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RESEARCH ARTICLE

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Socioeconomic status and emergency department visits in adults with a history of severe childhood asthma: a register-based study

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ABSTRACT

Background and Objective: Our knowledge of socioeconomic status (SES) and emergency department (ED) visits in adults with a history of severe childhood asthma is limited. Our aim was, therefore, to investigate these variables in individuals with a history of severe childhood asthma compared to a control population.

Methods: The Kongsberg cohort comprises Danish individuals with a history of severe childhood asthma and a previous 4-month stay at an asthma care facility in Kongsberg, Norway, between 1950 and 1979. The cohort was compared 1:1 to sex and age matched controls with no previous diagnosis of or treatment for obstructive airway disease (OAD). Data from the national Danish health registries were used for comparing cases and controls.

Results: A total of 1394 adults from the Kongsberg cohort were alive and residing in Denmark (mean age 63 years, 43% females) at the index date (June 2022). A Charlson comorbidity index score of ≥1 was higher in the study cohort compared to controls (7% versus 3%) ($p < 0.01$). Cases had a 1.5-fold increased likelihood of having a high educational level ($p < 0.001$) compared to controls. Compared to the controls, cases had a higher risk of all-cause ED visits, with individuals having lower educational levels showing the highest proportion of ED visits. Furthermore, 31.2% and 22.9%, respectively, of cases and controls with high educational levels had had ED visits. Compared to controls, logistic regression analysis revealed a 1.7-fold higher risk of all-cause ED visits in cases ($p < 0.001$).

Conclusions: In adults with a history of severe childhood asthma, educational level, comorbidity burden, and risk of ED visit were higher compared to matched controls with no history of obstructive airway disease.

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Introduction

Asthma is one of the most common respiratory conditions affecting up to one-third of the population in some countries and characterized by airway inflammation and symptoms such as wheeze, cough, and shortness of breath [1,2]. Asthma has been reported to be more prevalent in those with low socioeconomic status (SES), assessed by factors such as occupation and education [3,4].

A recent large prospective cohort study comprising 3430 children showed that childhood-onset asthma was associated with lower educational level in early adulthood [5]. A cohort study by Bacon et al. compared asthma patients with higher educational levels to asthma patients with lower educational levels and found that those with lower educational levels were more likely to have poor asthma control [4]. In a large population-based cohort of patients with asthma from UK primary care, asthma morbidity was higher among those with low SES, based on a weighted average across different domains, including employment, health, and education [6].

Asthma is associated with an increased risk of hospitalizations [7]. Furthermore, frequent use of emergency medical services has been reported in patients with asthma and low SES [4,8,9]. A large nation-wide cohort study from Sweden found that the risk of asthma-related hospitalization was associated with low educational level [10]. Additionally, studies from Korea [11] and Italy [12] have shown that individuals with lower SES backgrounds were considerably more likely to experience asthma exacerbations and be hospitalized due to asthma.

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Although many studies investigating the association between asthma and SES have been published, studies focusing on the impact of severe childhood asthma on SES and healthcare utilization in adulthood are limited [5,13].

We hypothesized that adults who had severe asthma in childhood would have lower SES and more emergency department (ED) visits compared to adults without a history of obstructive airway diseases, such as COPD and asthma. We, therefore, compared SES and ED visits in individuals with a history of severe childhood asthma to those with no evidence of obstructive airway disease (OAD).

Methods

Study cohort

The Kongsberg cohort comprises Danish individuals with a history of severe childhood asthma and at least one 4-month stay at the asthma care facility in Kongsberg, Norway, between 1950 and 1979, when they were 3–13 years of age. The selection process of participants in the study is illustrated in Figure 1. Further details on the identification and inclusion of eligible individuals have been published previously [14].

Register data

The present study was initiated in November 2021. We received data from Danish health registers on emergency department (ED) visits and demographics, education, civil status, comorbidities, and treatment for obstructive airway disease for both cases and controls in October 2022.

