

Decline in admissions for childhood asthma, a 26-year period population based study

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Asthma admissions in children are declining

ABSTRACT

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Background: The prevalence of childhood asthma has increased, although the rate of hospitalization for asthma seems to decrease. In Norway, the rate of hospital admission for childhood asthma from 1984 to 2000 increased. The aim of this study was to assess further trends in hospital admissions for childhood asthma up to 2010.

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Methods: A population based study including children 1-13 years of age hospitalized for asthma during six periods from 1984/1985 to 2009/2010 in Rogaland, Norway was performed. Medical records from 1536 admissions (1050 children) were studied; and gender, age, number of admissions, length of hospital stay, medications and symptoms recorded.

Results: For all age groups, the rate of admissions per 10.000 increased from 20.1 in 1984/85 to 33.7 in 1989/90, but declined to 14.4 in 2009/2010. Rates were highest in boys (OR 1.87; 95% CI: 1.69, 2.09), younger age groups (OR 2.51; 2.38, 2.64) and decreased from 1984 to 2010 (OR 0.92; 0.88, 0.94). The rates of readmissions were higher than for primary admissions (OR 1.33; 1.19, 1.47). From 1984 to 2010 there was an increased use of inhaled corticosteroids prior to admission (6 to 51%) and started at discharge (7 to 37%), and systemic steroids given during admission (19 to 83%).

Conclusion: There has been a substantial decline in the rate of hospital admissions for childhood asthma after 1989/1990, with major differences between age groups and genders. The decline could be due to improved care of children with asthma or a real reduction in asthma exacerbations.

Key words: Asthma: Clinical aspects, asthma: Epidemiology, asthma: Treatment, epidemiology: Prevalence, Environment: Air pollution.

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INTRODUCTION

The prevalence of asthma symptoms in developed countries have increased from 4-5% in 1955 to approximately 15% in 2010 (1). However, during the last years this trend seem to flatten or even decrease (2, 3). The admission rate for childhood asthma peaked in the 1990s, but may seem to decline in some studies (1, 2, 4). Few studies have reported continuous data regarding asthma hospitalization in children during the last three decades, and most studies are based on data from medical registers with possibilities of diagnostic shifts during the study period.

The lifetime prevalence of childhood asthma in Norway has also been increasing, but has not shown the same pattern of flattening as in other developed countries (5-7). Increasing rates of asthma admissions from 1980 to 1989, particularly in children younger than 4 years of age, was reported in a study from Oslo, with subsequently stabilizing until 1995 (4).

In an earlier population based study from South Rogaland, Norway studying medical records, we found an overall increase in annual admission rates for asthma in children aged 1-13 years from 1984 to 2000, but with substantial differences between age groups (8).

The aim of the present study was to study further trends in hospital admissions for childhood asthma in this area during six periods, each of two years, from 1984 to 2010, but with particular focus on changes from 2000 to 2010.

MATERIALS AND METHODS

Study area

The southern part of Rogaland county has 326.556 inhabitants (January 2010), including 69.179 children less than 14 years of age (9). The population in Rogaland is relatively stable and Stavanger University Hospital has received all admissions for acute childhood asthma in this area through the whole study period. The decision to admit to hospital or discharge a patient with acute asthma is based on clinical evaluation of the child. Both the medical expenses for hospital admission and medical costs for treatment of asthma at home have been covered by the Norwegian Social Security System during the whole study period.

Study subjects

Six two-year study periods were chosen; 1984/1985, 1989/1990, 1994/1995, 1999/2000, 2004/2005 and 2009/2010, each period separated from another by three years. Patients were retrospectively selected from the medical records. To secure a uniform diagnosis during the study periods, we studied the medical records of all children with the diagnosis of bronchiolitis and bronchitis (to avoid false negative diagnoses) and the diagnosis of asthma (to avoid false positive diagnoses).

Children discharged with the diagnosis of pneumonia, atelectasis or bronchiectasis, and without any of the diagnoses above, were not studied. The International Classification of Diseases (ICD) system was used; ICD8 until 1987, ICD9 from 1987 to 1998, and ICD10 from 1999.

