



Early View

Original article

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Educational and health outcomes of children treated for asthma: Scotland-wide record linkage study of 683,716 children

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ABSTRACT

Background The global prevalence of childhood asthma is increasing. The condition impacts physical and psychosocial morbidity; therefore wide-ranging effects on health and education outcomes are plausible.

Methods Linkage of eight Scotland-wide databases, covering dispensed prescriptions, hospital admissions, maternity records, death certificates, annual pupil census, examinations, school absences/exclusions and unemployment, provided data on 683,716 children attending Scottish schools between 2009 and 2013. We compared schoolchildren on medication for asthma with peers, adjusting for sociodemographic, maternity and comorbidity confounders, and explored effect modifiers and mediators.

Results The 45,900 (6.0%) children treated for asthma had an increased risk of hospitalisation, particularly within the first year of treatment (IRR 1.98, 95% CI 1.93-2.04), and increased mortality (HR 1.77, 95% CI 1.30-2.40). They were more likely to have special educational need for mental (OR 1.76, 95% CI 1.49-2.08) and physical (OR 2.76, 95% CI 2.57-2.95) health reasons, and performed worse in school exams (OR 1.11, 95% CI 1.06-1.16). Higher absenteeism (IRR 1.25, 95% CI 1.24-1.26) partially explained their poorer attainment.

Conclusions Children with treated asthma have poorer education and health outcomes than their peers. Educational interventions that mitigate the adverse effects of absenteeism should be considered.

Keywords

asthma; educational outcomes; health; population cohort; record linkage

Key messages

What is the key question?

- Childhood asthma is viewed as a health problem associated with hospitalisation and mortality, however adverse effects on educational outcomes are less well understood. How do asthmatic children compare against their healthy peers with respect to educational (absenteeism, exclusion, special educational need, attainment, unemployment) and health outcomes (morbidity and mortality)?

What is the bottom line?

- Asthmatic children experience disadvantage across a broad range of education and health outcomes. In addition to poorer health outcomes, adverse effects on other aspects of their life, such as educational performance, need to be recognised and addressed.

Why read on?

- This is the first countrywide study to evaluate the impact of childhood asthma on a number of wide-ranging outcomes covering both health and education. No previous studies have investigated as wide a range of school and health outcomes together and none have adjusted for as wide a range of sociodemographic and maternity factors in this context.

BACKGROUND

Asthma is the most common chronic disease of childhood in developed countries [1] affecting 1.1 million children in the UK. [2] Global prevalence is approximately 11% and 14% in children aged 6-7 and 13-14 years respectively [1] and is increasing due to urbanisation of developing countries leading to environment and lifestyle changes. [3] Prevalence between countries [1, 4] varies between 2% and 20% amongst school aged children through differing case ascertainment. [5-13] Asthma causes physical morbidity, through breathlessness, sleep disturbance, reduced exercise capacity, and psychosocial morbidity. Mood disorders are common through shared genetic and lifestyle risk factors, common disease pathways and treatment side-effects.[14] Asthma accounts for 1% of disability-adjusted life years lost and 1 in 250 deaths worldwide.[15] Annual per capita health service and societal burden is estimated at US\$3,000-3,500 in the USA and US\$2,000 in Europe.[16]

Asthma commonly results in school absence; [6,17-23] however, consensus lacks on whether this translates into reduced academic attainment [6,19-21] and employment. [23, 24] We linked Scotland-wide administrative health and education databases to undertake a large-scale, general population cohort study comparing education and health outcomes in children treated for asthma versus peers. We questioned whether children treated for asthma suffer increased absenteeism, exclusion, special educational need (SEN), unemployment, hospital admission, mortality, and poorer attainment compared to peers. We hypothesised that asthmatic children perform poorer than peers across all outcomes.

METHODS

Databases

We linked Scotland-wide individual-level data from four health databases, held by Information Services Division (ISD) of the National Health Service, and four education databases, held by Scottish Exchange of Educational Data (ScotXed). Linkage methodology has been described previously. [25,26] The prescribing information system (PIS) collects information on all prescriptions dispensed to Scottish residents by community pharmacies or primary care. The Scottish Morbidity Record (SMR) 02 maternity database collects data on maternal, obstetric and child factors. SMR 01 and SMR 04 record acute and psychiatric hospital admissions, including dates of admission and discharge and International Classification of Diseases (ICD-10) diagnostic codes. The National Records of Scotland collect data from death certificates, including date and cause of death.

