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อุบัติการณ์และผลกระทบของปัญหาที่เกี่ยวข้องกับการใช้ยาต่อการควบคุมโรคหืด และประสิทธิผลของโปรแกรมการให้ความรู้โดยเภสัชกรในเด็กโรคหืด

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Incidence and Impact of Drug-related Problems on Asthma Control, and Effectiveness of a Pharmacist-led Education Program in Pediatric Asthma

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บทคัดย่อ

ภูมิหลังและวัตถุประสงค์: โรคหืดเป็นโรคเรื้อรังที่พบบ่อยที่สุดในเด็ก ประเทศไทยมีความชุกร้อยละ 13 ปัญหาที่เกี่ยวข้องกับการใช้ยา (drug-related problems, DRPs) ได้แก่ ความไม่ร่วมมือในการใช้ยา และเทคนิคการสูดพ่นที่ไม่ถูกต้อง เป็นปัจจัยสำคัญต่อการควบคุมโรคหืด การศึกษานี้จึงมีวัตถุประสงค์เพื่อศึกษาอุบัติการณ์และชนิดของ DRPs ประเมินความสัมพันธ์ระหว่าง DRPs กับการควบคุมโรคหืด และประเมินประสิทธิผลของโปรแกรมการให้ความรู้โดยเภสัชกรต่อการควบคุมโรคหืด ณ โรงพยาบาลศรีนครินทร์ มหาวิทยาลัยขอนแก่น

วิธีการศึกษา: เป็นการศึกษาแบบย้อนหลังเชิงสังเกต ใช้ข้อมูลเวชระเบียนอิเล็กทรอนิกส์ของผู้ป่วยเด็กโรคหืดอายุน้อยกว่า 18 ปี ที่คลินิกโรคทางเดินหายใจกุมารเวชกรรม ช่วงวันที่ 1 มกราคม พ.ศ. 2566 ถึง 31 ธันวาคม พ.ศ. 2567 ทำการศึกษา (1) อุบัติการณ์และชนิดของปัญหาที่เกี่ยวข้องกับการใช้ยา โดยครอบคลุมความไม่ร่วมมือในการใช้ยาและเทคนิคการสูดพ่นที่ไม่ถูกต้อง (2) ความสัมพันธ์ระหว่าง DRPs กับการควบคุมโรคหืด และ (3) อัตราการควบคุมโรคหืดได้ภายหลังได้รับโปรแกรมการให้ความรู้โดยเภสัชกร โดยประเมินการควบคุมโรคตามเกณฑ์ Global Initiative for Asthma (GINA) 2024 เมื่อมาติดตามการรักษาครั้งถัดไป วิเคราะห์โดยใช้ Chi-square test และ Fisher's exact test เพื่อเปรียบเทียบอุบัติการณ์ของ DRPs และอัตราการควบคุมโรคหืด และใช้ multiple logistic regression เพื่อระบุปัจจัยอิสระที่มีความสัมพันธ์กับการควบคุมโรคหืดไม่ได้

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ผลการศึกษา: พบว่าผู้ป่วย 303 ราย ส่วนใหญ่เป็นเพศชายร้อยละ 58.4 อายุเฉลี่ย 8.0 ± 3.5 ปี พบ DRPs ร้อยละ 45.9 ความไม่ร่วมมือในการใช้ยา มีความสัมพันธ์อิสระกับการควบคุมโรคหืดไม่ได้ (adjusted OR 2.04, 95% CI 1.09–3.80, $p=0.020$) หลังได้รับโปรแกรมการให้ความรู้ ผู้ป่วยที่มี DRPs ควบคุมโรคหืดได้ร้อยละ 69.8 ($p=0.003$) กลุ่มอายุ 0–4 ปี มีอัตราการควบคุมโรคหืดได้สูงสุด (ร้อยละ 81.3, $p=0.001$) และกลุ่มอายุ 6–12 ปี ร้อยละ 76.9 ($p=0.008$) ในขณะที่กลุ่มวัยรุ่น 12–18 ปี มีอัตราการควบคุมโรคหืดได้ต่ำสุด (ร้อยละ 45.8, $p=0.200$)