Children 1-13 years of age admitted with acute bronchopulmonary obstruction (BPO) (wheezing, prolonged expiration) as the major cause of hospitalization with the response to bronchodilators and with a previous history of at least two episodes of BPO with or without hospitalization, were diagnosed as asthma and included in the analyses (10), but not included if BPO was not the major cause for admission.

Age, gender, length of stay, treatment prior to admission and during hospitalization were recorded. A primary admission was defined as not having a previous admission for BPO, either within or outside the study periods. A re-admission was defined as any previous admission for BPO, including admissions outside the study periods. A readmission was not included if it was considered as a readmission for the same episode. Based on the medical record, the children were given a symptom score from 0 to 6 according to a grading system published earlier (Table 1) (10). Three of the authors abstracted all data from the medical records.

Annual community-based demographic data for the population were obtained from the Official Bureau of Statistics (9).

Statistical analyses

Admissions were expressed as rates per 10,000 children. In the analysis, being hospitalized or not was seen as a binomial event, and possible differences analysed by logistic regression. Multiple polynomial regressions were used to study possible overall curvilinear relationships between hospitalization for asthma and time periods and adjusted for gender.

Year was set as a categorical covariate when comparing individual periods, and as a continuous variable when analysing time trends. Comparisons of percentages were done by chi-square test and comparisons of P for trend were done by the Cochran Armitage test.

Trends for length of stay in hospital and symptom score during the six time periods were analysed by linear regression analyses. Differences in symptom score between the different age groups were analysed by one-way ANOVA, and if the F-test was positive, by Bonferroni test. Results were considered significant when P-levels were below 0.05.

All statistical analyses were performed using the IBM-SPSS statistical package (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp).

RESULTS

Hospital admission rate (Figure 1 and 2, Table 2)

A total of 1536 admissions (66% boys, $P < 0.001$) for 1050 children were included. The rate of admissions per 10,000 increased from 1984/85 to 1989/90, but decreased from 1989/90 to 2009/10 (Table 2).

Male gender and younger age were positively associated and time periods negatively associated with admissions for asthma (Male gender: OR 1.87; 95% CI: 1.69, 2.09, Younger age: 2.51; 2.38, 2.64, Time periods: 0.92; 0.89, 0.94; $P_{\text{trend}} < 0.001$ for all, multiple polynomial logistic regression analyses). There were no interactions between gender and age or between gender and time periods and asthma admissions as outcome variable (data not shown).

The admission rates for the different age groups and periods are shown in Figure 1. For children aged 1-2 years, there was a peak in admissions in 1999/2000, but thereafter a decline ($P_{\text{trend}} < 0.001$ for both). For the age groups 3-4 and 10-13 years, the peak was seen in 1989/90 with a decline thereafter ($P_{\text{trend}} < 0.05$ for all). For the age group 5-9 years, we found a significant decline in admissions from 1989/90 ($P_{\text{trend}} < 0.001$).

The admission rates for the different age groups and periods, stratified for gender, are shown in Figure 2. For boys aged 1-2 years, the admission rates increased from 1984/85 to 1999/2000, but decreased thereafter ($P_{\text{trend}} < 0.05$ for both). For boys aged 3-4 years, there was an increase in admissions from 1984/85 to 1989/90, but thereafter a decline through all periods to 2009/10 ($P_{\text{trend}} < 0.05$ for both). For boys aged 5-9 years, there was a decreasing rate from the years 1994/95 ($P_{\text{trend}} < 0.001$). For the oldest age group 10-13 years of age, the overall rates of admissions were low for all periods. For boys, a significant increase was found from 1984/85 to 1989/90 and a decline was observed from 1989/90 ($P_{\text{trend}} < 0.05$ for both).

For girls aged 1-2 years the admission rates increased from 1984/85 to 1999/2000, but decreased thereafter ($P_{\text{trend}} \leq 0.01$ for both). For girls 3-4 years of age there was a decline in admissions from 1989/90 to 2009/10 ($P_{\text{trend}} = 0.002$). For girls aged 5-9 years there was a decreasing rate from 1989/90 ($P_{\text{trend}} < 0.001$). For girls aged 10-13 years of age a significant decline was observed from 1984/85 ($P_{\text{trend}} < 0.001$).

