies conducted among adolescents between 2002 and 2016 showed a divergent trend, with an increase in doctor-diagnosed asthma but a decrease in asthma-related symptoms, alongside persistent underdiagnosis (5).

The large differences in asthma prevalence and trends worldwide, as well as the rapid increase observed over recent decades, suggest that lifestyle and environmental factors play an important role. Genetic factors are unlikely to change substantially over such a short period of time. Studies examining environmental risk factors for asthma, including ISAAC and later research, have reported inconsistent findings, and the "Western lifestyle" has been suggested as one possible contributing factor. Differences in asthma diagnosis and treatment may also contribute to the observed variations (2,6–8).

Objective

The aim of this study was to assess the current prevalence of asthma and asthma-related symptoms among adolescents in Skopje and to examine changes between 2016 and 2026. We also compared these findings with the previously reported divergent pattern from 2002 to 2016 and examined changes in selected personal, family, behavioral, and environmental factors and their possible role in the observed trend.

Materials and Methods

The study was approved by the Ethics Committee for Human Research at the Faculty of Medicine in Skopje.

The 2026 survey was conducted in April and May and included 1,580 schoolchildren aged 6–15 from 16 randomly selected primary schools in Skopje. The inclusion criteria for the study were age and parental consent for participation. Children without parental consent or a completed questionnaire were, therefore, not included. Furthermore, children receiving corticosteroid or biological therapy for another disease, which could affect the interpretation of the results, were also excluded.

The present analysis was designed as a comparison of two repeated cross-sectional surveys among adolescents aged 12–15 years in Skopje. It included 690 participants from the 2016 survey and 323 from the 2026 survey, giving a total sample of 1,013 adolescents.

The same standardized questionnaire on respiratory health and asthma, developed at the University of Saskatchewan, Canada, was used in both surveys. (9,10) The questionnaire was completed as a written interview by the parent or guardian who was most familiar with the child's health, after providing informed consent. It included questions on respiratory symptoms, doctor-diagnosed asthma, use of

respiratory medication, and demographic, personal, family, perinatal, behavioral, and environmental factors.

To assess the changes in asthma prevalence, the 2026 findings were compared with corresponding data from the 2016 survey.

The analyzed outcomes included current asthma, ever doctor-diagnosed asthma, ever wheeze, wheeze in the past 12 months, wheeze causing sleep disturbance, wheeze limiting speech, exercise-induced wheeze, nocturnal dry cough, cough causing sleep disturbance in the absence of respiratory infections, and use of preventive anti-inflammatory therapy during the past 12 months.

Current asthma was defined as doctor-diagnosed asthma at any time in life combined with wheeze in the past 12 months and/or use of preventive anti-inflammatory therapy in the past 12 months.

The potential risk factors included paracetamol use, cat or dog domestic ownership, passive smoking at home, frequent truck traffic on the residential street, television viewing or video gaming for more than one hour per day, frequent fast-food consumption, household dampness, maternal and paternal asthma, and parental education.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics version 25.0 and JASP version 0.98.1.

For the calculation of the prevalence of asthma symptoms and doctor-diagnosed asthma, missing or other responses were included in the denominator. For the analysis of potential risk factors, only valid responses were included. (11)

Categorical variables were compared using Pearson's χ^2 test. Fisher's exact test was used when expected cell counts were small.

Associations between individual risk factors and asthma-related outcomes were first examined using binary logistic regression, with results presented as odds ratios (ORs) and 95% confidence intervals (CIs).

Multiple binary logistic regression was then used to assess the independent associations between the examined risk factors and asthma and asthma-related symptoms. Results are presented as adjusted odds ratios (aORs) with 95% CIs. The fully adjusted models included all examined risk factors simultaneously and were additionally adjusted for the survey year, age, and sex. The complete-case sample for these models included 787 participants.

Interaction analyses between the survey year and the selected risk factors (year × risk factor) were also performed to examine whether the strength of these associations differed between 2016 and 2026.Statistical significance was set at $p < 0.05$.

Results

The analysis included 1,013 adolescents aged 12–15 years: 690 from the 2016 survey and 323 from

the 2026 survey. The mean age was 12.94 ± 0.80 in 2016 and 12.80 ± 0.94 in 2026 (p = 0.028). Boys accounted for 50.1% of participants in 2016 and 49.2% in 2026 (p = 0.802).