สรุป: DRPs พบได้สูงในเด็กโรคหืด โดยเฉพาะความไม่ร่วมมือในการใช้ยา ซึ่งมีความสัมพันธ์อิสระกับการควบคุมโรคหืดไม่ได้ อย่างมีนัยสำคัญทางสถิติ โปรแกรมการให้ความรู้โดยเภสัชกรมีประสิทธิผลดีในเด็กเล็กและเด็กวัยรุ่น แต่กลุ่มวัยรุ่นยังต้องพัฒนากลยุทธ์เฉพาะกลุ่ม ผลการศึกษาสนับสนุนการบูรณาการบทบาทเภสัชกรคลินิกและการคัดกรอง DRPs อย่างเป็นระบบ

คำสำคัญ: โรคหืดในเด็ก ปัญหาที่เกี่ยวข้องกับการใช้ยา ความร่วมมือในการใช้ยา เทคนิคการสูดพ่นยา การให้ความรู้โดยเภสัชกร การควบคุมโรคหืด

Abstract

Background and objectives: Asthma is the most common chronic disease in children, with a prevalence of 13% in Thailand. Drug-related problems (DRPs), including poor medication compliance and incorrect inhaler technique, are major contributors to uncontrolled asthma. This study aimed to determine the incidence and types of DRPs, to evaluate the association between DRPs and asthma control, and to assess the effectiveness of a pharmacist-led education program on asthma control at Srinagarind Hospital, Khon Kaen University.

Methods: This was a retrospective observational study utilizing electronic medical records of pediatric patients with asthma aged less than 18 years attending the Pediatric Respiratory Clinic between January 1, 2023 and December 31, 2024. The outcomes of interest included: (1) the incidence and types of DRPs, encompassing poor medication compliance and incorrect inhaler technique; (2) the association between DRPs and asthma control; and (3) the rate of asthma control following a pharmacist-led education program. Asthma control was assessed according to the Global Initiative for Asthma (GINA) 2024 criteria at the subsequent clinic visit. Data were analyzed using the Chi-square test and Fisher's exact test to compare DRP incidence and asthma control rates, and multiple logistic regression to identify independent factors associated with uncontrolled asthma.

Results: A total of 303 patients were enrolled, of whom 58.4% were male, with a mean age of 8.0 ± 3.5 years. DRPs were identified in 45.9% of patients. Poor medication compliance was independently associated with uncontrolled asthma (adjusted OR 2.04, 95% CI 1.09–3.80, $p = 0.020$). Following the pharmacist-led education program, 69.8% of patients with DRPs achieved asthma control ($p = 0.003$). The highest asthma control rate was observed in the 0–4 year age group (81.3%, $p = 0.001$), followed by the 6–12 year age group (76.9%, $p = 0.008$), whereas the adolescent group aged 12–18 years demonstrated the lowest control rate (45.8%, $p = 0.200$).

Conclusions: DRPs were highly prevalent among pediatric asthma patients, particularly poor medication compliance, which was independently and significantly associated with uncontrolled asthma. The pharmacist-led education program demonstrated favorable effectiveness in young children and school-aged children; however, targeted strategies for adolescents were still needed. These findings supported the integration of clinical pharmacist roles and systematic DRP screening into routine asthma care.

Keywords: pediatric asthma, drug-related problems, medication compliance, inhaler technique, pharmacist education, asthma control

Introduction

Asthma was the most prevalent chronic respiratory disease in children worldwide, affecting approximately 262 million people globally according to the Global Burden of Disease study [1]. In Thailand, the prevalence of childhood asthma was estimated at 13%, representing approximately 1.8 million children [2]. Acute asthma exacerbations were a leading cause of emergency department visits and hospitalizations among children, resulting in substantial healthcare expenditures and significant impairment in quality of life for both patients and their families [3].

The severity of asthma symptoms ranged from intermittent mild episodes to persistent severe disease, with variable patterns of exacerbation and remission [4]. Without appropriate pharmacotherapy and proper patient education, asthma exacerbations could lead to life-threatening outcomes [5]. The Global Initiative for Asthma (GINA) 2024 guidelines emphasized that achieving and maintaining asthma control required not only appropriate pharmacological therapy but also effective patient and caregiver education regarding medication use [6].

