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Original Research

Paediatric asthma hospital utilization varies by demographic factors and area socio-economic status

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SUMMARY

Objectives: Associations of emergency department (ED) visits and hospital admissions for asthma in children with demographics and area socio-economic status (SES) were examined to evaluate long-term trends and identify vulnerable populations.
Study design: Retrospective population-based trend and cross-sectional analyses.
Methods: Asthma hospital admissions (2000–2007) and ED visits (2005–2007) for children aged 0–14 years living in Orange County, California were linked with zip-code-level SES data (2000 US Census). Annual population estimates were obtained to calculate age-specific admissions and ED visit rates. Average annual percentage changes (AAPC) were calculated with joinpoint analyses. The risks of ED visits and hospital admissions were estimated from SES indicators with negative binomial regression.
Results: Rates of asthma hospital admissions and ED visits were highest among children aged 0–4 years, males and African Americans, and lowest among Asian/Pacific Islanders. African Americans and Hispanics/Latinos were more likely to be uninsured. Asthma admissions decreased significantly for all age groups over the study period. The greatest declines per 100,000 were among children aged 0–4 years (AAPC: −15.3%, 95% confidence interval −17.0% to −13.4%). Rates of hospital admissions and ED visits were significantly higher in low-SES groups. Hospital admission rates were 30–60% higher and ED visits were 80–90% higher in zip codes in the lowest tertile of median household income compared with the highest tertile of median household income.
Conclusions: Paediatric asthma hospitalizations and ED visit rates are declining in Orange County. However, certain groups are disproportionately affected, including those living in areas with low SES. This information will help in targeting intervention strategies to children at highest risk for severe asthma episodes.

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Introduction

Asthma was estimated to affect 6.5 million children in the USA in 2005[1] and to account for 12.8 million missed school days in 2003, according to a national survey.[2] Rates of emergency department (ED) visits and hospital admissions for asthma have been reported to be highest among children, with those aged 0–4 years having the highest rates overall.[2] In addition, disproportionately higher rates of asthma have been reported for children who are male, non-Hispanic, African American or poor.[1,3,4] Compounding this burden of asthma is that for racial/ethnic minorities (including African Americans and Hispanics or Latinos) and poorer families, access to high-quality health care is limited in the USA due to lack of private insurance.[3–5]

Efforts to reduce severe asthma episodes requiring treatment in an ED or inpatient hospital setting include use of controller medications, and healthcare provider and patient education.[6] These approaches may be out of reach for children of low-income families in the USA who do not have private health insurance.[5] Stafford *et al.* reported that asthma-related office visits in the USA increased throughout the 1980s, then levelled off during the next decade, corresponding with an increase in controller-medication use including inhaled corticosteroids.[7] A recent meta-analysis reported that paediatric asthma education reduced mean numbers of hospitalizations and ED visits.[8] However, this requires adequate access to health care.

The present population-based study evaluated asthma hospital data for Orange County, California. Therefore, results cannot be generalized beyond this region but are likely to be similar for other US counties. Orange County (total population in 2000: 2,846,297, with 25% under 18 years of age) has a fairly diverse population, with 30.8% being of Hispanic or Latino ethnicity and 9.2% being below the poverty level, according to the 2000 US Census Bureau (http://factfinder.census.gov/home/saff/main.html%3f_lang%3den). The Asthma and Chronic Lung Disease (ACLD) Institute, supported by the Children and Families Commission of Orange County, launched a variety of clinical and educational initiatives in 2002 to reduce the burden of asthma in Orange County children aged 0–5 years, when most asthma symptom phenotypes first emerge. As part of this effort, data were collected on asthma ED visits and hospital admissions for children of all ages in Orange County to examine trends in recent years and to investigate whether area-level socio-economic status (SES) indicators may be associated with episodes of paediatric asthma that are treated in the hospital setting. The aim of this study was to evaluate annual trends in asthma hospital encounters, and to identify groups that may benefit from targeted prevention or intervention programmes.