Table 1 shows the prevalence of selected risk factors among adolescents in 2016 and 2026. In 2026, a cat or dog domestic ownership, frequent fast-food consumption, household dampness, parental history of asthma, and higher parental education were significantly more common. In contrast, spending more than one hour per day watching TV or playing video games was significantly less common. No statistically significant differences were found for paracetamol use, passive smoking at home, or frequent truck traffic on the residential street.

Table 1. Prevalence of selected risk factors among adolescents in 2016 and 2026

Factor	**2016, n/N (%)**	**2026, n/N (%)**	**p**
Paracetamol use in the past 12 months	479/670 (71.5%)	240/313 (76.7%)	0.088
Cat at home in the past 12 months	71/677 (10.5%)	92/268 (34.3%)	<0.001
Dog at home in the past 12 months	104/676 (15.4%)	111/282 (39.4%)	<0.001
Passive smoking at home in the past 12 months	221/688 (32.1%)	94/322 (29.2%)	0.349
Frequent truck traffic on the residential street on weekdays	254/686 (37.0%)	107/322 (33.2%)	0.241
TV/PC >1 hour/day	592/687 (86.2%)	170/323 (52.6%)	<0.001
Fast food >1 time/week in the past 12 months	311/678 (45.9%)	169/302 (56.0%)	0.004
Household dampness	63/680 (9.3%)	45/314 (14.3%)	0.017
Maternal asthma	12/657 (1.8%)	14/308 (4.5%)	0.015
Paternal asthma	7/656 (1.1%)	16/285 (5.6%)	<0.001
Higher maternal education	270/684 (39.5%)	274/320 (85.6%)	<0.001
Higher paternal education	346/682 (50.7%)	276/320 (86.2%)	<0.001

Percentages were calculated using valid responses for each risk factor. Unknown/invalid responses were excluded. p: Pearson's χ^2 test.

Table 2 shows the prevalence and ten-year trend of asthma and asthma-related symptoms in 2016 and 2026.

Table 2. Prevalence of asthma and asthma-related symptoms in 2016 and 2026

Outcome	**2016 (N=690)**	**2026 (N=323)**	**p**
Ever doctor-diagnosed asthma	19 (2.8%)	11 (3.4%)	0.568

Outcome	2016 (N=690)	2026 (N=323)	p
Current asthma	11 (1.6%)	8 (2.5%)	0.335
Ever wheeze	181 (26.2%)	84 (26.0%)	0.939
Wheeze in the past 12 months	38 (5.5%)	32 (9.9%)	0.010
Wheeze causing sleep disturbance	20 (2.9%)	35 (10.8%)	<0.001
Wheeze limiting speech	8 (1.2%)	13 (4.0%)	0.003
Exercise-induced wheeze	13 (1.9%)	20 (6.2%)	<0.001
Dry nocturnal cough in the absence of respiratory infection	66 (9.6%)	67 (20.7%)	<0.001
Dry nocturnal cough causing sleep disturbance, in the absence of respiratory infection	48 (7.0%)	51 (15.8%)	<0.001

p: Pearson's χ^2 test.

Doctor-diagnosed asthma and current asthma increased slightly, although the differences were not statistically significant. In contrast, current wheeze, exercise-induced wheeze, dry nocturnal cough, and all examined indicators of more severe current symptoms were significantly more common in 2026.

Tables 3 and 4 show the unadjusted and adjusted associations, respectively, between selected personal, family, environmental, and behavioral factors and the asthma-related symptoms whose prevalence changed significantly between 2016 and 2026.

Table 3. Unadjusted associations between selected risk factors and symptom outcomes — OR (95% CI)