The cornerstone of asthma pharmacotherapy in children was inhaled corticosteroids (ICS), which were delivered through specialized devices requiring proper technique for optimal drug delivery to the airways [7]. Drug-related problems (DRPs) were defined as events or circumstances involving drug therapy that actually or potentially interfered with desired health outcomes [8]. In pediatric asthma, DRPs were highly prevalent, with studies reporting that up to 61.25% of children receiving inhaled corticosteroids experienced at least one DRP [9]. The most common DRPs included poor medication adherence, incorrect inhaler technique, and adverse drug reactions [10].

Incorrect inhaler technique was particularly problematic in children. Studies had consistently demonstrated significant differences between children and adults in their ability to perform correct inhalation maneuvers [11]. Children frequently had difficulty coordinating actuation with inhalation and were often

unable to hold their breath after inhaling the medication [12]. Therefore, the use of spacer devices and repeated reinforcement of proper technique were essential components of asthma management in the pediatric population [13]. Prior studies had shown that repeated pharmacist-led counseling improved inhaler technique, enhanced asthma control, improved quality of life, and reduced emergency department visits [14,15].

Adverse drug reactions (ADRs) from asthma medications represented another important health concern in children. Long-term use of multiple medications in asthma therapy was associated with various ADRs, including headache, palpitations, oral candidiasis, sore throat, and dry mouth [16]. Many of these adverse effects were preventable with appropriate patient education and prophylactic measures [17].

Multiple patient-related factors contributed to DRPs in children, including age, sex, comorbidities, behavioral factors, type of inhaler device, and the adequacy of medication counseling [18]. However, data on the comprehensive burden of DRPs and their direct impact on asthma control outcomes in Thai pediatric populations remained limited. Furthermore, evidence on the effectiveness of structured pharmacist-led education programs in improving asthma outcomes in the Thai context was scarce.

Therefore, this study aimed to (1) determine the incidence and types of DRPs in pediatric asthma patients, (2) evaluate the association between DRPs and asthma control, and (3) assess the effectiveness of a structured pharmacist-led education program for improving asthma control in children with identified DRPs at Srinagarind Hospital, Khon Kaen University, Thailand.

Methods

Study design and setting

This retrospective observational study was conducted at the Pediatric Respiratory Clinic, Srinagarind Hospital, Faculty of Medicine, Khon Kaen University,

Thailand. Medical records of pediatric asthma patients who attended the clinic between 1 January 2023 and 31 December 2024 were reviewed.

Study population and eligibility criteria

Patients were included if they met all of the following criteria: (1) age less than 18 years, (2) physician-confirmed diagnosis of asthma based on GINA 2024 diagnostic criteria, including recurrent respiratory symptoms (wheeze, shortness of breath, chest tightness, or cough) and variable expiratory airflow limitation confirmed by spirometry or clinical assessment; and (3) referral to a clinical pharmacist for medication counseling during follow-up visits. Patients were excluded if there were no documented outcomes from the pharmacist counseling intervention. No formal sample size calculation was performed; all eligible patients attending the clinic during the study period were consecutively enrolled (convenience sampling).

Data collection

Data were extracted from electronic medical records and pharmaceutical care records. Collected variables included demographic characteristics (age, sex), comorbidities (atopic dermatitis, obstructive sleep apnea [OSA], allergic rhinitis), type of inhaler device (metered-dose inhaler [MDI], Accuhaler®, Turbuhaler®), the presence and type of DRPs (poor compliance, incorrect inhaler technique), and asthma control status at the subsequent clinic visit following the pharmacist-led education intervention [19].

DRP assessment was performed by a trained clinical pharmacist at each routine clinic visit as part of standard pharmaceutical care documentation. Assessment findings were prospectively recorded in the electronic medical record system during each visit, and these records were subsequently reviewed retrospectively for this study.