Readmissions (Figure 3)

For all time periods analysed together, the rate of readmissions were higher than the rate of primary admissions (OR 1.33 95% CI: 1.19, 1.47; $P < 0.001$) (Figure 3, Table 2).

The absolute readmission rate or the rate of re-admissions relative to first admissions did not differ through the study period (Table 2).

Length of stay and symptom score (Table 2)

The length of stay decreased during the six time periods ($B = -0.266$; 95% CI: -0.325, -0.207).

The mean symptom score did not differ through the six time periods ($B = -0.027$; 95% CI: -0.054, 0.001) or between the different age groups ($P = 0.929$).

Asthma management (Figure 4)

During the whole study period, almost all children were treated with inhaled bronchodilators at admission, both racemic epinephrine and β_2 -agonists. Regular anti-inflammatory treatment with inhaled corticosteroids (ICS) prior to admission increased gradually from 6 to 51% from the first to the last period ($P_{\text{trend}} < 0.001$). The use of systemic steroids (intravenously or orally) during hospitalization increased from 19 to 83% from the first to the last period ($P_{\text{trend}} < 0.001$). The number of children who started with ICS at discharge increased from 7 to 37% from the first to the last period ($P_{\text{trend}} < 0.001$ for all age groups).

DISCUSSION

The major result of this study is that the admission rate for childhood asthma in our region has shown a substantially decline during the last two decades, especially for the youngest age groups. For children aged one and two years, the peak rate was seen in 1999/2000, whereas for older children the peak was seen in 1989/90.

Hospital admission rate

Except for the youngest age group, the results are in agreement with studies from other countries, showing a peak in childhood asthma admissions around 1990 (1, 2). The present study shows that the decline in asthma admissions continues from the late 1990s and up to 2010, in agreement with studies from Spain, USA and Finland (11-13), but in contrast to the results from a French study (14). The Spanish study reported a decline in asthma hospitalization from 20.5 to 18.7 per 100.000 children aged 0-15 years from the years 2002 to 2010 (11), an incidence substantially lower than in the present study. However, comparing asthma hospitalization rates between different studies and over time, depends on accuracy and time consistence of the definition of asthma. Rates of asthma admissions based on registers may be subject to definitions or criteria differing between physicians, countries and over time (1, 12).

In our study, the peak in admissions was ten years later for the youngest age group compared to the other age groups. In the US, there was a 21% decline in asthma admissions for children 0-4 years from 2000 to 2009, to a level of 35/10.000 children (12). We found a 46% decline in admissions from 105/10.000 to 57/10.000 during the whole study period for the age group 1-2 years. It seems that the admission rate particularly for the youngest age group has been very high in our region, but during the last ten years are approaching the rates observed in other countries (12). However, most other studies analysed data from children younger than 1 years of age together with older children in one single group (11-13). We only included children older than 12 months of age, as children with wheezing during the first year of life often have transient conditions improving with time, whereas episodes with BPO that begin or persist into the second year of life more often are associated with persisting of symptoms (15, 16). The rates of admissions in the two oldest age groups seem lower and the decline from the year 2000 and onwards is steeper, than the ones reported from Spain (11) and

USA (12). However, the data are not fully comparable due to different age groups and time periods included in these studies.

The decline in asthma admissions for children has been explained by improved medical treatment, including controller therapy such as ICS. In Norway, the highest prescription rate of ICS is seen in children two years of age, and is also high in children one year of age (17). In children 0-4 years of age, both the prescription rate of ICS and rate of asthma admissions have been substantially higher in Norway than in the UK (17, 18). It is therefore possible that the continuous increase in admission rate for the youngest age group through the 1990s is due to less response to ICS in this age group, and that the decline in this age group from year 2000 may be explained by an actual decline in the incidence of asthma or wheezing over time. This is supported by a recent study from the Netherlands (19) and other studies from the western world, although these data are conflicting (20). Studies from Norway including data up to 2008 have shown increasing rates of asthma (5, 6), although for girls the trend seems to flatten and even decrease from 1995 to 2000 (21).