Factor	Current wheeze	Sleep disturbance due to wheeze	Speech limitation due to wheeze	Exercise-induced wheeze	Dry	Cough causing sleep disturbance
Paracetamol	2.27 (1.14–4.50)	2.14 (0.99–4.59)	2.11 (0.61–7.25)	0.98 (0.45–2.13)	1.14 (0.74–1.76)	1.10 (0.67–1.78)
Cat at home	2.06 (1.18–3.60)	2.73 (1.48–5.04)	2.45 (0.91–6.63)	2.26 (1.05–4.86)	1.31 (0.81–2.11)	1.28 (0.75–2.19)
Dog at home	0.97 (0.50–1.78)	1.34 (0.70–2.59)	2.24 (0.86–5.85)	1.05 (0.45–2.49)	1.45 (0.95–2.21)	1.29 (0.79–2.09)
Passive smoking at home	1.16 (0.70–1.94)	0.90 (0.50–1.64)	1.37 (0.56–3.33)	1.27 (0.62–2.62)	0.98 (0.66–1.46)	0.91 (0.57–1.43)
Frequent truck traffic	1.88 (1.15–3.10)	1.42 (0.82–2.45)	1.35 (0.56–3.24)	1.51 (0.75–3.04)	1.51 (1.05–2.19)	1.49 (0.98–2.27)

Factor	Current wheeze	Sleep disturbance due to wheeze	Speech limitation due to wheeze	Exercise-induced wheeze	Dry	Cough causing sleep disturbance
TV/PC >1 hour/day	0.80 (0.47–1.40)	0.60 (0.34–1.06)	0.52 (0.21–1.27)	0.38 (0.19–0.76)	0.64 (0.43–0.95)	0.72 (0.46–1.14)
Fast food >1 time/week	1.44 (0.87–2.40)	1.33 (0.76–2.34)	1.04 (0.43–2.53)	2.03 (0.97–4.27)	1.87 (1.27–2.75)	1.54 (1.00–2.38)
Household dampness	5.06 (2.90–8.76)	3.42 (1.78–6.55)	3.66 (1.38–9.74)	2.29 (0.97–5.42)	1.82 (1.10–3.03)	1.88 (1.07–3.32)
Maternal asthma	4.17 (1.60–10.80)	2.37 (0.69–8.16)	1.84 (0.24–14.24)	4.24 (1.20–14.90)	2.07 (0.81–5.25)	3.01 (1.18–7.71)
Paternal asthma	1.34 (0.30–5.84)	0.82 (0.11–6.24)	2.15 (0.28–16.79)	3.03 (0.68–13.55)	1.96 (0.71–5.38)	2.12 (0.70–6.37)
Higher maternal education	1.29 (0.79–2.10)	2.14 (1.18–3.89)	2.15 (0.83–5.58)	2.72 (1.22–6.09)	1.26 (0.87–1.82)	1.31 (0.86–2.01)
Higher paternal education	1.66 (0.96–2.90)	2.43 (1.23–4.78)	2.32 (0.77–7.05)	1.51 (0.69–3.32)	1.40 (0.94–2.07)	1.41 (0.90–2.21)

OR = odds ratio; CI = confidence interval. Reference category: absence of exposure; for parental education, ≤ secondary education.

Table 4. Adjusted associations between selected risk factors and symptom outcomes — aOR (95% CI)

Factor	Current wheeze	Sleep disturbance due to wheeze	Speech limitation due to wheeze	Exercise-induced wheeze	Dry nocturnal cough	Cough causing sleep disturbance
Paracetamol	2.40 (1.07–5.37)	2.43 (0.89–6.67)	2.57 (0.50–12.38)	0.85 (0.33–2.21)	1.08 (0.64–1.84)	1.11 (0.60–2.02)
Cat at home	1.80 (0.84–3.84)	1.14 (0.40–3.21)	0.51 (0.08–3.23)	1.07 (0.30–3.75)	0.70 (0.34–1.42)	0.73 (0.30–1.64)
Dog at home	0.70 (0.32–1.54)	0.88 (0.32–2.38)	2.46 (0.61–9.85)	1.01 (0.32–3.24)	1.21 (0.68–2.18)	1.09 (0.55–2.20)

