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ORIGINAL RESEARCH

Clinical Burden and Healthcare Resource Use of Asthma in Children in the UK

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Background: UK pediatric asthma prevalence is among the highest in Europe, and although the clinical and economic burden of asthma in UK adults is well described, childhood asthma data is lacking. We assessed the clinical and economic burden of asthma in children in the UK to better understand the impact of pediatric asthma.

Methods: This was a retrospective, case-matched, longitudinal analysis using the Clinical Practice Research Datalink GOLD database and linked patient-level data (Hospital Episode Statistics and Office for National Statistics datasets) of selected patient (aged 6–11 years) records in 2017. Severe exacerbation and re-exacerbation rates per patient-year (PPY), all-cause healthcare resource utilization (HCRU), and HCRU-related costs were assessed in asthma patients versus matched non-asthma controls, stratified by severity.

Results: Among 5950 patients, severe exacerbation rate was 0.06, 0.17 and 0.31 PPY for mild, moderate, and severe asthma, respectively. Incident rate of severe exacerbations were higher for moderate asthma (incident rate ratios [IRR; 95% CI] 2.87 [2.30–3.56], $P<0.0001$) and severe asthma (5.19 [4.20–6.41], $P<0.0001$) versus mild asthma. Risk of re-exacerbation was significantly increased for severe versus mild asthma (hazard ratio [95% CI]: 2.98 [1.90–4.65], $P<0.001$). All-cause HCRU (IRR [95% CI]) was higher in severe asthma patients versus controls (primary care: 3.81 [3.54–4.09], $P<0.0001$; inpatient admissions: 3.23 [2.31–4.62], $P<0.0001$]); total-cost ratios relative to controls for mild, moderate, and severe asthma were 1.58 (1.39–1.78, $P<0.0001$), 2.56 (1.97–3.33, $P<0.0001$), and 3.42 (2.54–4.61, $P<0.0001$), respectively. Asthma-related costs increased with severity (total-cost ratios: moderate versus mild, 1.68 [1.45–1.97], $P<0.0001$; severe versus mild, 2.67 [2.21–3.25], $P<0.0001$).

Conclusion: In children with asthma in the UK, increasing disease severity was associated with increased risk of severe exacerbations, re-exacerbations, and increased HCRU and costs.

Keywords: asthma, paediatric, United Kingdom, CPRD

Introduction

Asthma is the most common chronic disease in children worldwide and is recognized globally as a serious public health issue.[1–5] Poorly controlled asthma in childhood is associated with a significant reduction in health-related quality of life and incurs a substantial burden on healthcare systems, mainly due to the occurrence of exacerbations, some of which can lead to emergency room (ER) admission and hospitalization.[1,2,6–8] The UK has one of the highest rates of childhood asthma prevalence and emergency admissions in Europe; in 2016, approximately 1 million children in the UK received treatment for asthma, and almost 50% of them experienced an asthma exacerbation in the preceding year.[9] In England in 2019 and 2020, over 13,000 inpatient admissions for asthma occurred among children aged up to 9 years.[10]

Identifying and managing asthma in children presents a challenge to clinicians and healthcare systems, partly because the differences in diagnosis and treatment of asthma in children and adults are not clearly defined.[7,8] In particular, there are multiple definitions of severe asthma in children.[11] Many elements of asthma diagnosis, definition of severity, and management in children are taken from those used for adults, and specific guidance based on objective assessment of pediatric asthma is lacking.[7,8] Assessing the clinical and associated economic burden of uncontrolled asthma in children is instrumental in understanding the unmet need in children, who continue to experience exacerbation despite

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treatment.[7,8,12] A recent literature review of the economic burden of pediatric asthma in the United States found that children with asthma have considerably higher healthcare resource utilization (HCRU) and associated costs than children without asthma.[13]

Although the clinical and economic burden of asthma in UK adults is well described, data are lacking for childhood asthma, especially stratified by severity.[14] This study aims to assess the clinical and economic burden of asthma in children aged 6 to 11 years in the UK using records from the Clinical Practice Research Datalink (CPRD) database.