Definitions of variables

Drug-related problems were classified according to the Pharmaceutical Care Network Europe (PCNE) classification system version 9.1 [8]. The following categories were assessed:

Poor compliance was defined as self-reported or caregiver-reported non-adherence to the prescribed controller medication regimen, including (1) missing doses on 3 or more days per week, (2) irregular use, defined as use less than 5 days per week, and (3) premature discontinuation of therapy without medical advice [20].

Incorrect inhaler technique was defined as failure to perform one or more critical steps of the inhaler technique as assessed by a trained pharmacist using standardized device-specific checklists [11].

Asthma control was assessed according to the GINA 2024 criteria, which classified asthma control into well-controlled, partly controlled, and uncontrolled categories based on daytime symptoms, nighttime awakenings, reliever use, and activity limitation over the preceding 4 weeks [6]. For the purpose of this study, patients were dichotomized into “controlled” (well-controlled and partly controlled) and “uncontrolled” groups.

Intervention: structured pharmacist-led education program

Patients identified as having DRPs received a structured, individualized education session delivered by a clinical pharmacist. The intervention included: (1) assessment of current medication knowledge and inhaler technique, (2) demonstration of correct inhaler technique with teach-back verification, (3) education on the importance of medication adherence and the role of controller medications, (4) counseling on the prevention and management of common adverse drug reactions, and (5) provision of a written asthma action plan [14,15]. Asthma control was reassessed at the subsequent clinic visit following the education intervention, which typically occurred within 2–3 months.

Statistical analysis

Data were analyzed using STATA software (StataCorp, College Station, TX, USA). Categorical data were presented as frequencies and percentages. Continuous data were presented as mean $\pm$ standard deviation (SD) or median with interquartile range (IQR), depending on data distribution assessed by the Shapiro-Wilk test. Between-group comparisons were performed using the chi-square test or Fisher's exact test for categorical variables. Univariate logistic regression was initially performed to identify potential factors associated with uncontrolled asthma. Variables with $p < 0.25$ in univariate analysis or clinically relevant variables were entered into a multiple logistic regression model. Results were reported as adjusted odds ratios (OR) with 95% confidence intervals (CI). The proportion of patients achieving asthma control following the education program was reported as a single-arm post-intervention outcome. Logistic regression analyses were conducted using asthma control status assessed at the subsequent clinic visit following the education intervention as the outcome variable. Statistical significance was defined as $p < 0.05$.

Ethical consideration

This study was conducted in accordance with the Declaration of Helsinki. The study protocol was reviewed and approved by the Khon Kaen University Ethics Committee for Human Research (approval number: HE681230) on date 8 April 2026. Written informed consent was waived due to the retrospective nature of the study. All data were anonymized prior to analysis, and patient confidentiality was strictly maintained.

Results

Baseline characteristics

A total of 303 pediatric asthma patients were included. The baseline demographic and clinical characteristics were presented in Table 1. The mean age was 8.0 ± 3.5 years, with the majority being male

(58.4%). The age distribution showed that the largest group was children aged 6–12 years (55.1%), followed by the 4–6 years group (17.5%), the 12–18 years group (17.2%), and the 0–4 years group (9.9%). The most common comorbidity was allergic rhinitis (70.6%), followed by OSA (32.0%) and atopic dermatitis (6.3%). Regarding inhaler devices, Accuhaler® was the most frequently prescribed (40.9%), followed by Turbuhaler® (31.7%) and MDI (27.4%).

Incidence and types of DRPs

DRPs were identified in 139 of 303 patients (45.9%). Among patients with DRPs, 63 patients (20.8%) had poor medication compliance, 66 patients (21.8%) had incorrect inhaler technique, and 10 patients (3.3%) had both conditions. No adverse drug reactions were documented in the pharmacist records during the study period. The age distribution did not differ significantly between patients with and without DRPs ($p = 0.290$). A higher proportion of patients using Turbuhaler® devices was more common in the DRPs group compared to those without DRPs (38.1% vs. 26.2%, $p = 0.030$), while fewer Accuhaler® users had DRPs (35.3% vs. 45.1%, $p = 0.040$). No significant differences were observed for sex, comorbidities, or MDI use between the two groups.