Control population

Characteristics of the Kongsberg cohort was compared to a control population matched on age (year of birth) and sex 1:1. Individuals were eligible for the control population provided they had no previous record of hospital contacts with a diagnosis of obstructive airway disease, that is asthma or COPD, and no previous filled prescriptions for medication for obstructive airway disease. Statistics Denmark conducted searches in nationwide health registers, specifically, the National Patients Registry, for ICD-10

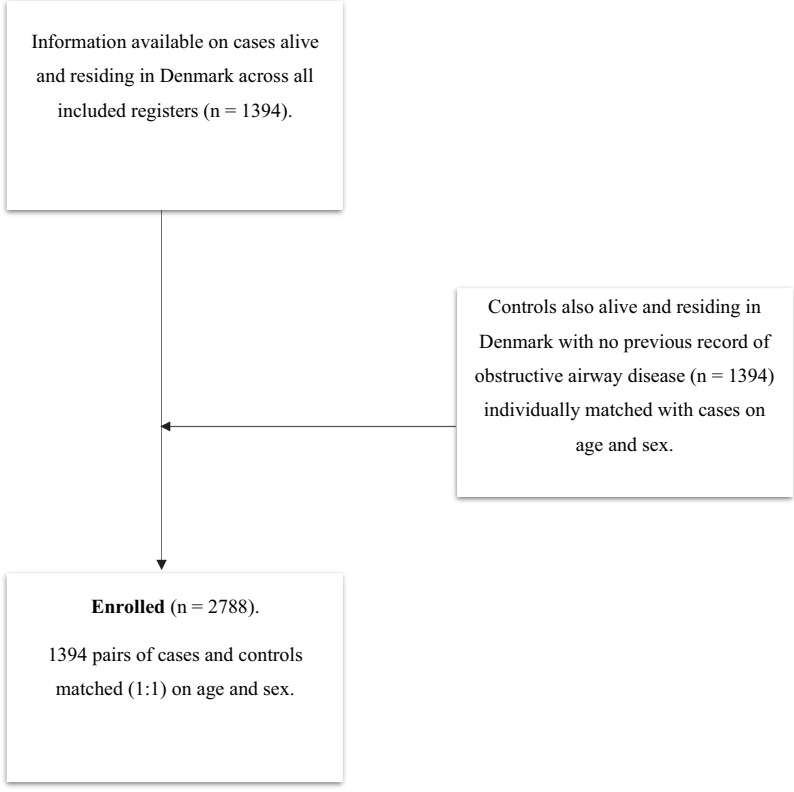

Figure 1. Flowchart of the selection process in the study.

The Kongsberg cohort included approximately 5000 children with asthma, referred for a 4-month stay at the Kongsberg asthma facility in Norway between 1950 and 1979, primarily from Queen Louise's Children's Hospital in Copenhagen. In 2021, data were available for 1394 individuals still living in Denmark across all included registers.

codes J44, J45, and J46 to exclude individuals with a registered diagnosis of COPD and/or asthma in secondary care. Identified individuals with no COPD (J44) and asthma (J45 and J46) diagnoses and no current or previous prescriptions were then identified through the ATC code R03 (drugs for obstructive airway disease) in the Danish National Prescription Registry and excluded up till the index date June 2022. Search methodology for data retrieval in Danish health registers for the control population was carried out as for the study cohort.

Definitions

Occupational status

Individuals were characterized according to the following levels of occupation as defined by Statistics Denmark: unemployed, employed, disability pension, or pension.

Civil status

Civil status was classified as defined by Statistics Denmark into single male, single female, married, couple (i.e. cohabitation), and other.

Educational level

Educational level was defined as either low (i.e. basic (compulsory school), upper secondary, or vocational) or high educational level (bachelor's or master's degree) [15].

Emergency department visits

Data on all-cause emergency department (ED) visits were obtained from the Danish National Patient Register (DNPR).