Methods

Study Design

A retrospective, case-matched, longitudinal analysis was conducted using the CPRD GOLD database and linked data (Hospital Episode Statistics [HES][15,16] and Office for National Statistics [ONS] datasets). Records entered between the index date, defined as the first diagnosis of asthma in 2017 or, for patients diagnosed prior to 2017, January 1, 2017, and December 21, 2017, were included in the analysis. We compared severe exacerbation rates (overall and by healthcare setting), healthcare utilization, and costs between patients with asthma and matched non-asthma controls. Also, we investigated the impact of asthma severity based on the Global Initiative for Asthma (GINA) classification, including mild, moderate, and severe asthma.[17]

Data Source

The study used CPRD GOLD, an anonymized research database providing data on demographics, diagnoses, symptoms, investigations, referrals, and prescriptions for over 13 million patients registered at nearly 700 primary care practices in the UK.[18,19] Approximately 60% of these practices participate in a linkage scheme, by which their patient records are linked to other data sources. These include the HES dataset (which provides data on all inpatient, accident and emergency, and outpatient contacts) and patient-level Index of Multiple Deprivation (IMD) datasets (which provide a small area-based deprivation indicator based on income, employment, education, health deprivation and disability, crime, barriers to housing and services, and living environment).[15,16,20,21] Studies using the CPRD database are covered by an ethics approval granted by the Trent Multicentre Research Ethics Committee (approval reference code: 05/MRE04/87). CPRD Independent Scientific Advisory Committee approval was granted for this study (approval code: ISAC 19_268).

Study Population

The study population consisted of UK patients who were aged 6 to 11 years in 2017 and who had a recorded diagnosis of asthma in 2016 or 2017. For patients diagnosed in 2017, the index date was the date of diagnosis. For patients diagnosed prior to 2017, the index date was defined as January 1, 2017. Patients who experienced an exacerbation in 2017 were followed up for a maximum of 12 months or censored on the date they left the practice or the date of the last data collection. Patients were followed up until either December 31, 2017, or end of follow-up, whichever came first.

Asthma severity was defined according to the GINA 2017 guidelines (increasing step numbers indicate increasing severity; Table S1), using current treatment and resource utilization data, based on the highest severity classification recorded in 2017.[17] A control group of patients with no history of asthma during or prior to the study period (2016–2017) was matched on age, gender, same primary care practice, and concurrent practice registration; non-asthma controls were required to be aged 6 to 11 years in 2017 and registered by June 30, 2017. Analyses of severe exacerbations and resource use were limited to a subgroup of patients who were part of the CPRD–HES linkage scheme.

Clinical Outcomes, HCRU, and Cost Variables

Severe Asthma Exacerbations

Severe asthma exacerbations were defined by meeting any of three criteria. First, an emergency inpatient admission (admission codes 21–23) with a primary International Classification of Diseases (ICD)-10 code for asthma in the HES admitted patient care dataset. Second, an admission to accident and emergency for asthma (National Health Service

[NHS] specific diagnosis code 251). Third, an acute course (defined as a prescription lasting for 3–29 days, prescribed during a consultation, and not a repeat prescription) of oral corticosteroids (OCS) or injectable corticosteroids according to the CPRD GOLD table of qualifying therapies. Exacerbations were classified as "severe exacerbation with inpatient/ER use" where there was hospital involvement (if the first and second criteria were met) or "severe exacerbation with no hospital involvement" (if only the third criterion was met). Exacerbation events categorized as severe according to these criteria were defined as unique when at least 7 days were recorded between exacerbations. The number and proportion of patients reporting 1, 2, or ≥3 severe exacerbations within the preceding year were also reported.