Association between DRPs and asthma control

The association between specific types of DRPs and asthma control status was presented in Table 2. Poor medication compliance was significantly more prevalent among patients with uncontrolled asthma compared to those with controlled asthma (30.5% vs. 17.2%, $p < 0.001$). The coexistence of poor medication compliance and incorrect inhaler technique was also significantly associated with uncontrolled asthma (63.4% vs. 43.4%, $p = 0.040$). Incorrect inhaler technique alone was not significantly different between the two groups (20.7% vs. 22.2%, $p = 0.840$).

Table 1 Demographic and clinical characteristics (n=303)

Variables	No DRPs (n=164) n (%)	DRPs (n=139) n (%)	p-values
Age (years), Average (mean±SD)	7.98±3.46	8.03±3.67	0.008
0–4	14 (8.5)	16 (11.5)	
4–6	33 (20.1)	21 (15.1)	
6–12	89 (54.3)	78 (56.1)	
12–18	28 (17.1)	24 (17.3)	
Gender; male	91 (55.5)	86 (61.9)	0.260
Comorbidities			
Atopic dermatitis	10 (6.1)	9 (6.5)	0.890
OSA	32 (20.1)	65 (46.8)	p < 0.001
Allergic rhinitis	114 (69.5)	100 (71.9)	p = 0.680
Inhaler devices			
MDI	46 (28.0)	37 (26.6)	0.180
Accuhaler®	75 (45.7)	49 (35.3)	0.040
Turbuhaler®	43 (26.2)	53 (38.1)	0.030

DRPs, drug-related problems; OSA, obstructive sleep apnea; MDI, metered-dose inhaler.

The p-value for Age refers to the chi-square test for the categorical age-group variable (0–4, 4–6, 6–12, and 12–18 years), not the continuous age variable. p-values for OSA and allergic rhinitis were p<0.001 and p=0.680, respectively. Statistical significance was defined as p<0.05.

Table 2 Association between poor compliance, poor technique, and asthma control at subsequent clinic visit following the education program

Variables	Uncontrolled asthma (n=82) n (%)	Controlled asthma (n=221) n (%)	p-values
Poor compliance	25 (30.5)	38 (17.2)	< 0.001
Poor technique	17 (20.7)	49 (22.2)	0.840
Poor compliance and/or poor technique (combined)†	52 (63.4)	96 (43.4)	0.040

† Poor compliance and/or poor technique (combined) denotes patients with either poor medication compliance, incorrect inhaler technique, or both; this variable was derived from the full cohort (n=303) and is not restricted to the 139 patients with identified DRPs.

Statistical note: percentages for poor compliance and poor inhaler technique are calculated within each asthma control group (uncontrolled n=82; controlled n=221). p-values were calculated using chi-square test or Fisher's exact test as appropriate. Statistical significance was defined as p<0.05.

Asthma control following pharmacist-led education program

Among the 139 patients with identified DRPs who received the structured pharmacist-led education program, asthma control outcomes assessed at the subsequent clinic visit were presented in Table 3. Overall, 97 patients (69.8%) achieved controlled

asthma following the intervention. When stratified by age group, the highest proportion achieving controlled asthma was observed in children aged 0–4 years (81.3%, p = 0.001) and 6–12 years (76.9%, p = 0.008). The proportion achieving controlled asthma was not statistically significant in children aged 4–6 years (61.9%, p = 0.100) and adolescents aged 12–18 years (45.8%, p = 0.200).

Table 3 Asthma control outcomes at subsequent clinic visit following the education program, stratified by age group (n=139)

Age groups in years (n)	Uncontrolled asthma n (%)	Controlled asthma n (%)	p-values
Overall (n=139)	42 (30.2)	97 (69.8)	0.003
0–4 (n=16)	3 (18.7)	13 (81.3)	0.001
4–6 (n=21)	8 (38.1)	13 (61.9)	0.100
6–12 (n=78)	18 (23.1)	60 (76.9)	0.008
12–18 (n=24)	13 (54.2)	11 (45.8)	0.200

Factors associated with uncontrolled asthma

Univariate logistic regression analysis of factors associated with uncontrolled asthma was presented in Table 4. Among all variables examined, poor medication compliance was the only factor significantly associated with uncontrolled asthma (OR = 2.10, 95% CI = 1.20–3.88, p = 0.010). The combined

effect of poor medication compliance and incorrect inhaler technique also showed borderline significance (OR = 1.67, 95% CI = 1.00–2.78, p = 0.050). Age group, gender, comorbidities, inhaler device type, and incorrect inhaler technique alone were not significantly associated with uncontrolled asthma.