The combination of sensitization and current exposure to high levels of sensitizing allergens and the presence of respiratory virus as well as air pollution are factors associated with hospitalization for asthma (22, 23). Norway was one of the first countries to introduce a national smoke-free legislation in 2004. There is now substantial evidence for the association between smoke-free legislation and a reduction in childhood hospital attendance for asthma (24, 25). In Norway, the out-door air quality is generally improved since 1990s and levels of nitrogen oxides has decreased, which may have contributed to the observed decline (26). In the US, the decline in hospitalizations for childhood asthma from 2000 to 2009 (12) was paralleled by a concomitant 21% decline in admissions for bronchiolitis in children <1 year of

age (12), a disease not preventable by ICS, emphasizing that environmental or other non-medical reasons may account for a decline in wheezing disorders in young childhood during recent years. However, we cannot explain why the decline in admissions for the youngest children seem to be delayed ten years in Norway compared to other countries like UK and Canada (1, 2).

Length of stay and symptom score

The decrease in the length of stay during the six time periods is in agreement with results reported in studies from Spain (11), the US (12) and Oslo (Norway) (4) and may partly be due to increased use of oral corticosteroids at admission. The symptom score in the present study did not differ through the time periods i.e. the threshold of being admitted to hospital did not differ throughout the study period and therefore do not explain the declining rate of admissions or length of stay. However, few comparable studies regarding symptom score and trends in hospitalization for asthma are found.

Readmissions

The high number of readmission vs. primary admission throughout the study period is in contrast to a study from Finland reporting a more slowly decrease of first admissions compared to all admissions, indicating that readmissions became less frequent (13). A study from Australia reported increasing rates of readmissions for childhood asthma, particularly in the youngest age groups, despite a decline in the asthma incidence (27) .

In studies from the US, adolescents (12-18 years of age), children with asthma admissions in the previous year and children with a complex chronic condition (28) and with low access to primary care (29), had increased risk of readmission for asthma. In the present study, the number of readmissions was not reduced during the study period despite the

increasing use of ICS. Therefore, there may be a group of children who for different reasons do not respond or have poor adherence to the medical treatment or advices given by their doctors (30).

Strenght and limitations

Strengths of this study are the long time follow up, and a thorough and consistent evaluation of the medical record for each case to secure a uniform diagnosis of asthma through all years, thereby avoiding the possibility of a diagnostic shift or changes in procedures of the hospital (1). Further, there have been no substantial changes regarding the medical service, the catchment area and the population in the area during the study period. However, as this is a single center study, local factors may be of importance, limiting the ability to generalize. We only registered treatment with short-acting bronchodilators, teophylline and systemic- and inhaled corticosteroids. Long-acting β 2 agonists were not included, as they are not approved for use in Norwegian children below 4 years of age and combinations with long-acting β 2 agonists and steroids were not permitted for use in Norway before around the year 2000.

Conclusion

In conclusion, after an increasing rate of asthma hospitalization for children aged 1-13 years during the 1990s in Norway, the rate is now declining for all age groups, but most substantially for the youngest age groups. The decline could either be the results of improved care of children with asthma or an overall reduction in asthma excacerbations.

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FIGURE LEGENDS

Figure 1

Annual admission rates per 10.000 for children aged 1–2, 3–4, 5-9 and 10-13 years admitted to hospital for acute asthma in South-Rogaland (Norway) during six time periods from 1984 to 2010.

Figure 2

Annual admission rates per 10.000 for boys and girls aged 1–2, 3–4, 5–9 and 10–13 years admitted to hospital for acute asthma in South-Rogaland (Norway) during six time periods from 1984 to 2010.

Figure 3

Annual primary admission rates and re-admission rates per 10.000 for children aged 1–13 years admitted to hospital for acute asthma in South-Rogaland, Norway.

Figure 4

The percentage of children receiving treatment with inhaled corticosteroids (ICS) prior to admission, systemic steroids or theophylline at admission and ICS started at discharge, when admitted for acute asthma in South-Rogaland (Norway) during six time periods from 1984 to 2010.

Table 1

Symptom score by clinical assessment in children with asthma (modified from K. Aas (10)).