Factor	Current wheeze	Sleep disturbance due to wheeze	Speech limitation due to wheeze	Exercise-induced wheeze	Dry nocturnal cough	Cough causing sleep disturbance
Passive smoking at home	1.21 (0.63–2.32)	0.70 (0.29–1.67)	0.54 (0.13–2.21)	0.76 (0.27–2.12)	1.03 (0.61–1.71)	0.85 (0.47–1.50)
Frequent truck traffic	1.76 (0.95–3.24)	1.37 (0.63–3.00)	0.91 (0.26–3.13)	1.27 (0.50–3.24)	1.59 (0.99–2.55)	1.99 (1.16–3.40)
TV/PC >1 hour/day	0.44 (0.21–0.94)	0.62 (0.24–1.58)	0.40 (0.11–1.51)	0.23 (0.08–0.64)	0.83 (0.46–1.52)	0.81 (0.41–1.60)
Fast food >1 time/week	1.36 (0.74–2.49)	1.73 (0.81–3.71)	0.72 (0.22–2.39)	2.70 (1.04–7.01)	1.92 (1.20–3.10)	1.75 (1.02–2.90)
Household dampness	5.96 (3.01–11.80)	4.08 (1.72–9.64)	3.91 (1.05–14.50)	2.38 (0.75–7.62)	2.17 (1.18–3.99)	2.03 (1.02–4.00)
Maternal asthma	5.56 (1.76–17.50)	2.57 (0.63–10.50)	2.07 (0.20–18.82)	8.01 (1.86–34.50)	2.63 (0.93–7.43)	3.98 (1.40–11.50)
Paternal asthma	0.72 (0.12–4.50)	0.47 (0.05–4.44)	1.79 (0.20–19.57)	2.21 (0.39–12.50)	1.48 (0.43–5.10)	1.26 (0.31–5.10)
Higher maternal education	0.69 (0.32–1.48)	0.53 (0.20–1.41)	0.49 (0.11–2.31)	1.07 (0.31–3.72)	0.56 (0.30–1.02)	0.56 (0.28–1.10)
Higher paternal education	1.45 (0.69–3.07)	1.55 (0.60–4.02)	1.81 (0.42–7.88)	0.80 (0.24–2.64)	1.04 (0.59–1.83)	1.24 (0.65–2.40)

aOR = adjusted odds ratio; CI = confidence interval. All risk factors were entered simultaneously, and models were additionally adjusted for survey year, age, and sex (complete-case n=787). Reference category: absence of exposure; for parental education, ≤ secondary education.

After adjustment in the multiple logistic regression models, household dampness was consistently associated with several asthma-related symptoms, including current wheeze, sleep disturbance and speech limitation due to wheeze, dry nocturnal cough, and cough causing sleep disturbance.

Maternal asthma was statistically significantly associated with current wheeze, exercise-induced wheeze, and cough causing sleep disturbance. However, these estimates had wide confidence intervals and, therefore, limited precision.

Frequent fast-food consumption was associated with exercise-induced wheeze, dry night cough, and cough causing sleep disturbance. Frequent truck traffic, used as an indicator of outdoor air pollution,

was significantly associated with cough-causing sleep disturbance. Borderline, but not statistically significant, associations were observed for current wheeze (p = 0.071) and dry nocturnal cough (p = 0.057).

Paracetamol use remained independently associated with current wheeze after adjustment for the other examined factors. For TV/PC use >1 hour/day, aOR values below 1 were found for current wheeze and exercise-induced wheeze.

To examine whether the associations between the selected risk factors and current asthma-related symptoms differed by survey year, interaction terms between survey year and selected risk factors (year × risk factor) were tested. No statistically significant interactions were found between 2016 and 2026. The strongest borderline finding was observed for the interaction between household dampness and survey year for exercise-induced wheeze (p = 0.086), but this did not reach statistical significance.

Table 5. Selected interaction analyses: survey year × risk factor

Interaction term	Symptom	Interaction OR (95% CI)	p
Paracetamol × year	Wheeze in the past 12 months	0.60 (0.15–2.40)	0.473
Truck traffic × year	Wheeze in the past 12 months	0.76 (0.28–2.04)	0.579
Truck traffic × year	Dry nocturnal cough	0.74 (0.35–1.59)	0.444
Fast food × year	Dry nocturnal cough	0.83 (0.38–1.83)	0.644
Household dampness × year	Wheeze in the past 12 months	0.99 (0.32–3.00)	0.980
Household dampness × year	Exercise-induced wheeze	0.21 (0.04–1.25)	0.086

Interaction models were adjusted for age and sex. p > 0.05 indicates that there was no statistical evidence that the strength of the association differed between 2016 and 2026.