Table 4 Univariate logistic regression analysis of factors associated with uncontrolled asthma at subsequent clinic visit following the education program

Variables	ORs	95% CIs	p-values
Age groups in years			
0–4 (reference)	1	–	–
4–6	0.96	0.34–2.64	0.940
6–12	0.81	0.33–1.96	0.640
12–18	1.86	0.69–4.96	0.210
Female gender	0.82	0.49–1.39	0.480
Comorbidities	0.60	0.22–1.59	0.300
MDI	1.02	0.61–1.70	0.920
Accuhaler®	0.95	0.56–1.61	0.870
Turbuhaler®	1.42	0.65–3.09	0.360
Poor compliance	2.10	1.20–3.88	0.010
Poor technique	0.93	0.50–1.74	0.840
Poor compliance and/or poor technique (combined)†	1.67	1.00–2.78	0.050

CI, confidence interval; OR, odds ratio; MDI, metered-dose inhaler

Multiple logistic regression analysis was presented in Table 5, adjusted for gender, age group, comorbidities, and inhaler device type. Poor medication compliance remained independently and significantly associated

with uncontrolled asthma (adjusted OR = 2.04, 95% CI = 1.09–3.80, p = 0.020). The combined effect of poor medication compliance and incorrect inhaler technique was also independently associated with

uncontrolled asthma (adjusted OR = 1.70, 95% CI = 1.01–2.90, $p = 0.040$). Incorrect inhaler technique alone was not significantly associated with

uncontrolled asthma after adjustment (adjusted OR = 1.06, 95% CI = 0.55–2.05, $p = 0.850$).

Table 5 Multiple logistic regression analysis of factors associated with uncontrolled asthma* at subsequent clinic visit following the education program

Variables	Adjusted ORs	95% CIs	p-values
Poor compliance	2.04	1.09–3.80	0.020
Poor technique	1.06	0.55–2.05	0.850
Poor compliance and/or poor technique (combined) [†]	1.70	1.01–2.90	0.040

CI, confidence interval; OR, odds ratio.

*Adjusted for gender, age group, comorbidities, and inhaler device type.

Discussion

This study demonstrated a high prevalence of DRPs among pediatric asthma patients, with nearly half of the cohort experiencing at least one medication-related issue. The overall DRP prevalence of 45.9% was consistent with previous studies; for instance, Rotta et al. reported that clinical pharmacy services identified DRPs in a substantial proportion of patients with chronic diseases [21], and studies in pediatric asthma populations had reported DRP prevalence rates ranging from 30% to over 60% depending on setting and assessment method [9]. Poor compliance (20.8%) and incorrect inhaler technique (21.8%) were the two predominant DRP types, underscoring the importance of both behavioral and technical factors in asthma management. The observed magnitude highlights the importance of structured assessment of medication use behaviors in routine asthma care.

Poor medication compliance was identified as the strongest independent predictor of uncontrolled asthma. Children with poor medication compliance had approximately a twofold increase in the odds of uncontrolled asthma. This finding was consistent with prior evidence demonstrating that non-adherence is a key modifiable determinant of asthma instability [22,23]. The GINA 2024 guidelines emphasized evaluating adherence before stepping up therapy, as

uncontrolled symptoms might have reflected behavioral barriers rather than pharmacologic failure [6].

Although incorrect inhaler technique is frequently reported in pediatric asthma populations [11,12], incorrect inhaler technique alone was not independently associated with uncontrolled asthma in our multivariable analysis. However, when incorrect inhaler technique coexisted with poor medication compliance, the combined effect significantly increased the likelihood of uncontrolled asthma. This finding is consistent with research indicating that inhaler misuse reduces effective drug delivery and may compromise asthma stability, particularly when medication exposure is inconsistent [24].