HCRU and Cost Variables

Primary care contacts are based on CPRD GOLD and were classified according to consultation type and staff role. Associated costs were derived from the Units Costs of Health and Social Care 2017,[22] based on mapping tables applied to each contact. Inpatient and outpatient admissions are based on the HES admitted patient care dataset; Healthcare Resource Groups (HRGs) were assigned to each admission and then linked to the 2017 National Tariff, after adjustment for elective versus emergency admission and excess length of stay.[23] Asthma-related records were classified as those with an ICD-10 code for asthma (for inpatients) or a respiratory medicine specialty code 340 (for outpatients). Accident and emergency attendances are based on the HES accident and emergency dataset, and associated costs were based on allocated HRGs linked to the 2017 National Tariff; asthma-related contacts were classified as those with a diagnosis code (251) for asthma.[23] Costs for asthma-related prescriptions recorded in CPRD were based on the net ingredient cost per prescription from the Prescription Cost Analysis for England 2015.[24]

Data Analysis

A Poisson regression model assessed rates of severe exacerbations by level of asthma severity. Incident rate ratios (IRRs) with 95% CIs were reported by GINA-severity classification, with patients with mild asthma used as the reference category.[17] The regression model was a priori adjusted for age, gender, and the presence of selected comorbidities (allergic rhinitis, allergic conjunctivitis, atopic dermatitis, and chronic rhinosinusitis). A binary comparison was also conducted for all GINA-severity classifications: moderate versus mild, severe versus mild, and severe versus moderate. A sensitivity analysis was performed in which the duration between exacerbations used to define unique events was extended to 28 days. For patients with a severe exacerbation during 2017, 12-month re-exacerbation rates were calculated using Kaplan–Meier analysis; hazard ratios (HRs) and 95% CIs were generated using Cox proportional hazards model.

Healthcare contacts were assessed for patients with asthma and their matched controls and reported as total number of contacts and contact rates per patient-year (PPY), using total events as the numerator and total person follow-up time as the denominator.

Rates of all-cause HCRU were compared between asthma patients and non-asthma controls using a Poisson regression model, adjusted for age, gender, and presence of selected comorbidity (allergic rhinitis, allergic conjunctivitis, atopic dermatitis, chronic rhinosinusitis) and IMD. Incident rate ratios (95% CIs) were reported comparing asthma patients (defined by calculated GINA-severity classification) with their respective non-asthma controls who formed the reference category (IRR=1.000). For asthma-related HCRU, a similar Poisson model was used to derive IRRs (95% CIs) comparing GINA-severity classification with mild cases as the reference category (IRR=1.000). In addition, a binary comparison was made for all GINA-severity classifications (moderate versus mild; severe versus mild; severe versus moderate).

All HCRU analyses were replicated for associated costs. The cost analyses also included prescription costs and total costs defined as the sum of all individual cost elements. All cost estimates were modelled assuming a gamma distribution.

Results

Baseline Characteristics

Overall, 5950 patients in CPRD GOLD had linked HES and ONS data and were therefore considered suitable for inclusion in the study. All but one patient (due to missing data) with asthma were successfully matched to non-asthma

controls. In summary, approximately 60% of patients were male, and the mean age was 8.7 years. Overall, 1 in 4 patients were classified in the upper quintile (most affluent) and 1 in 5 patients were classified in the lowest quintile (most deprived) of the IMD. In the cohort of children with asthma, almost 25% of patients were classified as having moderate (14.2%) or severe (9.0%) asthma based on GINA-treatment definitions (Table S2).

Severe Exacerbations

Annualized rates of severe exacerbation events increased with increasing asthma-severity level, with 0.06, 0.17, and 0.31 exacerbations PPY in patients with mild (n=4574), moderate (n=842), and severe (n=534) asthma, respectively (Table 1). Trends were similar for severe exacerbation events with inpatient or ER admissions and events without inpatient or ER admissions. The proportion of patients with 1, 2, or ≥3 severe asthma exacerbations annually was slightly higher in severe patients compared with mild and moderate patients (Table 1). Poisson regression analysis confirmed a significantly increased rate of severe exacerbation in children with moderate (IRR [95% CI]: 2.87 [2.30–3.56]; $P<0.0001$) and with severe asthma (IRR [95% CI]: 5.19 [4.20–6.41]; $P<0.0001$), compared with patients with mild asthma (Table S3). Similarly, the rate of severe exacerbations was significantly higher among those with severe versus moderate asthma (IRR [95% CI]: 1.75 [1.38–2.23]; $P<0.0001$). A sensitivity analysis using a 28-day gap (n=470) to define unique severe exacerbation events confirmed the main findings (Table 1).