0. Normal
1. No dyspnoea. Slightly faint respiratory sounds.
2. No dyspnoea. Fine crackles or wheezing on auscultation.
3. No dyspnoea at rest. Considerable wheezing on auscultation. Slight use of auxiliary respiratory muscles.
4. Considerable wheezing audible with or without stethoscope. Moderate use of auxiliary muscles. Chest wall recessions.
5. Considerable wheezing. Considerable use of auxiliary muscles. Possible slight cyanosis.
6. Poor respiratory effort. Quiet respiratory sounds. Cyanosis usual.

Table 2. Changes in hospital admission rate, primary admission rate, readmission rate, days in hospital and symptom score for childhood asthma in South-Rogaland (Norway) 1984-2010.

	1984/1985	1989/1990	1994/1995	1999/2000	2004/2005	2009/2010	P-value
	a	b	c	d	e	f	
Annual admission rate / 10.000	20.1	33.7	30.6	29.1	17.6	14.4	$P_{\text{trend}} < 0.001$ (b vs. a and b vs. f)
Primary admission rate / 10.000	7.8	14.0	13.4	15.0	5.9	6.6	$P_{\text{trend}} = 0.193$
Readmission rate / 10.000	12.0	19.7	17.1	14.2	11.6	8.5	$P_{\text{trend}} = 0.349$
Readmission / total admission (%)	61	58	56	49	66	56	$P_{\text{trend}} = 0.599$
Length of stay; mean (SD)	3.4 (2.5)	2.7 (1.7)	2.1 (1.8)	1.9 (1.3)	1.8 (1.7)	2.2 (1.7)	$P_{\text{trend}} < 0.001$
Symptom score; mean (SD)	4.1 (0.8)	4.1 (0.7)	4.1 (0.8)	4.6 (0.8)	3.9 (0.9)	3.8 (0.9)	$P_{\text{trend}} = 0.055$