The pupil census, conducted annually by all Scottish local authority run primary, secondary and special schools, records whether a child has a special educational need including type. Absences and exclusions, collected prospectively, are appended at the end of each school year. The Scottish Qualifications Authority collects examination attainment data for all Scottish schoolchildren. The school leaver database collects pupil information six months after leaving school: paid/voluntary employment, higher/further education, training or unemployment.

Inclusion criteria, definitions and outcomes

Our cohort included individual records from pupil censuses recorded between 2009 and 2013. Mean number of observed school years per pupil was 3.65 (range 1 – 5 years). We excluded records where age was <4 years or >19 years. For same sex multiple births we cannot be certain that the correct child has linked; therefore, this study was restricted to singleton children. We used PIS data to ascertain asthma; described previously [26] and defined as an inhaled corticosteroid and beta agonist both dispensed more than once over a school year. Children dispensed one, or more, of these medications who did not meet the definition were excluded from the study (Figure 1).

We studied six school outcomes: annual number of days absent, annual number of school exclusions for challenging/disruptive behaviour, annual record of special educational need, type of special educational need, final academic achievement and subsequent unemployment. The latter two outcomes were restricted to school leavers during the study period. Absence and exclusion data were only available for years 2009, 2010 and 2012.

Special educational need is defined as inability to benefit from school education without help beyond that normally given to schoolchildren of the same age. We included special educational need attributed to intellectual disabilities, learning difficulties, dyslexia, language or speech disorder, physical, motor or sensory impairment, autistic spectrum disorder, social, emotional and behavioural difficulties, physical health conditions, and mental health conditions. Children could have more than one type. Academic achievement across the last three years of secondary school (S4-S6) was derived using total number of awards attained at each level of the Scottish Credit Qualifications Framework (SCQF) [27] and converted into

an ordinal variable: low, basic, broad/general and high attainment. Destination six months after leaving school was collapsed into a dichotomous variable: education/employment/training or unemployment. We studied three health outcomes: all-cause hospital admission, admission due to respiratory disease (ICD codes J00–J99) and all-cause mortality. We also reported deaths due to suicide. Hospitalisation and death data were available until September 2014 providing mean follow-up of 4.3 years (maximum 5 years).

The pupil census provided children's sex, age and ethnicity. Area socioeconomic deprivation was derived from postcode of residence using Scottish Index of Multiple Deprivation (SIMD) 2012, with children allocated to general population quintiles. SIMD is derived from 38 indicators across 7 domains (income, employment, health, housing, geographic access, crime and education, skills and training) using information from datazones of residence (median population 769). Retrospective linkage to SMR02 provided maternal age at delivery, parity, maternal smoking, gestation at delivery, mode of delivery and 5 minute Apgar score. We derived sex-, gestation-specific birthweight centiles as a measure of intra-uterine growth.

Statistical analyses

Characteristics of asthmatic children were compared with peers using chi square tests for categorical data and chi square tests for trend for ordinal data. Special educational need, absences and exclusions, recorded annually, were analysed as yearly outcomes using population-averaged generalised estimating equations (GEE) [28] adjusting for correlations between measurements on the same pupil across different census years. We used the user written QIC statistic to compare different correlation structures; selecting the structure with the lowest trace QIC as most appropriate. [29] Number of days absent and number of school

exclusions were modelled using longitudinal GEE analyses with a negative binomial distribution and log link function to produce incidence rate ratios. Number of possible annual attendances was used as an offset variable adjusting for individual exposure time. Special educational need was modelled using GEE analyses with a binomial distribution and logit link to produce odds ratios. Logistic regression (ordinal and binary) modelled attainment and unemployment respectively whilst subsequent hospitalisation and mortality were modelled using Cox proportional hazards. These four longer-term end-outcomes were summarised and modelled on a pupil, rather than yearly, basis dependent on children having previously been prescribed asthma medication at any point within the study period. Therefore, with no repeated measures, longitudinal methods were not required. In the Cox models, children prescribed relevant asthma medication were followed from the date of their first asthma prescription during the study period. The pupil census is recorded each September, a few weeks after the start of the school year. Children who did not receive any asthma prescriptions during the study period were followed from the date of their first pupil census within the study period. This methodology has been described previously. [26] Proportionality was tested using the `estat phtest` command within Stata. Where the assumption did not hold, Poisson piecewise regression models were used.