Methods

Hospital admissions and emergency-department visits

Two separate population-based datasets were obtained from the California Office of Statewide Health Planning and Development (OSHPD), one for asthma hospital admissions and another for asthma ED visits for children who live in Orange County. The hospital admissions data were available for 2000–2007. ED data collection began on 1 January 2005 and were available for 2005–2007. Reporting on ED visits and hospital admissions is required of all non-federal hospitals (excluding veterans administration hospitals). Both datasets included observations for children aged ≤14 years with a principal diagnosis of asthma (ICD-9 CM code 493). In secondary analyses of the relationship between asthma trends and trends in other lower respiratory illnesses (in the Discussion section), data were also obtained on the following illnesses (ICD-9 CM codes): acute bronchitis and bronchiolitis (466); bronchitis not otherwise specified (NOS) (490); chronic bronchitis (491); pneumonia (480–487); chronic airway obstruction, NEC (496); and symptoms involving the respiratory system/other chest symptoms (786). In addition to the principal diagnosis, variables obtained from the OSHPD datasets included patient age in years, gender, race, ethnicity, zip code of residence, hospital, other diagnoses, admission and discharge dates, length of stay (for hospital admissions) or visit date (for ED visits), and expected source of payment. Expected source of payment was used as an indication of insurance status and categorized as either private insurance or other (government-sponsored or self-pay); distributions were examined in relation to race/ethnicity. Logistic regression was used to examine whether minority racial/ethnic groups were more likely to be uninsured or to need government-sponsored payments rather than have private insurance (dependent variable) compared with non-Hispanic Whites, adjusting for age group (0–4, 5–9 and 10–14 years). This was assessed for both hospital admissions and ED visits. Differences in insurance status by age group were also evaluated, adjusting for race/ethnicity. Finally, logistic regression models were used to evaluate whether minority racial/ethnic groups admitted to hospital were more likely to live in zip codes with lower SES (based on the proportion of the population with income at least twice the poverty level, median household income, and educational attainment for the population aged ≥25 years).

2000 US Census data and annual population estimates

2000 US Census data for Orange County were used to obtain population denominators by age, gender and race/ethnicity, as well as zip-code-level SES variables described above. The County Characteristics Resident Population Estimates File [CC-EST2008-ALLDATA-(ST-FIPS)] from the Population Division, US Census Bureau was used to obtain population estimates for the entire county by age, gender and race/ethnicity for 2001–2007. These estimates were used for denominators in calculations of age-specific rates per 100,000 for each year.

Trends in rates over time

JoinPoint Version 3.5.1 (Statistical Research Branch, National Cancer Institute, Bethesda, MD, USA) was used to calculate the average annual percentage change (AAPC) in asthma hospital admissions and the significance of the change over time by age group (overall and within ethnic/race groups). The

JoinPoint regression model connects several different lines together at the 'joinpoints' and uses permutation tests for identifying changes in trend.[9] JoinPoint takes trend data (e.g. disease rates) and fits the simplest model that the data will allow from the minimum (e.g., 0 joinpoints, which is a straight line) to the maximum number of joinpoints. The programme starts with the minimum number of joinpoints, and tests whether more joinpoints are significant and must be added to the model (up to the maximum number). This enables the user to test whether an apparent change in trend is significant. The tests of significance use a Monte Carlo Permutation method, with 999 permutations (default value) used in the present study. Models were adjusted for autocorrelated errors (AR1). In addition to summarizing the trend for the entire time period over which the data were observed (2000–2007), the AAPC was used to summarize the trend for the subinterval 2003–2007, which was found to be a period of changing rates. Joinpoint analyses were not conducted for ED visits as only 3 years of data were available for this analysis.

Analyses of SES indicators in relation to hospital admissions and ED visits

Asthma admission and ED visit rates were analysed in relation to the 2000 US Census SES data by zip code. This analysis aimed to assess whether there are disparities in rates that are potentially amenable to targeted intervention among certain population groups. The SES variables were divided into tertiles and included in regression models against asthma hospital admissions during 2000–2007 and ED visits during 2005–2007 for US Census age groups 0–4 years, 5–9 years and 10–14 years. Rate ratios and 95% confidence intervals (CI) were estimated using negative binomial distribution as there was evidence of overdispersion in the data for some groups using Poisson regression. The log of the population for each age group and within each zip code (from the 2000 US Census) was included as an offset in the models. Analyses were conducted using SAS Version 9.1 (SAS Institute, Cary NC, USA).

Table 1 – Characteristics of paediatric patients admitted to hospital or with emergency department (ED) visits for asthma in Orange County.