Table 6. Persistence of asthma-related symptoms according to preventive therapy use among adolescents aged 12–15 years

Symptom	2016 without therapy n=673	2016 with therapy n=17	p	2026 without therapy n=256	2026 with therapy n=25	p
Wheeze in the past 12 months	32 (4.8%)	6 (35.3%)	<0.001	17 (6.6%)	14 (56.0%)	<0.001
Wheeze causing sleep disturbance	18 (2.7%)	2 (11.8%)	0.084	24 (9.4%)	10 (40.0%)	<0.001
Wheeze limiting speech	7 (1.0%)	1 (5.9%)	0.182	9 (3.5%)	4 (16.0%)	0.020
Exercise-induced wheeze	11 (1.6%)	2 (11.8%)	0.038	13 (5.1%)	6 (24.0%)	0.003

Symptom	2016 without therapy n=673	2016 with therapy n=17	p	2026 without therapy n=256	2026 with therapy n=25	p
Dry nocturnal cough	59 (8.8%)	7 (41.2%)	<0.001	50 (19.5%)	12 (48.0%)	0.004
Cough causing sleep disturbance	40 (5.9%)	8 (47.1%)	<0.001	38 (14.8%)	12 (48.0%)	<0.001

p: Fisher's exact test. Percentages were calculated within preventive therapy groups. In 2026, 42 adolescents with unknown/invalid preventive therapy status were excluded only from this analysis.

In both 2016 and 2026, asthma-related symptoms were more common among adolescents receiving preventive anti-inflammatory therapy. In 2026, the differences were statistically significant for all six symptoms examined.

Discussion

This study provides an updated assessment of the current prevalence and ten-year trend of doctor-diagnosed asthma, asthma-related symptoms, and changes in the risk-factor profile among adolescents aged 12–15, living in Skopje. The prevalence of doctor-diagnosed asthma remained low compared with the reported prevalence of childhood asthma in Europe of around 9% (12). Over the ten-year period, doctor-diagnosed asthma increased, although the difference was not statistically significant. At the same time, several current and clinically relevant asthma-related symptoms increased significantly. Underdiagnosis also remained an important problem, together with an unsatisfactory response to preventive anti-inflammatory therapy. In addition, changes in exposure to several environmental and lifestyle factors were observed during the ten-year period.

These findings are particularly important when compared with previous studies among adolescents in Skopje. Alas, repeated cross-sectional surveys conducted in 2002, 2006, and 2016 showed a divergent trend as follows: doctor-diagnosed asthma increased, whereas several asthma-related symptoms decreased (5). The current findings suggest that this pattern did not continue during the past decade. Instead, several asthma-related symptoms increased together with the increase in doctor-diagnosed asthma.

Our findings are consistent with results from four repeated surveys conducted among children in Poland between 1993 and 2014, where both asthma symptoms and diagnosed asthma increased, suggesting a real increase in asthma occurrence (13). A similar increase in current asthma attacks and diagnosed asthma was reported in the general population in Italy over a 25-year period (14).

However, trends have not been the same in all countries. Studies in Denmark showed stabilization of wheeze and asthma prevalence over a nine-year period, (15) while no further increase was observed among preschool children in Bavaria over eight years (16). In the Netherlands, a large study of children aged 5–18 years found a decrease in the incidence of diagnosed asthma after 2008 (17). In England, the prevalence of current doctor-diagnosed asthma decreased among children and adults younger than 45, while the use of preventive anti-inflammatory therapy and treatment of asthma exacerbations increased (18).

The ISAAC study also showed different trends across countries over 5–10 years periods. Asthma prevalence generally increased in many low- and middle-income countries, while it tended to stabilize or decrease in many high-income countries (3,4).

The parallel increase in asthma symptoms and their severity, together with the increase in doctor-diagnosed and current asthma, suggests a real increase in asthma among young adolescents in Skopje during the past ten years. At the same time, the much higher prevalence of asthma-related symptoms during the past12 months compared with the prevalence of diagnosed and current asthma suggests that asthma remains underdiagnosed.

In the corresponding 2016 study among children aged 5–15 living in Skopje, only 14.9% of children with wheeze during the past 12 months had been diagnosed with asthma, although 73.6% of these children were receiving treatment for breathing problems. This pattern was similar to findings from Ukraine and Belarus, while the situation was considerably better in Canada and Poland (9). These findings suggest that, in addition to asthma being underdiagnosed, the diagnosis itself may sometimes be avoided by physicians and parents. Some children may instead be diagnosed with recurrent obstructive bronchitis and treated with preventive therapy.