Comorbidity

A Charlson Comorbidity Index ('Charlson score') with updated weights was used to describe comorbidity burden [16].

Asthma treatment

Asthma reliever and maintenance treatment in the study cohort was defined as having redeemed prescriptions belonging to the ATC codes R03AC02-R03AC03, R03AC12-R03AC13, R03AK06-R03AK08, R03AK10-R03AK11, R03AL01-R03AL09, R03AL12, R03BA01-R03BA02, R03BA05, R03BA07-R03BA08, R03BB04-R03BB07, and R03DC03.

Ethics

This study was a register-based cohort study. The study was approved by the Knowledge Center for Data Reviews, a part of the Danish Data Protection Agency, (H-2020–1064) in the Capital region of Denmark.

Data analysis

The study population demographics, comorbidities, and asthma treatment were assessed using the most recent data set from 2018 provided by Statistics Denmark. The extracted register data are reported as mean values ± one standard deviation (SD). Categorical variables are presented as numbers and percentages. Variables associated with socioeconomic status for the study cohort were compared to the control population using independent sample t-test for continuous variables and for categorical variables chi-square test or Fisher's exact test, the latter if cells had expected frequencies less than five for categorical variables. We applied multivariate logistic regression models to estimate the odds ratios with 95% confidence intervals to examine differences between cases and controls. Furthermore, ED visits were retrospectively assessed over a time-period ranging from 1996 to 2018. A p-value <0.05 was considered statistically significant. Data were analyzed using the statistical program R Statistics 3.61 software (R Foundation for Statistical Computing, Vienna, Austria).

Results

A total of 1394 individuals with a history of severe asthma in childhood and a previous stay at the Kongsberg asthma facility were identified and compared to the matched controls (mean age 62.7 years, 43% females) (Table 1).

Characteristics

Minor differences in civil status were found between cases and controls. Prevalence of Charlson comorbidity index score of ≥1 was higher in the study cohort compared to controls (7% versus 3%). More cases (31%) lived in the Capital region compared to controls (19%) (Table 1). Treatment characteristics of the study cohort are given in Table 2.

Table 1. Characteristics of the study cohort ($n = 1394$) with a previous stay at the asthma care facility in childhood in Kongsberg, Norway, and a history of severe childhood asthma versus matched (by age and sex 1:1) controls ($n = 1394$) with no previous diagnosis or treatment for obstructive airway disease.

Variable		Controls ($n = 1394$)	Cases ($n = 1394$)	p-value
Age in years, mean (Standard deviation)		62.7 (8.2)	62.8 (8.3)	
Sex, no. (%)	Male	791 (56.7)	791 (56.7)	
	Female	603 (43.3)	603 (43.3)	
Civil status, no. (%)	Single Male	198 (14.4)	220 (15.9)	
	Single Female	179 (13.0)	217 (15.7)	
	Married	754 (54.7)	710 (51.3)	
	Couple	105 (7.6)	109 (7.9)	
	Other	143 (10.4)	127 (9.2)	NS
Place of residence	Capital region	249 (19.1)	426 (31.5)	
	Outside Capital region	1057 (80.9)	925 (68.5)	<0.01
Occupational status	Employed	692	677	
	Unemployed	57	69	
	Disability pension	92	115	
	Pension	508	498	<0.01
Charlson Index, no. (%)	0	1155 (82.9)	837 (60.0)	
	1	48 (3.4)	347 (24.9)	
	≥2	163 (11.7)	192 (13.8)	<0.01

All characteristics included were obtained from recent data from national health registers.

Table 2. Treatment characteristics of the study cohort ($n = 1394$) with a previous stay at the asthma care facility in childhood in Kongsberg, Norway.