All models were unadjusted and then adjusted for sociodemographic and maternity confounders exploring age, sex and deprivation as potential effect modifiers by testing for statistical interactions and undertaking sub-group analyses. We re-ran the academic attainment and unemployment models including absenteeism to explore whether it was a mediator. We then performed formal mediation analyses using the STATA user written *paramed* command to decompose the total effect of asthma on attainment (recoded into a binary variable: low/basic vs broad/general/high attainment) and unemployment into a direct effect (not mediated through absenteeism) and an indirect effect (mediated through

absenteeism) adjusted for sociodemographic and maternity factors. We also re-ran these models excluding children with special educational needs. To test the robustness of our asthma definition, children omitted because they had been dispensed one, or more, asthma medications but fell short of our definition were re-included in the asthma group. We re-analysed the main educational and health outcomes to observe whether original associations remained. Statistical analyses were undertaken using Stata MP version 14.1

Approvals

The study was approved by the National Health Service National Services Scotland Privacy Advisory Committee. A data processing agreement was drafted between Glasgow University and ISD and a data sharing agreement between Glasgow University and ScotXed.

RESULTS

Between 2009 and 2013, 2,793,185 pupil records were analysed for 766,244 singleton children attending Scottish schools. Of these 82,528 (10.8%) children received inhaled asthma medication but did not satisfy our definition for treatment of asthma and were excluded from the study. Of the 683,716 children remaining, 45,900 (6.0%) were asthmatic according to our study definition. Asthmatic children were more likely to be male, Asian and live in deprived areas (Table 1). They were of lower gestation, smaller for gestational age, more likely to have required operative deliveries and had lower five-minute Apgar scores. Their mothers were younger, more likely to have smoked during pregnancy and more likely to have been nulliparous.

Table 1. Characteristics of schoolchildren by presence or not of treated asthma

		No asthma		Asthma		P value
		N=637,816		N=45,900		
		N	%	N	%	
Sociodemographic factors						
Sex						
	Male	318,360	49.9	26,806	58.4	<0.001
	Female	319,456	50.1	19,094	41.6	
	Missing	0		0		
Deprivation quintile						
	1 (most deprived)	141,585	22.2	12,357	26.9	<0.001
	2	126,279	19.8	9,941	21.7	
	3	122,827	19.3	8,917	19.4	
	4	126,335	19.8	7,985	17.4	
	5 (least deprived)	120,288	18.9	6,667	14.5	
	Missing	502		33		
Ethnic group						
	White	606,601	96.3	43,388	95.5	<0.001
	Asian	14,222	2.3	1,364	3.0	
	Black	1,634	0.3	126	0.3	
	Mixed	5,471	0.9	439	1.0	
	Other	1,732	0.3	125	0.3	
	Missing	8,156		458		
Maternity factors						
Maternal age (years)						
	≤24	171,602	26.9	13,868	30.2	<0.001
	25-29	187,171	29.4	13,516	29.5	
	30-34	182,432	28.6	12,209	26.6	
	≥35	96,600	15.2	6,307	13.7	
	Missing	11		0		
Maternal smoking						
	No	411,276	72.8	28,269	69.2	<0.001
	Yes	153,337	27.2	12,595	30.8	
	Missing	73,203		5,036		
Parity						
	0	284,289	44.8	21,760	47.7	<0.001
	1	221,459	34.9	15,205	33.3	
	>1	128,980	20.3	8,673	19.0	
	Missing	3,088		262		
Mode of delivery						
	SVD	552,730	67.8	29,750	62.4	<0.001
	Assisted vaginal	75,713	11.9	5,587	2.4	
	Breech vaginal	1,825	0.3	154	12.2	
	Elective CS	48,267	7.7	3,700	0.3	
	Emergency CS	79,325	12.4	6,700	8.1	
	Other	141	0.0	9	0.0	

Missing	2		0		
Gestation (weeks)					
<24	17	0.0	3	0.0	<0.001
24-27	753	0.1	178	0.4	
28-32	5,338	0.8	719	1.6	
33-36	28,351	4.5	2,836	6.2	
37	30,587	4.8	2,613	5.7	
38	79,248	12.4	6,058	13.2	
39	132,322	20.8	9,448	20.6	
40	193,364	30.3	13,103	28.6	
41	143,715	22.6	9,451	20.6	
42	22,979	3.6	1,416	3.1	
43	542	0.1	32	0.1	
>43	120	0.0	9	0.0	
Missing	480		34		
Sex-gestation-specific birthweight centile					
1-3	25,763	4.0	2,153	4.7	<0.001
4-10	56,669	8.9	4,308	9.4	
11-20	75,633	11.9	5,582	12.2	
21-80	375,540	59.0	26,539	57.9	
81-90	54,540	8.6	3,758	8.2	
91-97	34,407	5.4	2,490	5.4	
98-100	14,266	2.2	1,000	2.2	
Missing	810		70		
5 minute Apgar					
1-3	3,044	0.5	264	0.6	<0.001
4-6	5,864	0.9	565	1.2	
7-10	622,502	98.6	44,568	98.2	
Missing	6,406		503		