Characteristics	Number of admissions 2000–2007 *n* (%)	Average annual rate per 100,000	Number of ED visits 2005–2007 *n* (%)	Average annual rate per 100,000
Age 0–4 years	3836 (100)	221	4010[a] (100)	621
Sex				
Male	2553 (66.6)	287	2678 (66.8)	808
Female	1283 (33.4)	152	1331 (33.2)	423
Race				
Non-Hispanic White	1523 (39.7)	276	1365 (34.0)	668
Hispanic White	1275 (33.2)	189	1938 (48.3)	604
Black	116 (3.0)	518	150 (3.7)	1913
Asian/Pacific Islander	318 (8.3)	159	257 (6.4)	288
Other	308 (8.0)	–[b]	154 (3.8)	
Unknown	296 (7.7)	–	146 (3.6)	
Age 5–9 years	1670 (100)	95	3121[a] (100)	504
Sex				
Male	1015 (60.8)	113	2016 (64.6)	637
Female	659 (39.2)	77	1104 (35.4)	365
Race				
Non-Hispanic White	618 (37.0)	109	1163 (37.3)	528
Hispanic White	530 (31.7)	84	1324 (42.4)	457
Black	65 (3.9)	272	177 (5.7)	1946
Asian/ Pacific Islander	135 (8.1)	70	204 (6.5)	258
Other	121 (7.3)		129 (4.1)	
Unknown	201 (12.0)		124 (4.0)	
Age 10–14 years	749 (100)	43	1983 (100)	299
Sex				
Male	460 (61.4)	51	1238 (62.4)	363
Female	289 (38.6)	34	745 (37.6)	231
Race				
Non-Hispanic White	307 (41.0)	48	854 (43.1)	337
Hispanic White	225 (30.0)	38	770 (38.8)	262
Black	51 (6.8)	185	119 (6.0)	1159
Asian/Pacific Islander	38 (5.1)	20	97 (4.9)	111
Other	49 (6.5)		56 (2.8)	
Unknown	79 (10.5)		87 (4.4)	

a Two cases were reported with unknown sex.
b not reported.

As a sensitivity analysis, analyses of hospital admissions were restricted to the same time period as the ED visits (2005–2007) to assess whether results were consistent. These results are presented in the online appendix.

Results

Patient characteristics for hospital admissions and ED visits

Table 1 displays patient characteristics including sex, race/ethnicity and age group for asthma hospital admissions for 2000–2007 and ED visits for 2005–2007 in Orange County. The youngest age group (0–4 years) had the highest rates of asthma admissions and ED visits, and males had higher rates of asthma admissions and ED visits than females for all age groups. Of the racial/ethnic groups, African Americans had the highest rates of asthma admissions and ED visits, followed by non-Hispanic Whites, Hispanics or Latinos, and Asians/Pacific Islanders. In proportion to ED visits, more children aged 0–4 years per 100,000 were admitted to hospital (36%) than children aged 5–9 years (19%) or 10–14 years (14%). All of the above differences in the characteristics of subjects admitted to hospital for asthma in 2000–2007 were similar when data were restricted to the same period for which ED visit data were available (2005–2007) (Table S1, online appendix).

Table 2 presents the results of analyses of insurance status by race/ethnicity and age among children with asthma hospital admissions and ED visits. There was a significant variation in insurance status by both race/ethnicity and age. Compared with non-Hispanic Whites, African Americans and Hispanics or Latinos with asthma hospital admissions were two and five times more likely, respectively, to be without private insurance, and findings were similar among children with asthma ED visits. Asian/Pacific Islanders seen in the ED were less likely than non-Hispanic Whites to be without private insurance. Patient age was also related to insurance status for both hospital admissions and ED visits. Children aged 5–9 and 10–14 years were more likely to be covered by private insurance compared with children aged 0–4 years. Results were consistent in sensitivity analyses of asthma hospital admissions restricted to the same period for which ED visit data were available (2005–2007) (Table S2, online appendix).

Analyses of the relationship between SES and asthma admissions

Results for the analysis of subjects admitted to hospital showed that African Americans, Hispanics and Asians were more likely to live in a zip code with the highest tertile of people living below 200% of the poverty level than non-Hispanic Whites [Blacks, odds ratio (OR) 1.77, 95% CI 1.36–2.31; Hispanics or Latinos, OR 5.94, 95% CI: 5.24–6.72; Asians, OR 2.18, 95% CI: 1.80–2.63]. Results for median income and education were similar.