In both 2016 and 2026, asthma-related symptoms were more common among adolescents receiving preventive anti-inflammatory therapy. In 2026, the differences were statistically significant for all six symptoms examined. This should not be interpreted as evidence that preventive therapy is ineffective. A likely explanation is confounding by indication: adolescents with more severe or persistent symptoms are more likely to be prescribed preventive treatment. Other possible explanations include lower-than-required doses, irregular or insufficiently long treatment, or incorrect inhaler technique.

In the multivariable analysis, household dampness was one of the factors most consistently associated with asthma-related symptoms. After adjustment for other potential risk factors, it remained associated with current wheeze, more severe wheeze causing sleep disturbance, wheeze limiting speech, dry nocturnal cough, and cough causing sleep disturbance. However, because of the cross-sectional design, these findings show associations and do not establish causality.

Frequent truck traffic on the residential street, used as an indicator of outdoor air pollution, was associated only with current severe cough causing sleep disturbance. This is similar to a previous finding from Skopje, where truck traffic was also identified as a risk factor for current wheeze (19). Traffic-related air pollution has also been identified as a risk factor for asthma internationally (12).

Frequent fast-food consumption was positively associated with exercise-induced wheeze, dry nocturnal cough, and cough causing sleep disturbance during the past 12 months, in line with findings from ISAAC and other studies (12,20). Paracetamol use was positively associated with current wheeze. Similar associations between paracetamol use and asthma symptoms have been reported in previous local and international studies (21–23).

When we examined whether the associations between the risk factors and current asthma symptoms varied by survey year, there was no statistical evidence that the strength of these associations between 2016 and 2026. Diagnosis and treatment practices in our setting may, therefore, be among the factors contributing to the observed asthma trend.

An important strength of this study is the repeated cross-sectional design in the same geographical area and age group, using the same standardized questionnaire. The main limitations are the use of questionnaire-based data, the possibility of response bias, and the inability to establish causal relationships because of the cross-sectional design. In addition, detailed information on adherence to preventive therapy, inhaler technique, treatment dose, and duration was not available.

Conclusion

Among young adolescents in Skopje, asthma showed an increasing trend over the last ten years, accompanied by a significant increase in several asthma-related symptoms. Asthma remains underdiagnosed, and the findings also indicate problems with adequate preventive treatment.

These results highlight the need for better education of healthcare professionals to improve the recognition, diagnosis, and treatment of asthma. Education of patients and parents is also important, particularly regarding the regular and correct use of prescribed preventive therapy.

Declarations

Ethics approval and consent to participate: The study was approved by the Ethics Committee of the Faculty of Medicine, Ss. Cyril and Methodius University in Skopje, on 14 February 2026.

Informed consent: Written informed consent was obtained from the parents or legal guardians of all children who took part in the study. Participation was voluntary, and all collected data were kept confidential.

Conflict of interest: The authors declare no conflict of interest.

Funding: This research received no external funding.

Availability of data and materials: The data used in this study are available from the corresponding author upon reasonable request.

Authors contributions: All authors read and approved the final manuscript.

Artificial Intelligence (AI) statement: No AI tools were used in the preparation of this manuscript.

References:

1. Global Initiative for Asthma. Global strategy for asthma management and prevention. 2026 update. Fontana (WI): Global Initiative for Asthma; 2026. Available on www.ginasthma.org.
2. Lai CKW, Beasley R, the ISAAC Phase Three Study Group, 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; 64:476-483.
3. The global asthma report 2011. Paris, France: The International Union Against Tuberculosis and Lung Diseases; 2011. ISBN 978-2-914365-83-3.

4. Pearce N, Ait-Khaled N, the ISAAC Phase Three Study Group, et al. Worldwide trends in the prevalence of asthma symptoms: phase III of the International Study of Asthma and Allergies in Childhood (ISAAC). Thorax 2007; 62:758-66.

5. Vlaski E, Stavrikj K, Kimovska M, et al. Divergent trends in the prevalence of asthma-like symptoms and asthma in a developing country: three repeated surveys between 2002 and 2016. Allergol Immunopathol (Madr) 2020;48(5):475-83.

6. Masoli M, Fabian D, Holt S, Beasley R for the Global Initiative for Asthma (GINA) Program. The global burden of asthma: executive summary of the GINA Dissemination Committee Report. Allergy 2004;59:469-78.11.