Re-Exacerbations

Of 392 patients with an initial exacerbation event, 104 patients (26.5%) had a record of re-exacerbation within 12 months. A higher proportion of patients with severe asthma had re-exacerbation events (45.3%) compared with moderate (23.0%) or mild (18.8%) asthma. The risk of re-exacerbation was significantly increased for severe versus mild asthma (HR [95% CI]: 2.98 [1.90–4.65]; $P<0.001$) (Figure 1).

HCRU

All-Cause HCRU

All-cause HCRU was significantly higher in patients with asthma compared with matched controls across all types of healthcare contacts and increased by degree of asthma severity. The adjusted IRRs (95% CIs) for severe asthma versus

Table 1 Number/Rate of Severe Asthma Exacerbations (7-Day Gap and 28-Day Gap Definitions) and Number/Rate of Patients Experiencing 1, 2, or ≥3 Severe Asthma Exacerbations (7-Day Gap Definition) in 2017

	Mild Patients (n=4574)		**Moderate Patients (n=842)**		**Severe Patients (n=534)**	
Severe asthma exacerbation gap definition	**7-day gap**	**28-day gap**	**7-day gap**	**28-day gap**	**7-day gap**	**28-day gap**
Severe asthma exacerbation, n (PPY)						
All	222 (0.06)	218 (0.06)	129 (0.17)	123 (0.17)	149 (0.31)	129 (0.27)
With inpatient/ER admission	103 (0.03)	101 (0.03)	54 (0.07)	50 (0.07)	65 (0.14)	59 (0.12)
Without inpatient/ER admission	119 (0.03)	117 (0.03)	75 (0.10)	73 (0.10)	84 (0.17)	70 (0.15)
Patients reporting 1, 2, or ≥3 severe asthma exacerbations,[a] n (%)						
1 exacerbation	172 (3.8)	–	82 (9.7)	–	65 (12.2)	–
2 exacerbations	20 (0.4)	–	12 (1.4)	–	20 (3.7)	–
≥3 exacerbations	<5	–	6 (0.7)	–	13 (2.4)	–

Note: [a]7-day gap definition only.
Abbreviations: ER, emergency room; PPY, per patient-year.

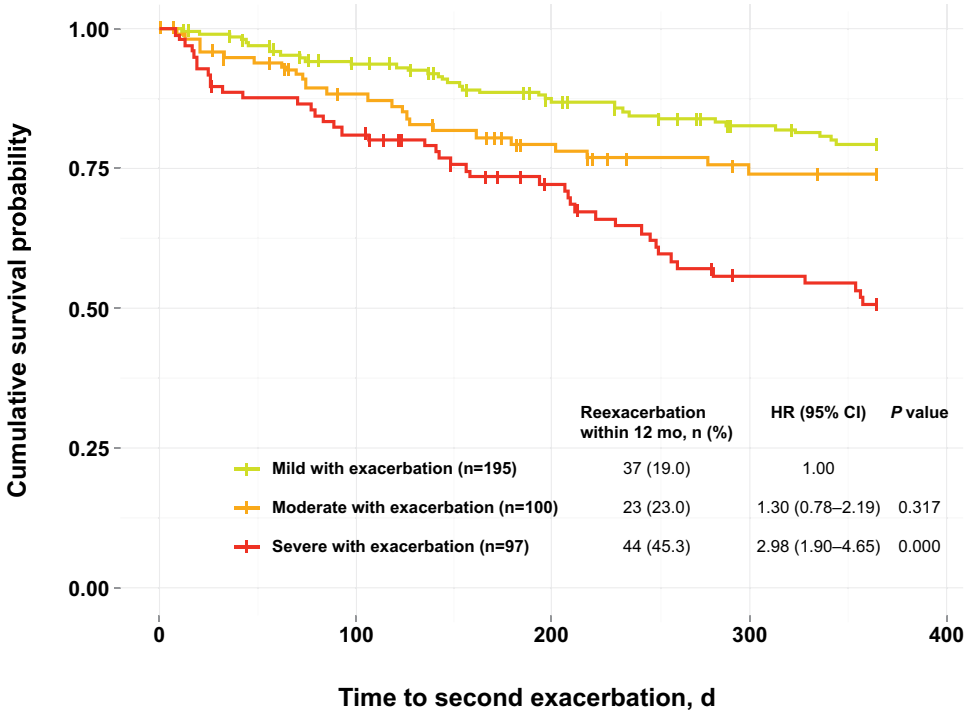

Figure 1 Kaplan–Meier curves for first re-exacerbation event in pediatric asthma patients aged 6 to 11 years by GINA classification 2017 with adjusted HRs for moderate and severe asthma vs mild asthma.
Abbreviations: GINA, Global Initiative for Asthma; HR, hazard ratio.