Table 3 presents results of the zip-code-level analyses of socio-economic indicators, derived from the 2000 US Census, and age-specific rates of asthma admissions and ED visits. Zip codes with the lowest tertiles of the population being above 200% of the poverty level, with at least an associate's degree, or of average median household income had significantly increased rates of asthma hospital admissions and ED visits for all age groups. Results were nominally consistent in sensitivity analyses of asthma hospital admissions restricted to the same period for which ED visit data were available (2005–2007) (Table S2, online appendix). Differences were only significant for children aged 0–4 years.

Plots of rates of hospital admissions and ED visits in 0–14-year-olds by median household income are displayed in Figs. 1 and 2, respectively, including regression lines and 95% CIs. While both plots demonstrate decreasing rates as median household income increases, the slope appears to be steeper for ED visits.

Hospital admission rates over time

Annual age-specific rates of asthma hospital admissions per 100,000 are displayed in Fig. 3 for 2000–2007. The base population for each age group was updated for each year using estimates from the 2000 US Census. Rates were fairly steady until 2003 or 2004, after which rates declined, with the steepest decline occurring in children aged 0–4 years.

Table 4 presents results of the joinpoint analyses showing the AAPC in asthma hospital admission rates for all subjects

Table 2 – Insurance status by race/ethnicity and age in children with asthma hospital admissions and emergency department visits in Orange County.

Characteristic	Private insurance (%)	No private insurance (%)	OR (95% CI)[a] for no private insurance
Hospital admissions			
Race/ethnicity			
Non-Hispanic White	71.0	29.0	1 (referent)
Black	54.4	45.6	2.15 (1.64–2.81)[c]
Hispanic White	30.8	69.2	5.50 (4.89–6.20)[c]
Asian/Pacific Islander	67.8	32.2	1.15 (0.94–1.40)
Other/Unknown	64.4	35.6	1.36 (1.04–1.78)[b]
Age (years)			
0–4	51.4	48.6	1 (referent)
5–9	55.2	44.8	0.84 (0.74–0.95)[b]
10–14	60.4	39.6	0.69 (0.58–0.82)[c]
Emergency department visits			
Race/ethnicity			
Non-Hispanic White	63.7	36.3	1 (referent)
Black	46.0	54.0	2.09 (1.71–2.55)[c]
Hispanic White	37.0	63.0	2.94 (2.67–3.23)[c]
Asian/Pacific Islander	79.6	20.4	0.44 (0.35–0.55)[c]
Other/Unknown	60.2	39.8	1.29 (1.02–1.61)[b]
Age (years)			
0–4	48.2	51.8	1 (referent)
5–9	53.0	47.0	0.85 (0.76–0.94)[b]
10–14	56.6	43.4	0.75 (0.67–0.84)[c]

OR, odds ratio; CI, confidence interval.
a OR of 'no private insurance' from logistic regression models including both race/ethnicity and age group.
b $P < 0.05$.
c $P < 0.0001$.

Table 3 – Asthma hospital admissions in 2000–2007 and emergency department visits in 2005–2007 in relation to census-derived zip-code-level socio-economic status (SES) variables in Orange County.

Census-derived SES variable	Age 0–4 years	Age 5–9 years	Age 10–14 years
	Rate ratio (95% CI)	Rate ratio (95% CI)	Rate ratio (95% CI)
Hospital admissions			
Proportion of population above 200% poverty level			
Highest tertile	Referent	Referent	Referent
Middle tertile	1.20 (1.08–1.33)[b]	1.26 (1.08–1.47)[a]	0.94 (0.75–1.19)
Lowest tertile	1.36 (1.25–1.49)[b]	1.44 (1.26–1.64)[b]	1.43 (1.18–1.73)[b]
Proportion of population with at least an AA associate degree			
Highest tertile	Referent	Referent	Referent
Middle tertile	1.22 (1.10–1.36)[b]	1.14 (0.98–1.33)	1.00 (0.79–1.26)
Lowest tertile	1.41 (1.28–1.55)[b]	1.35 (1.18–1.55)[b]	1.45 (1.20–1.82)[b]
Median household income			
Highest tertile	Referent	Referent	Referent
Middle tertile	1.22 (1.12–1.33)[b]	1.27 (1.11–1.45)[b]	1.14 (0.93–1.39)
Lowest tertile	1.33 (1.22–1.44)[b]	1.33 (1.17–1.51)[b]	1.66 (1.38–2.00)[b]
Emergency department visits			
Proportion of population above 200% poverty level			
Highest tertile	Referent	Referent	Referent
Middle tertile	1.27 (1.14–1.43)[b]	1.38 (1.23–1.55)[b]	1.07 (0.93–1.22)
Lowest tertile	1.88 (1.71–2.06)[b]	1.75 (1.58–1.94)[b]	1.28 (1.14–1.44)[b]
Proportion of population with at least an AA associate degree			
Highest tertile	Referent	Referent	Referent
Middle tertile	1.47 (1.31–1.66)[b]	1.58 (1.40–1.80)[b]	1.15 (1.00–1.32)
Lowest tertile	2.20 (1.98–2.44)[b]	1.99 (1.77–2.23)[b]	1.41 (1.24–1.60)[b]
Median household income			
Highest tertile	Referent	Referent	Referent
Middle tertile	1.45 (1.32–1.60)[b]	1.48 (1.34–1.64)[b]	1.24 (1.10–1.40)[b]
Lowest tertile	1.90 (1.75–2.08)[b]	1.80 (1.63–1.99)[b]	1.54 (1.37–1.73)[b]