Variable		Cases ($n = 1394$)
Asthma reliever treatment, no. (%)	SABA	570 (40.9)
	SABA/SABA	18 (1.3)
Asthma maintenance treatment, no. (%)	ICS*	908 (65.1)
	• + LABA	519 (37.2)
	• + LAMA	21 (1.5)
	• + LTRA	33 (2.4)
	• + LABA + LTRA	22 (1.6)
	• + LABA + LAMA	69 (4.9)
	• + LABA + LAMA + LTRA	5 (0.4)

All characteristics included were obtained from recent data from national health registers.

Abbreviations: LTRA, leukotriene receptor antagonist; ICS, inhaled corticosteroid; LABA, long-acting beta2 agonist; LAMA, long-acting muscarinic antagonist; SABA, short-acting beta2 agonist; SAMA, short-acting muscarinic antagonist.

*Having redeemed at least one ICS-containing prescription.

Socioeconomic status and ED visits

Data from national registers showed that 435 (31.2%) cases and 320 (22.9%) controls had a high educational level (that is bachelor's or master's degree), and of these, 217 (49.9%) and 116 (36.6%), respectively, had ED visits in the past 12 months (Table 3). Among those with a low educational level, over half had visited the ED in the previous 12 months (52.3%), while the percentage of individuals with ED visits was lower (38.9%) among those

Table 3. Educational level and ED visits of the study cohort ($n = 1394$) with a previous stay at the asthma care facility in childhood in Kongsberg, Norway, versus matched (by age and sex 1:1) controls ($n = 1394$) with no previous diagnosis or treatment for obstructive airway disease.

		n*	%	Mean (SD)
Cases + high educational level		435	31.2	4.37 (0.48)
	ED visits	217	49.9	
Cases + Low educational level		942	67.6	2.28 (0.92)
	ED visits	493	52.3	
Controls + high educational level		320	22.9	4.33 (0.47)
	ED visits	116	36.3	
Controls + Low educational level		1040	74.6	2.29 (0.92)
	ED visits	405	38.9	

All characteristics included were obtained from recent data from national health registers. Low educational level includes the following levels: basic (1), upper-secondary (2), and vocational (3). High educational level includes the following: bachelor's (4) and master's degree (5).

*n: number of cases with any ED visit in the last 12 months.

in the control group with low education levels (i.e. basic, upper-secondary, and vocational) (Table 3).

The study cohort had higher risk of all-cause ED visits compared to the controls (OR 1.7 (95% confidence interval (CI): 1.5–1.9) ($p < 0.001$). Furthermore, the odds of having a high educational level were 1.5 (OR 95% CI: 1.3–1.8) ($p < 0.001$) for the study cohort compared to the control population (Table 4).

The study cohort showed a higher increase in prevalence of all-cause ED visits with increasing age compared to the control population (Figure 2).

Discussion

Our study revealed that adults with a history of childhood asthma had higher educational levels overall, an increased burden of comorbidities, and a greater incidence of ED visits among those with lower educational levels compared to the control population.

Our present findings regarding SES and ED visits in individuals with a history of severe asthma in childhood, that is the Kongsberg cohort, are in line with previously reported findings [4,6]. The study by Bacon

Table 4. Comparison of characteristics between cases ($n = 1394$) with a previous stay at the asthma care facility in childhood in Kongsberg, Norway, and matched (by age and sex 1:1) controls ($n = 1394$) with no previous diagnosis or treatment for obstructive airway disease.

	OR	Lower CI	Upper CI	P-value
Low educational level	Ref.			
High educational level	1.50	1.27	1.78	<0.001
No ED visits	Ref.			
ED visits	1.72	1.48	1.99	<0.001
Female	1.00	0.86	1.16	0.98
Age	0.99	0.99	1.01	0.95

The 95% confidence intervals (CI) and p-values for odds ratios (OR) were obtained from multivariable logistic regression with 'controls' as the reference category. For every one unit added to a variable included in this analysis there is either an increase or decrease in odds.