controls were 3.81 (3.54–4.09) for primary care contacts, 3.23 (2.31–4.62) for inpatient admissions, 3.40 (2.99–3.88) for outpatient appointments, and 2.94 (2.37–3.67) for accident and emergency contact. Similarly, adjusted IRRs also for HCRU demonstrated higher use among patients with moderate asthma than non-asthma controls (Table 2).

Asthma-Related HCRU

Increased asthma-related HCRU was associated with increasing asthma severity across all categories (Table 2). In the binary comparison of all GINA-severity classifications, the adjusted IRRs (95% CI) for moderate and severe asthma (compared with mild asthma) were 1.35 (1.30–1.40) and 1.53 (1.47–1.60) for primary care contacts; 3.20 (2.16–4.69) and

Table 2 Asthma-Related HCRU (Asthma Cohort Only), All-Cause HCRU for Pediatric Asthma Patients and Non-Asthma Controls, and All-Cause IRR for Asthma Vs Control Cohort

	Asthma cohort		Control cohort	All-cause IRR (95% CI)	*P* value
	Asthma-related events (PPY)	All-cause events (PPY)	All-cause events (PPY)		
Primary care contacts					
Mild	13,286 (3.51)	16,578 (4.4)	7508 (2.1)	1.98 (1.92–2.03)	<0.0001
Moderate	3551 (4.81)	4826 (6.5)	1454 (2.1)	2.91 (2.74–3.09)	<0.0001
Severe[a]	2622 (5.46)	3890 (8.1)	904 (2.1)	3.81 (3.54–4.09)	<0.0001
All patients	19,459 (3.89)	25,294 (5.1)	9866 (2.1)	2.24 (2.19–2.30)	<0.0001

(*Continued*)

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Table 2 (Continued).

	Asthma cohort		Control cohort	All-cause IRR (95% CI)	*P* value
	Asthma-related events (PPY)	All-cause events (PPY)	All-cause events (PPY)		
Primary care surgery contacts					
Mild	13,015 (3.44)	14,180 (3.7)	6201 (1.7)	2.05 (1.98–2.11)	<0.0001
Moderate	3469 (4.70)	4115 (5.6)	1154 (1.7)	3.18 (2.97–3.41)	<0.0001
Severe[a]	2599 (5.41)	3333 (7.0)	747 (1.8)	3.95 (3.65–4.28)	<0.0001
All patients	19,083 (3.81)	21,628 (4.3)	8102 (1.7)	2.35 (2.29–2.41)	<0.0001
Primary care home visits					
Mild	<5	680 (0.2)	421 (0.1)	1.50 (1.33–1.71)	<0.0001
Moderate	<5	130 (0.2)	84 (0.1)	1.42 (1.06–1.90)	0.0206
Severe[a]	<5	137 (0.3)	55 (0.1)	2.19 (1.61–3.02)	<0.0001
All patients	<5	947 (0.2)	560 (0.1)	1.55 (1.39–1.73)	<0.0001
Inpatient admissions					
Mild	66 (0.02)	414 (0.1)	249 (0.1)	1.55 (1.31–1.82)	<0.0001
Moderate	43 (0.06)	131 (0.2)	51 (0.1)	2.38 (1.70–3.37)	<0.0001
Severe[a]	64 (0.13)	154 (0.3)	41 (0.1)	3.23 (2.31–4.62)	<0.0001
All patients	173 (0.03)	699 (0.1)	341 (0.1)	1.87 (1.63–2.14)	<0.0001
Outpatient appointments					
Mild	18 (0.00)	4084 (1.1)	2880 (0.8)	1.30 (1.24–1.37)	<0.0001
Moderate	19 (0.03)	974 (1.3)	540 (0.8)	1.77 (1.59–1.98)	<0.0001
Severe[a]	52 (0.11)	1105 (2.3)	286 (0.7)	3.40 (2.99–3.88)	<0.0001
All patients	89 (0.02)	6163 (1.2)	3706 (0.8)	1.52 (1.46–1.59)	<0.0001
Accident and emergency contacts					
Mild	93 (0.03)	1573 (0.4)	1058 (0.3)	1.40 (1.29–1.51)	<0.0001
Moderate	38 (0.05)	418 (0.6)	175 (0.3)	2.26 (1.88–2.73)	<0.0001
Severe[a]	60 (0.12)	354 (0.7)	107 (0.3)	2.94 (2.37–3.67)	<0.0001
All patients	209 (0.04)	2345 (0.5)	1340 (0.3)	1.62 (1.51–1.73)	<0.0001