CI, confidence interval.
a $P < 0.01$.
b $P < 0.001$.

and for racial/ethnic groups for the period of changing rates (2003–2007). A maximum of one joinpoint was selected. Significant reductions in rates were observed for all age groups in the analysis of combined race/ethnic groups. The largest decrease was seen in children aged 0–4 years and the smallest decrease was seen in children aged 10–14 years. However, within each racial/ethnic stratum, significant reductions were primarily observed for children aged 0–4 and 10–14 years, probably due to reductions in statistical power.

Children with wheeze (especially those aged 0–4 years) may have been less likely to be coded as asthma (ICD 10493) and more likely to be coded with lower respiratory illnesses in later years, thus explaining the decreasing trend. To assess this, a joinpoint analysis was conducted to examine whether there were significant changes in rates of admission for other lower respiratory illnesses between 2003 and 2007. A small but significant reduction in lower respiratory illness admission rates was observed for children aged 0–4 years (AAPC −4.2, 95% CI −7.2 to −1.1). No significant reduction was observed for children aged 5–9 years (AAPC −0.4, 95% CI −6.2 to 5.8). However, a non-significant increase was seen for children aged 10–14 years (AAPC 4.7, 95% CI −3.8 to 13.8).

Annual age-specific rates of asthma ED visits per 100,000 for 2005–2007 are displayed in Fig. 4. Rates for all age groups appeared to decline from 2005 to 2006, then level off by 2007. Due to the shorter duration of available data for ED visits, joinpoint analyses could not be conducted with these data.

Average length of hospital stay for asthma admissions was also examined by age group and year (data not shown). The older age groups appear to have slightly longer average hospital stays than the youngest age group (average of 2.54, 2.24 and 2.01 days for 10–14, 5–9 and 0–4 years, respectively), but the average length of stay did not change over time.

Discussion

The highest admission rate per 100,000 people was found among African Americans, and the smallest admission rate per 100,000 people was found among Asians and Pacific Islanders, who were at least as well insured as non-Hispanic Whites. The higher rates among African Americans are consistent with US national data,[10–12] and suggest that targeted interventions and risk factor identification are needed. An analysis of the National Health Interview Survey suggested that the higher risk among African Americans is due to socio-economic influences rather than genetic variation, because the risk differences in prevalence of childhood asthma were only seen among poorer African American families.[12] Zip-code-level analyses support this. Areas with lower SES, as measured by median household income, proportion of the population below 200% of the poverty level and educational attainment, were found to have higher rates of asthma hospitalizations and ED visits. Areas with low SES have