All characteristics included were obtained from the most recent data from national health registers. Low educational level includes the following: basic, upper-secondary, and vocational. High educational level includes the following: bachelor's and master's degree.

Abbreviations: ED, emergency department.

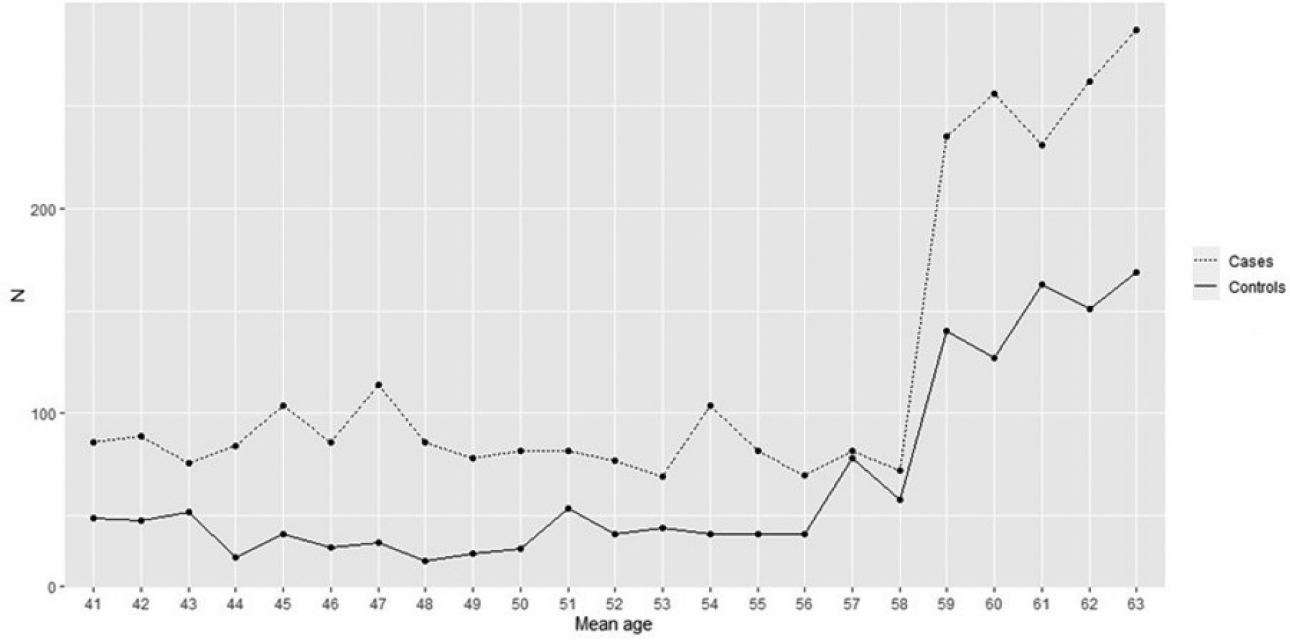

Figure 2. All-cause emergency department (ED) prevalence (n) according to mean age of both cases and control from 1996 to 2018.

X-axis label: Mean age (years). Y-axis label: N (number of cases or controls). Dotted line: study cohort cases ($n = 1394$) with a previous stay at the asthma care facility in childhood in Kongsberg, Norway, and a history of severe childhood asthma. Solid line: control population ($n = 1394$) with no previous diagnosis of or treatment for obstructive airway disease and matched with the study cohort on age (year of birth) and sex 1:1.