Notes: Mild (n=4574), moderate (n=842), severe (n=533); adjusted for age, gender, baseline allergic rhinitis, conjunctivitis, and atopic dermatitis unless otherwise specified.[a]adjusted for age, gender, and IMD.

Abbreviations: IMD, Index of Multiple Deprivation; HCRU, healthcare resource utilization; IRR, incident rate ratio; PPY, per patient-year.

7.04 (4.94–10.02) for inpatient admissions; 5.21 (2.72–10.00) and 20.19 (12.03–35.49) for outpatient appointments; and 1.88 (1.30–2.68) and 4.20 (3.03–5.76) for accident and emergency admission (Table S4).

Among patients with an exacerbation event, IRRs relative to those without exacerbation were 1.53 (95% CI 1.46–1.59; $P<0.0001$) for primary care contacts, 3.82 (95% CI 3.14–4.63; $P<0.0001$) for inpatient contacts, 1.81 (95%

CI 1.67–1.95; $P<0.0001$) for outpatient contacts and 2.28 (95% CI 2.01–2.56; $P<0.001$) for accident and emergency contacts (Table S5).

Healthcare Costs

All-Cause Costs

Cost ratios for total costs in mild, moderate, and severe asthma patients relative to controls were 1.58 (1.39–1.78), 2.56 (1.97–3.33), and 3.42 (2.54–4.61). These trends appeared similar across each HCRU category (Table 3).

Table 3 HCRU Costs Ratios for Pediatric Patients with Asthma and Matched Controls per Patient-Year

	Cost ratio (95% CI)	*P* value
Primary care contacts		
Mild	1.70 (1.58–1.83)	<0.0001
Moderate	2.45 (2.10–2.86)	<0.0001
Severe[a]	2.71 (2.16–3.39)	<0.0001
All patients	1.88 (1.77–2.01)	<0.0001
Primary care surgery contacts		
Mild	1.77 (1.64–1.90)	<0.0001
Moderate	2.82 (2.40–3.32)	<0.0001
Severe[a]	2.93 (2.40–3.57)	<0.0001
All patients	2.00 (1.87–2.13)	<0.0001
Primary care home visits		
Mild	1.31 (1.12–1.54)	0.001
Moderate	1.12 (0.75–1.66)	0.5595
Severe[a]	1.82 (0.91–3.76)	0.0512
All patients	1.34 (1.16–1.56)	<0.0001
Inpatient admissions		
Mild	1.61 (1.18–2.21)	0.0018
Moderate	3.20 (1.65–6.21)	<0.0001
Severe[a]	5.59 (2.40–13.06)	<0.0001
All patients	1.99 (1.52–2.61)	<0.0001
Outpatient appointments		
Mild	1.30 (1.11–1.53)	0.0012
Moderate	1.74 (1.29–2.35)	0.0002
Severe[a]	3.57 (2.56–4.97)	<0.0001
All patients	1.51 (1.33–1.73)	<0.0001

(*Continued*)

Table 3 (Continued).