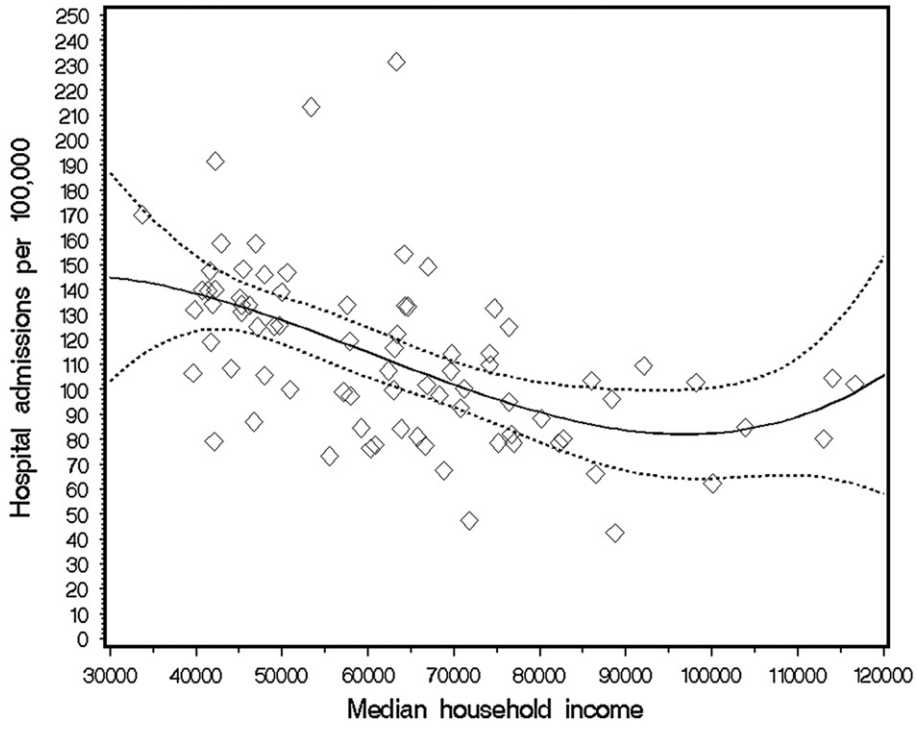

Fig. 1 – Asthma hospital admissions in relation to median household income by zip code among children aged 0–14 years in Orange County, 2000–2007. Admissions data were linked to US Census data by zip code to obtain population denominators and median household income data (in US dollars). Age-specific admission rates were calculated and summed across age groups in each zip code. Average annual rates per 100,000 population were calculated and cubic regression lines with 95% confidence intervals were plotted by the median household income (for each zip code from US Census data) using procedure gplot in SAS Version 9.1.

predominately Hispanic populations in Orange County, but also include minority African American and Asian populations. These communities may also benefit from early intervention and preventive efforts. There was not sufficient statistical power to evaluate SES differences among the African American population, which is relatively small compared with other groups in Orange County. However, it was observed that African Americans and Hispanics or Latinos with asthma hospital admissions or ED visits were more likely to be without private insurance than non-Hispanic Whites. Therefore, lack of private insurance could be associated with reduced opportunity for preventive care, and could potentially contribute to the higher observed rates of asthma hospital admissions and ED visits among African Americans compared with non-Hispanic Whites. However, it is not clear why Hispanic children did not have higher rates of asthma hospital admissions and ED visits despite the higher proportion of uninsured people in this group, although this result is consistent with other studies in the USA.[4]

Associations between increased admissions and low SES were not as apparent when admissions data were restricted to 2005–2007, partly due to the reduction in sample size compared with admissions data for 2000–2007 or ED visits for the comparable period (2005–2007). There may also have been more disparity in preventive care for the 5 years earlier in the decade. To test this, hospital admissions were also analysed for 2000–2004 ($n = 4443$, Table S4, online appendix). Risk of admission was found to be associated with all three variables representing lower SES in 2000–2004 for children aged 0–4 and 5–9 years, but in children aged 10–14 years, the rate ratio for the lowest tertile was only significant for median household income. The finding of a significant association between increased admissions and low SES for ED data during the later period (2005–2007) could be due to greater statistical power for ED visits ($n = 4010$) than for hospital admissions during that same period ($n = 1812$). An alternative explanation is that ED data are more relevant to frequent hospital use for people with limited access to preventive care.

A decreasing trend was found in annual hospital admissions for asthma per 100,000 children in Orange County among all age groups, but it was most dramatic in children aged 0–4 years followed by children aged 10–14 years. This is consistent with US national trends of a plateau and possible decrease in asthma morbidity during the current decade after a steep rise during the 1980s and 1990s.[10,11] This trend in improving asthma outcomes has generally been attributed to the increasing use of preventive medications, particularly inhaled corticosteroids.[7] Whether the declining rates may be due to changes in reporting practices by a shift in making a primary diagnosis of asthma to one of a lower respiratory illness was investigated. Evidence was found for a decrease in

