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Trends in racial disparities for asthma outcomes among children 0-17 years, 2001-2010

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Abstract

Background—Racial disparities in childhood asthma have been a long-standing target for intervention, especially disparities in hospitalization and mortality.

Objectives—Describe trends in racial disparities in asthma outcomes using both traditional population-based rates and at-risk rates (based on the estimated number of children with asthma) to account for prevalence differences between race groups.

Methods—Estimates of asthma prevalence and outcomes (emergency department visits, hospitalizations and deaths) were calculated from national data for 2001 to 2010 for black and white children. Trends were calculated using weighted log-linear regression, and changes in racial disparities over time were assessed using Joinpoint.

Results—Disparities in asthma prevalence between black and white children increased from 2001 to 2010; at the end of this period, black children were twice as likely as white children to have asthma. Population-based rates showed that disparities in asthma outcomes remained stable (ED visits and hospitalizations) or increased (asthma attack prevalence, deaths). In contrast, analysis with at-risk rates which account for differences in asthma prevalence showed that disparities in asthma outcomes either remained stable (deaths), decreased (ED visits, hospitalizations), or did not exist (asthma attack prevalence).

Conclusion—Using at-risk rates to assess racial disparities in asthma outcomes accounts for prevalence differences between black and white children, and adds another perspective to the population-based examination of asthma disparities. An at-risk rate analysis shows that among children with asthma, there is no disparity for asthma attack prevalence, and that progress has been made in decreasing disparities in asthma ED visit and hospitalization rates.

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Keywords

asthma; child; race; disparities; prevalence; emergency room; hospitalization; mortality; epidemiology

INTRODUCTION

Adverse asthma outcomes, such as hospitalization and death, are largely preventable, but rates are higher among some minority children compared to white children.(1-6) In 2004-2005, although black children had 1.6 times higher asthma prevalence compared to white children, they were 4 times more likely to be hospitalized and over 7 times more likely to die from asthma.(1) Federal efforts to reduce childhood asthma disparities include not only broad initiatives to track and address health inequities such as Healthy People(7) and the National Partnership for Action,(8;9) but also a coalition of federal agencies formed specifically to address childhood asthma disparities under the auspices of the President's Task Force on Environmental Health Risks and Safety Risks to Children. This group released a Coordinated Federal Action Plan to Reduce Racial and Ethnic Asthma Disparities in 2012.(10)

Health disparities are measured to track progress toward their elimination, and to more effectively target interventions to improve outcomes in the most adversely affected groups.(10) Analytic methods are as important in measuring trends in disparities as the quality of the underlying data because different methods may lead to different conclusions.(11) For childhood asthma, a consideration that could influence interpretation of asthma outcome disparities is asthma prevalence differences between race/ethnic groups. Asthma outcome rates calculated using the entire population of children in a race/ethnic group as the denominator--population based rates (PBRs)--provide an overall measure of asthma impact for each group. However, because asthma prevalence varies between race/ethnic groups, PBRs may not provide specific information about the risks of poor outcomes for those with asthma in each group. Use of at-risk outcome rates (ARRs), which measure outcomes among those with asthma, removes the contribution of underlying prevalence differences between groups from the outcome rates. Limiting the denominator to only the group at risk for adverse asthma outcomes also acknowledges the nature of interventions to address asthma. There is no unified understanding of the factors driving the continued rise in asthma prevalence, and no widely accepted primary prevention interventions for asthma, but there are evidence-based interventions to control asthma once it develops. These secondary and tertiary prevention measures are directed toward reducing adverse outcomes among persons who have asthma. Therefore, analyzing ARRs in addition to PBRs may offer additional insight into racial disparities in asthma outcomes. We analyzed recent trends in asthma prevalence and outcomes among children by race (black and white) in national data sets from the National Center for Health Statistics (NCHS). We compared trends in disparities calculated using PBRs of asthma outcomes to those using ARRs.

METHODS

Nationally representative data from the National Center for Health Statistics (NCHS) were used to calculate estimates of asthma prevalence and outcomes (asthma attack prevalence, health care use, and mortality) among children aged 0-17 years. Trends were assessed from 2001, the year in which the measure of current asthma prevalence was first used in the National Health Interview Survey (NHIS), to 2010, the most recent year of available data from all the included NCHS data sets. Race groups included in the study were limited to black and white race (single race without regard to ethnicity) because sample sizes do not always permit analysis for other race groups, and because Hispanic origin is not available across all the included data sets.