	Cost ratio (95% CI)	*P* value
Accident and emergency contacts		
Mild	1.32 (1.16–1.51)	<0.0001
Moderate	2.44 (1.85–3.21)	<0.0001
Severe[a]	2.77 (2.04–3.76)	<0.0001
All patients	1.53 (1.37–1.72)	<0.0001
Total cost		
Mild	1.58 (1.39–1.78)	<0.0001
Moderate	2.56 (1.97–3.33)	<0.0001
Severe[a]	3.42 (2.54–4.61)	<0.0001
All patients	1.83 (1.65–2.03)	<0.0001

Notes: Mild (n=4,574), moderate (n=842), severe (n=534); adjusted for age, gender and baseline allergic rhinitis, conjunctivitis, and atopic dermatitis; for all-cause HCRU one patient with severe asthma could not be matched. [a]adjusted for age, gender, and IMD.
Abbreviations: HCRU, healthcare resource use; IMD, Index of Multiple Deprivation; PPY, per patient-year.

Asthma-Related Costs

The binary comparison of all GINA-severity classifications highlighted significantly increased costs with increasing asthma severity. Cost ratios (95% CI) for total costs were 1.68 (1.45–1.97; $P<0.0001$) for moderate versus mild asthma; 2.67 (2.21–3.25; $P<0.0001$) for severe versus mild asthma; and 1.54 (1.18–2.02; $P=0.0014$) for severe versus moderate asthma (Table S4).

For patients with an exacerbation, the cost ratio for total all-cause costs was 2.09 (95% CI 1.62–2.77; $P<0.0001$) versus asthma patients without an event. A significant increase was observed for each HCRU category (Table S6). Asthma-related costs in patients with an exacerbation (Table S7) were also increased with a cost ratio of 2.71 (95% CI 2.02–3.73; $P<0.0001$) versus asthma patients without an event.

Discussion

In this real-world cohort study of children with asthma, almost 25% of all patients were classified as having moderate or severe disease according to GINA guidelines 2017.[17] Patients with moderate and severe asthma were observed to have had a significantly increased incidence of symptoms relative to patients with mild asthma.[25] We found that the frequency of severe asthma exacerbations increased with increasing GINA-defined asthma severity, with a 3-fold increase in the rate of severe exacerbations in those with moderate versus mild asthma and a 5-fold increase in those with severe versus mild asthma. Among patients experiencing a first exacerbation event during the study period, the risk of a subsequent re-exacerbation was almost trebled in children with severe asthma compared with mild disease. Furthermore, 25% of patients were classified as most affluent according to the IMD, which aligns with previous findings of a higher reported prevalence of asthma in higher income countries.[26] In contrast, low socioeconomic status (defined by education, income, and insurance type) was associated with poor asthma control in a study of African─American adolescents in the US, while socioeconomical deprivation (according to a local levels of living index) was associated with increased asthma symptoms in a study of adolescents in South Africa.[27,28] This suggests a link between asthma and socioeconomic status, with varying influences on prevalence and severity. When measured as level of education, low parental socioeconomic status has also shown to be related to pediatric asthma/wheeze in a Swedish population-based cohort study, however, the association of parental income and asthma/wheeze was less clear.[29] In a recent Korean population-based cohort study,

children with lower socioeconomic status had increased risk of asthma exacerbation, hospital admission, and requiring treatment for symptoms of severe asthma compared with children with asthma and higher socioeconomic status.[30]

Asthma was associated with significantly increased rates of HCRU and associated costs compared with controls in all healthcare categories, and increased severity was associated with higher HCRU and cost burden. Both primary care contacts (surgery and home visits) and secondary care involving inpatient admissions and visits to accident and emergency departments contributed to overall HCRU.

This report is complementary to an article reporting on the prevalence of pediatric asthma and treatment patterns, as well as symptoms and comorbidities between asthma patients and matched controls, using CPRD GOLD data from the same analysis.[25] Overall, recent data for the impact and burden of childhood asthma in the UK are lacking. Two studies, one nationwide and the other a single-center study from the north of England, concluded that some aspects of acute childhood asthma care in the UK require improvement.[31,32] The serious and costly consequences of severe asthma in childhood was highlighted in another recent UK study, focusing on admissions to a pediatric intensive care unit (PICU) in England between April 2006 and March 2013.[33] The authors found that social deprivation was an important indicator of PICU admission for severe asthma, further emphasizing the importance of avoiding or reducing the risk of severe disease and exacerbations.[33] Recent experiences during the COVID-19 pandemic also highlight the implications of risk of asthma exacerbations on severe outcomes and costly HCRU. For example, among children with asthma in Scotland, uncontrolled asthma was associated with an elevated risk of COVID-related hospitalization by between 3-fold and 6-fold compared with pre-COVID asthma admissions.[34] A similar trend with regards to the economic burden of childhood asthma has been observed in the United States, with children with asthma having much higher healthcare resource utilization and costs than children without asthma.[13]