N number; SVD spontaneous vaginal delivery; CS Caesarean section

School attendance

Analyses of absence and exclusion included 1,415,923 pupil records for 624,573 children. Asthmatic children experienced more absenteeism (Table 2). There were interactions with age ($p < 0.001$) and deprivation ($p < 0.001$). The relative association was stronger in younger age groups and among children in less deprived areas (Table 2). Among non-asthmatic children, absenteeism was higher in the most than least deprived quintile (medians 11 versus 5 days). Among asthmatic children, absences were still more common in the most deprived quintile (medians 14 versus 7 days).

Table 2. Association between treatment for asthma and annual absenteeism by sex, age and area deprivation.

	Univariate		Multivariable*		Multivariable**	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Overall	1.30	1.28-1.31	1.25	1.24-1.26	1.25	1.24-1.26
Boys	1.28	1.27-1.30	1.24	1.23-1.26	1.25	1.23-1.26
Girls	1.32	1.30-1.35	1.26	1.24-1.28	1.26	1.24-1.28
<11 years	1.38	1.36-1.40	1.32	1.31-1.34	1.32	1.30-1.33
11-14 years	1.29	1.26-1.31	1.24	1.22-1.26	1.26	1.24-1.28
>14 years	1.17	1.15-1.19	1.14	1.12-1.16	1.15	1.13-1.17
1 (more deprived)	1.19	1.17-1.21	1.19	1.17-1.21	1.21	1.19-1.23
2	1.25	1.23-1.28	1.26	1.23-1.28	1.26	1.23-1.28
3	1.26	1.24-1.29	1.26	1.23-1.29	1.25	1.23-1.28
4	1.30	1.27-1.33	1.29	1.26-1.32	1.28	1.25-1.31
5 (least deprived)	1.32	1.28-1.36	1.31	1.27-1.35	1.29	1.26-1.33

*adjusted for age, sex, deprivation quintile and ethnic group (as appropriate)

**also adjusted for maternal age, maternal smoking, parity, mode of delivery, gestation at delivery, sex- gestation-specific birthweight centile and 5 minute Apgar score

IRR incidence rate ratio (annual incidence in children treated for asthma divided by the annual incidence among children not treated for asthma); CI confidence interval

Asthma was associated with increased school exclusion on univariate analysis (IRR 1.16, 95% CI 1.08-1.24) but decreased exclusion after adjusting for sociodemographic (IRR 0.90, 95% CI 0.84-0.96) and maternity confounders (IRR 0.91, 95% CI 0.85-0.97). There was an interaction with deprivation ($p=0.012$). The protective association between asthma and exclusion was greatest among children in the most deprived areas (fully adjusted IRR 0.88, 95% CI 0.79, 0.97). Compared to children in the least deprived quintile, those in the most deprived had more exclusions whether on asthma medication (7.6% versus 1.9%) or not (7.1% versus 1.3%).

Special educational need

On analysing 2,472,798 school records for 683,716 schoolchildren, asthmatic children had greater special educational need on univariate analysis (OR 1.47, 95% CI 1.43-1.50) and after adjustment for sociodemographic (OR 1.31, 95% CI 1.28-1.35) and maternity (OR 1.28, 95% CI 1.25-1.32) factors (Figure 2). There were interactions with sex ($p<0.001$) and age ($p<0.001$). The association was stronger in girls (OR 1.39, 95% CI 1.33-1.46) than boys (OR 1.24, 95% CI 1.20-1.28) and strongest among children aged over 14 years (OR 1.40, 95% CI 1.35-1.46). Asthma was associated with all types of special educational need. Strongest associations were with physical (fully adjusted OR 2.76, 95% CI 2.57-2.95) and mental health conditions (fully adjusted OR 1.76, 95% CI 1.49-2.08).