Device selection also influenced medication-related problems. In this study, a higher proportion of DRPs was observed among users of dry powder inhalers. These devices require sufficient inspiratory flow, which younger children may not consistently achieve [25]. Current clinical recommendations support individualized inhaler selection based on age and coordination ability [26].

Following the pharmacist-led education program, 69.8% of patients with identified DRPs achieved controlled asthma at the subsequent clinic visit. Similar post-intervention rates of asthma control improvement had been demonstrated in structured pharmacy-based asthma care programs [27,28].

Randomized controlled trials had also shown that pharmacist-delivered medication review interventions could produce clinically meaningful improvements in asthma outcomes [29].

Age-stratified analysis revealed greater benefit among younger children compared with adolescents. In early childhood, caregivers typically supervised medication administration, allowing educational interventions to directly influence treatment behaviors [30]. In contrast, adolescence was often associated with reduced adherence due to psychosocial and developmental factors [31]. Barriers such as desire for autonomy, stigma, and competing priorities may have interfered with consistent medication use.

From a systems perspective, multidisciplinary care models incorporating pharmacist involvement and structured medication review had demonstrated benefits in chronic respiratory disease management. Integrating routine DRP screening into pediatric asthma follow-up could therefore enhance long-term disease control.

Our findings had important implications for clinical practice. First, systematic screening for DRPs, particularly medication non-adherence, should have been a standard component of every asthma follow-up visit. Second, the integration of clinical pharmacists into multidisciplinary asthma care teams could have provided substantial benefits, especially in resource-limited settings where physician time was constrained. Third, the development of age-specific educational interventions, with particular attention to the adolescent population, was warranted.

Several limitations should be considered when interpreting these results. First, the retrospective design limited our ability to establish causal relationships between DRPs and asthma control outcomes. The assessment of asthma control relied on GINA criteria documented in clinical records, which might have been subject to inter-observer variability. Second, the study was conducted at a single tertiary care center, which might have limited the generalizability of the

findings to primary care or community settings. Third, medication compliance was assessed through self-report or caregiver-report rather than objective measures such as electronic monitoring devices or prescription refill data, which might have underestimated the true prevalence of non-adherence. Fourth, we did not assess other potential confounders such as environmental triggers, socioeconomic status, parental education level, or disease severity classification, which might have influenced both DRPs and asthma control. Fifth, no formal sample size calculation was performed; all eligible patients during the study period were consecutively enrolled, and the study might have been underpowered to detect smaller effect sizes. Finally, since all patients presented with uncontrolled asthma at enrolment and asthma control was assessed only at the subsequent clinic visit without a control group, improvements in asthma control might have partially reflected regression to the mean or natural disease fluctuation rather than the intervention effect alone.

Conclusions

DRPs were identified in 45.9% of pediatric asthma patients, with poor medication compliance (20.8%) and incorrect inhaler technique (21.8%) as the predominant types. Poor compliance was independently associated with uncontrolled asthma (adjusted OR 2.04), and the combination of both DRP types further increased this risk. A structured pharmacist-led education program was effective for improving asthma control in 69.8% of patients with DRPs, with the greatest benefit observed in younger children and school-age patients. Adolescents represented a particularly challenging group requiring tailored interventions. These findings supported the integration of clinical pharmacists into pediatric asthma care teams and the implementation of systematic DRP screening as a standard of care. Future prospective, controlled studies were needed to further validate the effectiveness of pharmacist-led interventions and to develop age-specific strategies for optimizing asthma outcomes in children.

Conflict of interest

The authors declare that they have no competing interests.

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Author contributions

LM and TU conceptualized and designed the study, collected all the data, carried out analyses, drafted the manuscript, revised the final manuscript and agreed to be accountable for all aspects of the work. RP conceptualized and designed the study, collected all the data, carried out the analyses, drafted the manuscript, and revised the final manuscript. All the authors agree to be accountable for all aspects of the work.

Consent for publication

Not applicable.

Data availability statement

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

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