Strengths of this analysis include the use of high-quality data from the CPRD database that is assessed on a practice and patient level. CPRD data are considered to be "up to standard" depending on whether they are recorded within a prespecified expected range based on practice size and demographics. Patients are required to have a valid coding for gender and birth year on file and be registered permanently at the general practice in order for their data to be released for research. Patients who are registered temporarily are not eligible for inclusion in research.[16] These criteria ensure that only acceptable data are released for research purposes. Using the CPRD-, HES-, and ONS-linked datasets is also likely to reflect real-world practice rather than an ideal and therefore hypothetical scenario. Data in the CPRD are routinely collected for reasons other than research, predominantly relating to the health-system administration and financial reimbursement.

Limitations

All studies of childhood asthma are impacted by the lack of pediatric-specific diagnostic and assessment procedures; definitions are instead based on criteria established for adult asthma.[7,8] Additionally, only primary care prescriptions were available within the CPRD datasets. However, specific therapies, such as biologics, are administered solely within the hospital setting.[7] Therefore, treatment-prescribing patterns and their influence on treatment and outcomes are likely to be underestimated in this analysis. As our classification of severe exacerbation required a prescription for an OCS during the consultation when asthma was recorded, it is possible that CPRD data may underestimate the number of severe exacerbations when a diagnosis was omitted. The total number of asthma patients may be underestimated, because not all primary care contacts for asthma may have an asthma-related diagnosis code on record. Evidence from previous studies indicates that asthma is widely underdiagnosed in the outpatient setting.[35] Thus, patients with asthma but without a speciality asthma code would have been excluded from this analysis. While a considerable proportion of patients with asthma were classified as most affluent according to the IMD, it is not possible to rule out a potential bias towards more affluent patients in the database. Asthma can profoundly impact quality of life in children and may lead to school absenteeism and hospitalization, which have been associated with poor academic achievement in young children in Wales.[1,3,14,36] However, the burden of asthma in this context was not addressed in the current study. Nor were indirect medical and nonmedical costs included in the estimations. Studies that capture the full spectrum of clinical and economic burden of childhood asthma, possibly in an interventional setting to understand the opportunities to reduce or avoid the impact of disease, would be desirable.

Conclusion

In pediatric patients diagnosed with asthma, increasing disease severity was associated with elevated risk of exacerbations and re-exacerbations. Pediatric asthma was associated with increased HCRU rates and costs compared with children without asthma; HCRU rates and costs also increased with disease severity. Our results indicate that management strategies for childhood asthma that reduce severity and risk of exacerbations can have clinical and economic benefits to patients, healthcare professionals, and the UK NHS.

Data Sharing Agreement

This study is based in part on data from the CPRD obtained under licence from the UK Medicines and Healthcare products Regulatory Agency. The data is provided by patients and collected by the NHS as part of their care and support. ONS data was provided by the National Office of Statistics. HES and ONS data (Copyright © 2023), was re-used with the permission of The Health & Social Care Information Centre. All rights reserved. The interpretation and conclusions contained in this study are those of the authors alone. Due to the license arrangements with CPRD, it is not possible to share data used in this study.

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Disclosure

Imène Gouia, Asif H Khan, and Florence Joulain are employees and stockholders of Sanofi. Yi Zhang was an employee and stockholder of Regeneron Pharmaceuticals Inc at the time this study was conducted. Christopher Morgan is an employee of Pharmatelligence Ltd, which has received funding from Sanofi and Regeneron Pharmaceuticals Inc for this analysis. The authors report no other conflicts of interest in this work.

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