Academic attainment and subsequent unemployment

Of 125,211 children with attainment data, asthmatic children had poorer attainment on univariate analysis (OR 1.09, 95% CI 1.04-1.13) and after adjustment for sociodemographic

(OR 1.10, 95% CI 1.05-1.16) and maternity (OR 1.11, 95% CI 1.06-1.16) factors. There were no interactions with age, sex or deprivation. On excluding children with special educational need, the association attenuated slightly (fully adjusted OR 1.08, 95% CI 1.03-1.14). The association disappeared after adjusting for absenteeism (OR 0.96, 95% CI 0.91-1.01). A formal mediation analysis on all pupils **suggested** that the effect of asthma on attainment (OR 1.14 CI 1.05-1.22) was **likely to be** an indirect effect mediated by absenteeism (OR 1.15 CI 1.13-1.18) **rather than a** direct effect (OR 0.98 CI 0.92-1.05).

Of 197,430 children who left school during the study period, 3,915 (32.7%) asthmatic children left school before 16 years of age compared with 52,654 (28.4%) of their peers. On univariate analysis, asthma was associated with increased unemployment overall (OR 1.11, 95% CI 1.05-1.18) and among girls (OR 1.18, 95% CI 1.07-1.29). On multivariable analysis these associations disappeared (OR 1.00, 95% CI 0.95-1.07). However, when children with special educational need were excluded from the analyses, the association in girls remained in the fully adjusted model (OR 1.14, 95% CI 1.03-1.27). Including absenteeism as a covariate made the association disappear (1.07, 95% CI 0.96-1.19) A formal mediation analysis among girls with no recorded special educational need **suggested** that the effect of asthma on unemployment (OR 1.13 CI 1.02-1.26) was **likely to be** an indirect effect mediated by absenteeism (OR 1.04 CI 1.03-1.05) **rather than a** direct effect (OR 1.09 CI 0.98-1.20).

Hospitalisation and mortality

Linkage to hospital records provided 2.94 million person years of follow-up. Mean follow up time was 4.29 years. Of 683,716 pupils followed up, 135,482 experienced 260,705 hospital admissions. In Cox proportional hazards models, asthmatic children experienced increased risk of hospitalisation for any cause and for respiratory disease. However, the proportionality

assumption was not met ($p < 0.001$) for either model. Figure 3a shows fully adjusted incidence rate ratios for all-cause hospitalisation for each year of follow-up using a Poisson piecewise regression model. Asthmatic children were more likely to be hospitalised over all five study years. However, the incidence rate ratio was greatest in the first year after treatment was recorded (IRR 1.98, 95% CI 1.93-2.04) and fell over time (Figure 3a). There was an interaction with sex ($p < 0.001$) whereby the association between asthma and admission for respiratory disease was stronger for boys than girls, especially over the first two years (Figure 3b).

There were few deaths ($n=437$). However, asthmatic children were more likely to die over follow-up, on univariate analysis (HR 1.92, 95% CI 1.42-2.60), and following adjustment for sociodemographic (HR 1.83, 95% CI 1.35-2.48) and maternity (HR 1.77, 95% CI 1.30-2.40) factors. Percentage of deaths attributed to suicide (ICD10 X60–X84, Y87.0) was comparable among children with (10.6%) and without (10.8%) asthma.

Sensitivity analyses

Re-including children previously omitted, because they were dispensed one, or more, asthma medications but did not meet our definition, and categorising them as asthmatic, did not substantially alter the effect sizes of the respective associations with the main outcomes. After adjusting for sociodemographic and maternity factors, asthmatic children still experienced increased risk of absenteeism (IRR 1.20, 95% CI 1.19-1.21), special educational need (OR 1.19, 95% CI 1.17-1.21), hospitalisation (HR 1.47, 95% CI 1.45-1.48), mortality (HR 1.44, 95% CI 1.15-1.80), and poorer attainment (OR 1.07, 95% CI 1.04-1.10). There remained decreased risk of exclusion for asthmatic children compared to peers (fully adjusted

IRR 0.94, 95% CI 0.90-0.98) and no association with unemployment (fully adjusted OR 0.97, 95% CI 0.94-1.02).

DISCUSSION

Asthmatic children experienced increased absenteeism and increased special educational need, for mental and physical health reasons. They left school earlier and achieved lower examination grades, even with no identified special educational need. Poorer exam grade attainment was attributable to higher school absence. However, reassuringly, poorer grades did not translate into subsequent higher unemployment, after adjusting for sociodemographic and maternity factors. Developing interventions to improve attendance or mitigate the impact of missed school days could improve grades of asthmatic children. Teachers were less likely to exclude asthmatic children, compared with peers. Asthmatic children experienced increased risk of hospitalisation and mortality, particularly within one year of first recorded use of asthma medication. Associations with special educational need and unemployment were greater in girls, despite boys being more likely to be hospitalised for respiratory problems.