et al. included 781 adults with asthma to assess SES and ED visits. Participants in their study filled in asthma control questionnaires (Asthma Control Questionnaire, Asthma Quality of Life Questionnaire, and Asthma Self-Efficacy Scale) and provided information on asthma-related emergency health service use (total number of ED visits and hospitalizations for asthma). An association was found between use of asthma-related emergency health services and low socioeconomic status, defined as having less than 12 years of education [4]. In a large cohort study including 127,040 asthma patients from the Optimum Patient Care Research Database (OPCRD) from the United Kingdom (UK), Busby et al. recently investigated the association between asthma morbidity, healthcare utilization, and SES. Increased asthma morbidity, defined as worse disease control, lower peak expiratory flow, and increased risk of asthma exacerbation, was seen in patients with low SES [6]. The results of our study align with the mentioned studies, demonstrating an association between SES and ED visits among individuals with a history of severe asthma in childhood. Both Busby et al. and Bacon et al. found that low SES, characterized by factors such as lower educational levels, was linked to increased use of asthma-related emergency health services [4,6].

In contrast to our findings, a recent study from Sweden reported that childhood-onset asthma was associated with lower educational level [5]. Briefly, the study by Schyllert et al. was based on the Obstructive Airway Disease In Northern Sweden Studies and included children from the age of 8 followed to the age of 28 years ($n = 3430$). Asthma was grouped into either childhood-onset or adult-onset asthma. Childhood-onset asthma was significantly associated with having compulsory school as the highest educational level. In contrast to these findings, our study revealed that individuals with a history of childhood asthma were more likely to be educated at university level than the control group. However, the prevalence of residence in the Capital region of Denmark was higher in the study cohort compared to the control population in our study. The Capital region of Denmark has, compared to other regions, a lower proportion of residents with low education level and confounding by area of residence might, at least partly, explain the differences between our findings and the previous study [17].

A recent cross-sectional study by Ilmarinen et al. explored the relationship between educational level and asthma control [18]. Their study comprised participants with asthma (mean age 59 [SD 13]) from the Obstructive Lung Disease in Northern Sweden study (OLIN, $n = 593$), the Seinäjoki Adult Asthma Study (SAAS, $n = 200$), and the West Sweden Asthma Study (WSAS, $n = 301$) and was conducted between 2009 and 2014. Questionnaires were used to collect data on respiratory symptoms, smoking habits, pharmacological treatment, educational level, and asthma control (Asthma Control Test). Education levels were categorized as primary (9 years), secondary (12 years), or tertiary education (>12 years). Similar to the study by Bacon et al. [4], the study concluded that a lower educational level (primary education) was a risk factor for uncontrolled asthma (ACT ≤ 19). Ilmarinen et al. and our study both investigate and reveal the importance of socioeconomic factors for health outcomes in individuals with asthma. However, our study explored the socioeconomic and healthcare outcomes of adults who had severe asthma in childhood compared to a control group. While both our study and the study by Ilmarinen et al. have their strengths, our study's use of national health registers most likely provide a broader perspective on the lasting impacts of severe childhood asthma, and by that complementing the detailed, cross-sectional findings by Ilmarinen et al.

Furthermore, a cross-sectional analysis by Mazurek et al. included 10,452 participants aged at least 20 years to investigate the association between a history of childhood asthma and the longest-held occupation and educational level in adulthood using 2001 to 2004 data from the National Health and Nutrition Examination Survey (NHANES) from the US. Individuals with a history of childhood asthma (5%) tended to have a higher educational level than those with no asthma history. However, the childhood asthma prevalence estimate was based on self-reported data requiring respondents to recall a diagnosis of asthma in childhood, and educational level was only stratified into three groups: less than high school, high school diploma, and more than high school [19]. The study by Brew et al. also focused on investigating the association between childhood asthma and educational level in adolescence by including data on 10,963 children born 1992 to 1998 included in the Childhood and Adolescent Twin Study of Sweden cohort [20]. At follow-up in adolescence (age 15–16 years), the study found no significant association between childhood asthma and being qualified for high school. However, the study relied on parent's report on their child's ever or current asthma status, which might have caused recall bias. In general, the available findings suggest that the association between childhood asthma and educational outcomes are not straightforward. The variation in the observed association between childhood asthma and educational outcomes underlines the importance of taking study limitations and design into account when interpreting the

findings, including reliance on parent-reported asthma status in childhood. However, it is noteworthy that our study overcame this limitation as all our cases had a doctor's diagnosis of asthma in childhood. Our study, therefore, provides valuable insights into the interplay between childhood asthma, socioeconomic status, and educational outcomes in adulthood.