7. Akinbami LJ, Simon AE, Rossen LM. Changing trends in asthma prevalence among children. Pediatrics 2016;137(1):1-7. [https://doi: 10.1542/peds.2015-2354].

8. Sears MR. Trends in the prevalence of asthma. Chest 2014;145(2):219-25. [https://doi: 10.1378/chest.13-2059].

9. Lawson JA, Brozek G, Shpakou A, Fedortsiv O, Vlaski E, Beridze V, et al. An international comparison of asthma, wheeze, and breathing medication use among children. Respir Med. 2017;133:22–8.

10. Lung Health Study, University of Saskatchewan. Supported by a grant from the Saskatchewan Health Research Foundation.

11. ISAAC Phase Three Newsletter. December 2001, 9. http://isaac.auckland.ac.nz/news/media.html#

12. 12.Zhou W, Tang J. Prevalence and risk factors for childhood asthma: a systematic review and meta-analysis. BMC Pediatr. 2025;25(1):50. doi:10.1186/s12887-025-05409-x.

13. Brozek G, Lawson J, Szumilas D, Zejda J. Increasing prevalence of asthma, respiratory symptoms, and allergic diseases: four repeated surveys from 1993-2014. Respir Med 2015;109(8):982-90. [https:// doi: 10.1016/j.rmed.2015.05.010].

14. Maio S, Baldacci S, Carrozzi L, Pistelli F, Angino A, Simoni M, et al. Respiratory symptoms/diseases prevalence is still increasing: a 25-yr population study. Respir Med 2016;110:58-65. [https://doi: 10.1016/j.rmed.2015.11.006].

15. de Korte-de Boer D, Mommers M, Gielkens-Sijstermans CM, Creemers HM, Mujakovic S, Feron FJ, et al. Stabilizing prevalence trends of eczema, asthma and rhinoconjunctivitis in Dutch schoolchildren (2001-2010). Allergy 2015;70(12):1669-73. [https:// doi: 10.1111/all.12728].

16. Weber A, Herr C, Hendrowarsito L, Meyer N, Nennstiel-Ratzel U, von Mutius E, et al; GME Study Group. No further increase in the parent reported prevalence of allergies in Bavarian preschool children: Results from three cross-sectional studies. Int J Hyg Environ Health 2016;219(4-5):343-8. [https:// doi: 10.1016/j.ijheh.2016.02.001].

17. Engelkes M, Janssens HM, de Ridder MA, de Jongste JC, Sturkenboom MC, Verhamme KM. Time trends in the incidence, prevalence and age at diagnosis of asthma in children. Pediatr Allergy Immunol 2015;26(4):367-74. [https:// doi: 10.1111/pai.12376].

18. Bloom CI, Saglani S, Feary J, Jarvis D, Quint JK. Changing prevalence of current asthma and inhaled corticosteroid treatment in the UK: population-based cohort 2006-2016. Eur Respir J 2019;53:1802130 [https://doi.org/10.1183/13993003.02130-2018].

19. Vlaski E, Stavric K, Seckova L, Kimovska Hristova M, Isjanovska R. The self-reported density of truck traffic on residential streets and the impact on asthma, hay fever and eczema in young adolescents. Allergol Immunopathol (Madr). 2014;42(3):224–9.

20. Ellwood P, Asher MI, García-Marcos L, Williams H, Keil U, Robertson C, et al. Do fast foods cause asthma, rhinoconjunctivitis and eczema? Global findings from the International Study of Asthma and Allergies in Childhood (ISAAC) Phase Three. Thorax. 2013;68(4):351–60.

21. Vlaski E, Stavric K, Isjanovska R, Seckova L, Kimovska M. Acetaminophen intake and risk of asthma, hay fever and eczema in early adolescence. Iran J Allergy Asthma Immunol. 2007;6(3):143–9.

22. Beasley RW, Clayton TO, Crane J, von Mutius E, Lai CKW, Montefort SR, et al. Acetaminophen use and risk of asthma, rhinoconjunctivitis, and eczema in adolescents: International Study of Asthma and Allergies in Childhood Phase Three. Am J Respir Crit Care Med. 2011;183(2):171–8.

23. Singh M, Varukolu S, Chauhan A, et al. Paracetamol exposure and asthma: what does the evidence say? An overview of systematic reviews. Pediatr Pulmonol. 2021;56(10):3189–99.