Previous studies investigating health outcomes of asthmatic children have used hospitalised cohorts or no comparison group. Ours was a large, non-selective study including children across the whole of Scotland. Because the sampling frame was mainstream and special schools, rather than hospital clinics, inclusion was not restricted to most severe asthma cases and we adjusted for sociodemographic and maternity factors. The large cohort provided sufficient power to test for statistical interactions and undertake sub-group analyses and we analysed a range of educational and health outcomes within the same study. Our proxy for asthma using prescriptions has previously been used and validated showing high positive

predictive value of 0.75-0.9 in children aged 4.5-17 years. [30,31] We previously validated this definition [32] consistent with the British Thoracic Society (BTS) / NICE Guidelines [33] recommending that all children diagnosed with asthma be prescribed a short acting beta agonist alongside their inhaled corticosteroid or leukotriene antagonist.

Our study included children attending local authority maintained schools however, in Scotland, less than 5% of children attend private schools. According to the 2011 Scottish Census, 11% of Scottish residents aged 5-19 years were born outside of Scotland; consistent with 12.3% of Scottish children we could not link to Scottish maternity records. Prevalence of asthma medication was lower (4.24%) in pupils who did not link versus those who did (5.99%). We used existing, administrative databases established for other purposes. However, they undergo regular quality assurance checks. Linkage of education and health records utilised probabilistic matching; validated to be 99% accurate for singletons. [25]

Ours is the largest study, to date, to evaluate educational outcomes of asthmatic children. Previous studies reported that asthmatic children have more absences from school, [19] however, few have examined special education need and consensus lacks on possible lower academic achievement. [19] One study of 9,014 schoolchildren reported moderately increased absenteeism but no deficit in standardised test scores, [18] whilst a larger study, reported increased absenteeism and lower grades.[20] Fowler et al. [21] demonstrated increased absenteeism, learning disability and use of educational services, but comparable rates of grade failure in asthmatic children compared to peers. Kohen et al [6] found that, compared to children with no chronic conditions, asthmatic children had more absences, increased use of education services, poorer standardised test scores and poorer maternal ratings of school performance. Increased distress and anxiety [22], poorer wellbeing,

decreased happiness and increased mental health issues [23] have been observed in asthmatic children. Kuo et al. [34] reported no increase in all-cause mortality but higher risk of suicide. In our study, 1.91% of asthmatic girls were also prescribed antidepressants compared with 0.84% of girls without asthma. However, there was no evidence of increased suicide among asthmatic children.

CONCLUSION

Asthmatic children have worse educational and health outcomes than peers. Increased absenteeism appears to mediate some of these outcomes. Educational interventions that mitigate the adverse effects of absenteeism, especially in girls, should be considered.

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DECLARATION OF INTERESTS

All authors declare no competing interests.

AUTHOR CONTRIBUTIONS

JPP had the original concept. All authors agreed the study design. DC and AK provided data and undertook record linkage. MF and DFM undertook the statistical analyses. All authors interpreted the results. MF and JPP drafted the manuscript and all other authors contributed revisions. All authors reviewed and approved the final version of the manuscript. MF is guarantor for the study.

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Figure 1 – Flow diagram illustrating the number of pupils included and excluded from the cohort at each stage of data cleaning.

Figure 2 - Forest plot of the association between treatment for asthma and special educational need by sex and age.

adjusted for age, sex, deprivation quintile, ethnic group, maternal age, maternal smoking, parity, mode of delivery, gestation at delivery, sex- gestation-specific birthweight centile and 5 minute Apgar score

SIMD – Scottish Index of Multiple Deprivation

Figure 3 Poisson regression model of the risk of hospitalisation over five years follow-up from first record of treatment.

a. Any-cause hospitalisation

b. Respiratory hospitalisation by sex (boys=solid square; girls=hollow diamond)

adjusted for age, sex, deprivation quintile, ethnic group, maternal age, maternal smoking, parity, mode of delivery, gestation at delivery, sex- gestation-specific birthweight centile and 5 minute Apgar score

SIMD – Scottish Index of Multiple Deprivation

Pupils in dataset

Pupils excluded