Strengths and limitations

Our study has strengths worth mentioning. First, this study provided characteristics of SES and healthcare utilization among adults with a history of severe childhood asthma, that is the Kongsberg cohort. In addition, we performed a comparison of the Kongsberg cohort to controls with no previous record of or treatment for OAD to investigate the impact of severe asthma in childhood for SES and ED visits in adulthood. The analysed data originated primarily from the Danish National Patient Registry, which comprises data on all hospital contacts, that is admissions, ED visits and outpatient clinic visits. Nationwide registers include real-world comprehensive data and does not include risk of recall bias [21]. All hospital contacts in Denmark are registered with at least one diagnosis (ICD-10). Previous studies from both Norway and Denmark have, similarly to the present study, used national patient registers to calculate Charlson comorbidity index [22,23].

Our study also has limitations worth mentioning. First, we did not include clinical data on potential confounders such as lung function, smoking status, and BMI as these data were not available from national registers. Second, we had no information on socioeconomic parameters in childhood and available data in national registers are limited to a specific range of years. Furthermore, impact on socioeconomic and health outcome may unfold over an extended time period, and without earlier data, the study may not fully capture the long-term impact of childhood asthma on SES and ED visits. Overall, a limited time would impact validity and generalizability of study results, and findings should be interpreted in the context of potential constraints due to data availability. Third, the potential lack of statistical power due to only having a 1:1 match between the study cohort and the control population might have influenced the findings. However, it is essential to provide context for the control population for better understanding. A 1:1 match was the only possibility as there were not enough individuals in the background population without a registered diagnosis or treatment for obstructive airway disease within the available time periods in the national registries. It is important to mention that a larger control group may have affected the outcome by increasing statistical power, providing more precise estimates which would increase external validity, and reduce the risk of sampling bias. Also, matching cases with controls on age and sex in a study may have both benefits and potential risks. Benefits include reduced risk of confounding and increased comparability, which would improve the internal validity of the study. Risks include limited generalizability due to matching limited to only specific demographic variables. Furthermore, due to the restricted time-interval of data in the included registries, it is plausible to assume that some individuals in the control population might have been previously prescribed asthma therapy that were not registered. Additionally, our control population was required to have no prior diagnosis of obstructive airway disease, based solely on the absence of previously recorded ICD-10 codes for obstructive airway disease associated with hospital contacts. This might have interfered with results.

Studies have highlighted comorbidity burden in individuals with asthma [24]. However, the relationship between comorbidity burden, SES, and asthma outcomes remains largely unexplored. The relationship between SES, ED visits, and the burden of comorbidities in the current study implies that treating comorbidities could represent an approach to improve asthma outcomes and reduce healthcare use. Additional investigation is required to clarify the precise mechanisms by which comorbidities impact SES and ED visits, thereby paving the way for focused interventions.

Conclusion

The present study explored socioeconomic and healthcare outcomes among adults with a history of severe asthma in childhood compared to controls. The Kongsberg cohort had a higher prevalence of comorbidities, as indicated by a Charlson comorbidity index score of ≥1, compared to controls. Additionally, the study cohort showed a significantly increased risk of all-cause ED visits compared to the control population. Notably, cases had higher educational levels, although lower educational levels within the study cohort were associated with a higher frequency of ED visits. These findings emphasize the impact of severe childhood asthma on health outcomes in adulthood, including the complex relationship between educational attainment and healthcare utilization.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Author contributions

OS and CSU contributed to the acquisition of the data. OS analyzed the data and drafted the first version of the manuscript. All authors contributed to designing the study, interpreting the data, revising of manuscript and approved the final manuscript.

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