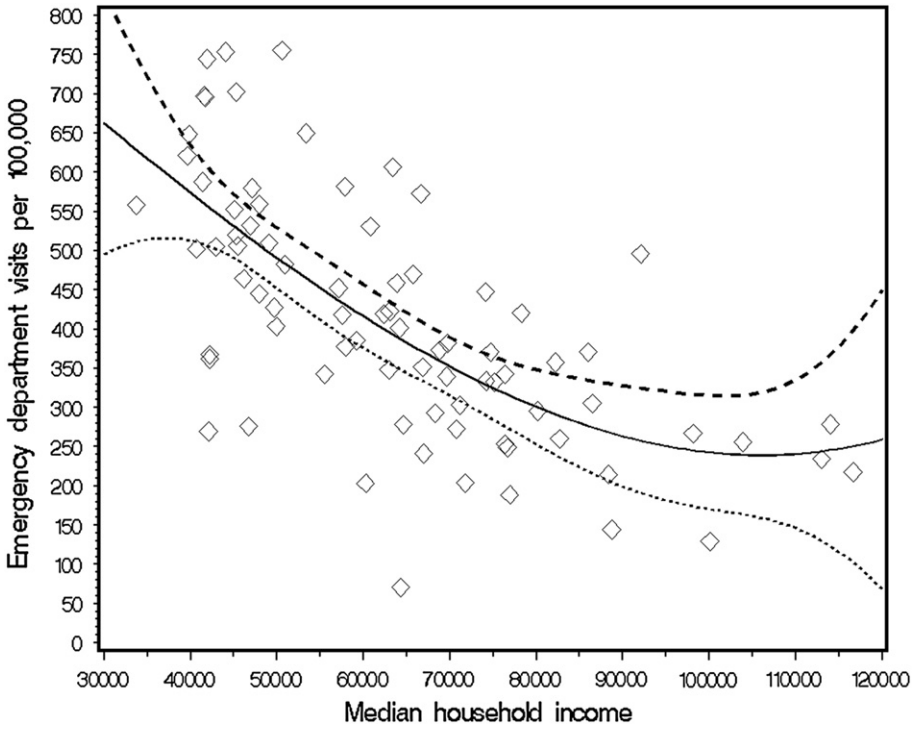

Fig. 2 – Asthma emergency department visits in relation to median household income by zip code among children aged 0–14 years in Orange County, 2005–2007. Emergency department data were linked to US Census data by zip code to obtain population denominators and median household income data (in US dollars). Age-specific emergency department visit rates were calculated and summed across age groups in each zip code. Average annual rates per 100,000 population were calculated and cubic regression lines with 95% confidence intervals were plotted by the median household income (for each zip code from US Census data) using procedure gplot in SAS Version 9.1.

the rate of other lower respiratory illnesses among the youngest age group (0–4 years; AAPC −4.6, 95% CI: −7.2 to −2.0), but this was much smaller than the annual decrease in asthma rates for this age group (AAPC −15.3, Table 4) and there was no significant change in the AAPC of lower respiratory illnesses for children aged 5–9 or 10–14 years. This evidence, taken together, suggests that the decrease in hospital visits for asthma among children in Orange County