SD; standard deviation

Figure 1

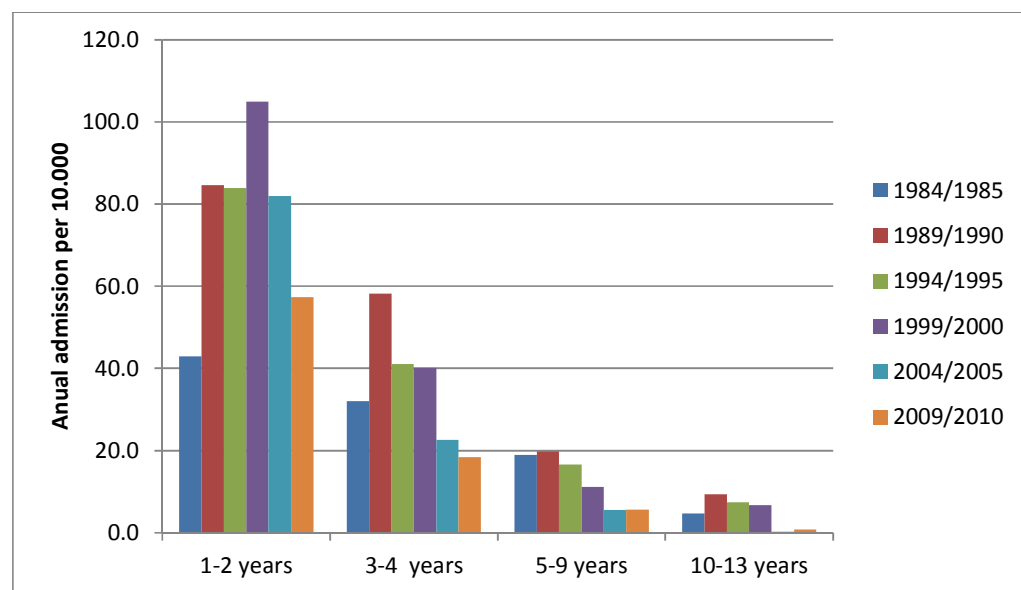


Figure 2

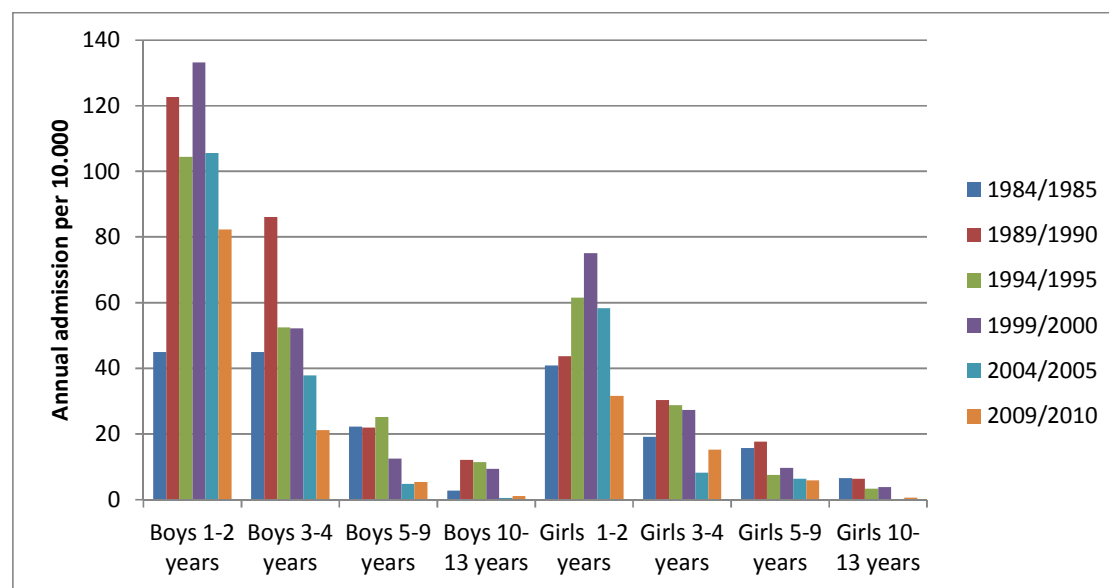


Figure 3

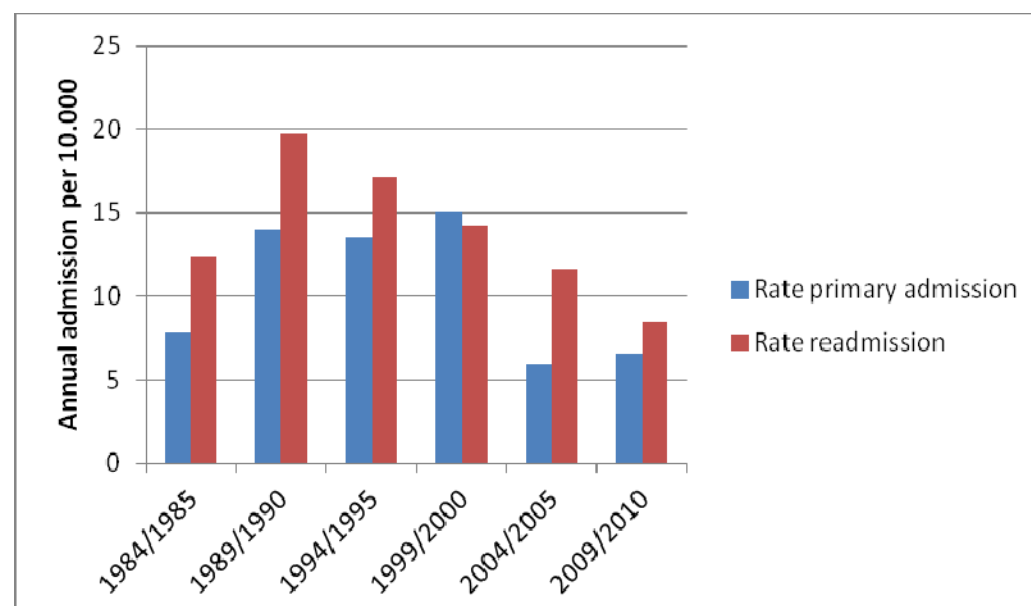


Figure 4