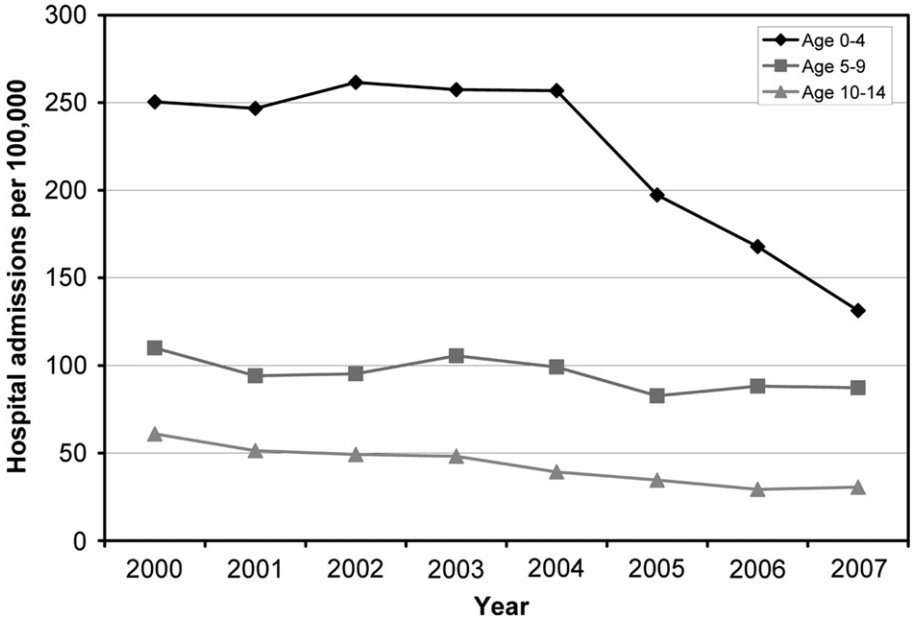

Fig. 3 – Rates of paediatric asthma hospital admissions in Orange County, 2000–2007.

Table 4 – Average annual percentage change (AAPC) in asthma hospital admissions in Orange County, 2003–2007.

Age group (years)	AAPC (95% CI) for asthma admissions
All races/ethnicities	
0–4	−15.3 (−17.0 to −13.4)[a]
5–9	−2.8 (−5.1 to −0.5)[a]
10–14	−11.6 (−17.4 to −5.4)[a]
Non-Hispanic White	
0–4	−16.0 (−20.0 to −11.8)[a]
5–9	−1.3 (−5.1 to 2.8)
10–14	−11.6 (−17.4 to −5.4)[a]
Hispanic	
0–4	−16.7 (−20.3 to −12.9)[a]
5–9	−2.8 (−5.3 to −0.2)[a]
10–14	−15.5 (−25.5 to −4.0)[a]
Asian/Pacific Islander	
0–4	−12.3 (−17.9 to −6.4)[a]
5–9	0.1 (-6.8 to 7.6)
10–14	−0.7 (−5.9 to 4.8)
Black	
0–4	−13.1 (−24.3 to −0.3)[a]
5–9	−2.4 (−16.9 to 14.7)
10–14	−9.9 (−18.0 to −0.9)[a]

CI, confidence interval.
a $P < 0.05$.

in recent years is unrelated to trends in lower respiratory illnesses.

A limitation of this study is that many subjects had 'unknown' race/ethnicity (Table 1) due to missing data in hospital discharge reports, and many also had 'other' race/ethnicities, likely due to mixed race. Rates per 100,000 cannot be calculated for the unknown and other race data (not including Hispanic) because no similar 2000 US Census data are available. This could lead to under- or over-estimation of rates. Another limitation is that the results cannot be generalized beyond the USA, and some counties in the USA may show different trends and risk differences.

In conclusion, a substantial decrease in hospital admissions and ED visit rates was found for children aged 0–4 years over the last decade, and concordant but smaller decreases were found in other age groups. This suggests that recent interventions, potentially including those conducted by the ACLD Institute, have diminished the severity of asthma, especially among preschool children. It is conceivable that preventive interventions during early childhood could lead to additional decreases in asthma morbidity in older paediatric age groups in the future. Some groups were identified to be at greater risk for hospitalization for asthma, including African Americans and people living in zip codes with low SES. These children should be targeted in the future with additional preventive interventions.

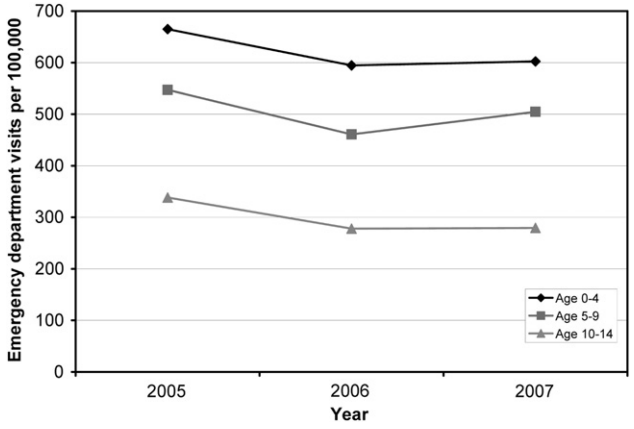

Fig. 4 – Rates of paediatric asthma emergency department visits in Orange County, 2005–2007.

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Ethical approval

This study was approved by the University of California Irvine Institutional Review Board and the Committee for the Protection of Human Subjects, California Health and Human Services Agency.

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Competing interests

None declared.

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Appendix A. Supplementary material

Supplementary material associated with this article can be found, in the online version at doi:10.1016/j.puhe.2012.04.011.

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