Asthma prevalence

Current asthma prevalence data were obtained from the NHIS, a face-to-face household interview of respondents included in a multistage, clustered sample of the noninstitutionalized civilian US population.(12) In each sampled household, a randomly chosen sample adult responded, and if children were present, a responsible adult served as a proxy respondent for a randomly chosen sample child. Current asthma prevalence estimates are based on affirmative responses to two questions, “Has a doctor or other health professional ever told you that your child had asthma?” and “Does your child still have asthma?”

Weighted estimates of the number of children with asthma from the 2001-2010 NHIS were used as denominators for asthma outcome ARRs. Records with missing responses for asthma status (range 0.2-0.4%, depending on the year) were excluded. Because there may be unreported asthma among the missing responses, the number of children with asthma may be underestimated.

Sociodemographic data were also collected by respondent report. Missing responses for race (<1% in each survey year) were imputed by NCHS to one of the Office of Management and Budget (OMB) race groups by the hot-deck method which uses the race of other family household members if known, or race of members of other households within a small geographic area. Beginning in 2003, a response of “other race” was treated as missing and imputed if it was the only race response. If “other race” was mentioned along with one or more OMB race groups, the “other race” response was dropped and the OMB race group was used.(12)

Asthma Outcomes

Asthma attack prevalence—Asthma attack prevalence is a crude measure of asthma symptom control. Estimates of the percentage of children with at least one asthma attack in the past 12 months were based on the proportion of the sample with affirmative responses to both of two questions in the NHIS: “Has a doctor ever told you that your child had asthma?” and “During the past 12 months, has your child had an episode of asthma or an asthma attack?”

Asthma ED visits—Asthma ED visits are considered an adverse outcome that represents exacerbations not responsive to outpatient treatment. The National Hospital Ambulatory Medical Care Survey (NHAMCS) comprises a national probability sample of ED visits to non-federal, noninstitutional short stay hospitals. Hospitals were selected using a multi-stage probability sampling design, the final stage of which involved sampling visits during a specified 4-week period. Data were abstracted from medical records.(13) Asthma visits were identified using the first-listed physician diagnosis with ICD9-CM code 493. Race was missing for 10% to 15% of records from 2001 to 2010 and was imputed by NCHS using a hot deck method through 2008, and a model-based single, sequential regression method beginning in 2009.(14) We performed a sensitivity analysis excluding records with imputed values (see Online Repository). In contrast to other outcomes rates which are presented as annual rates, rates for asthma ED visits were calculated as two-year annual averages to obtain more reliable estimates.

Asthma hospitalizations—An asthma hospitalization represents a severe adverse outcome, is theoretically preventable with effective asthma management, and is a risk factor for future exacerbations. The National Hospital Discharge Survey (NHDS) includes a multi-stage probably sample of discharges from non-federal, noninstitutional short stay hospitals. Asthma hospitalizations were identified using the first-listed physician diagnosis ICD9-CM code 493. For each year, between 16% to 31% of discharges were missing race.(15) NCHS does not impute missing values for race in the hospital data and therefore, records with missing values for race were excluded. A sensitivity analysis was performed in which records with unknown race were added to those of white race to obtain the most conservative (smallest) estimate of racial disparities (see Online Repository).(16)

Asthma deaths—Asthma deaths are rare among children but remain a major target of preventive interventions given the high cost of years of healthy life lost. The National Vital Statistics System (NVSS) obtains a complete count of deaths from resident death certificates from the 50 States and the District of Columbia. Asthma deaths were identified using underlying cause of death ICD-10 codes J45 and J46. Race information on the death certificate is reported by a funeral director as provided by an informant or in the absence of an informant, on the basis of observation. Beginning in 2003, records for which more than one race is reported were bridged to one of the five single-race OMB categories. For records in which race is recorded as “other race,” “not stated,” “not classifiable,” or “unknown” (<1% per year), the race of the previous record is assigned.(17)

Outcome rates

Estimated numbers of persons (asthma attack prevalence) or events (ED visits from NHAMCS, and hospitalizations from NHDS) were obtained by applying survey weights to each record to obtain nationally representative estimates. Counts from NVSS already represent a complete count of deaths and therefore required no weighting. PBRs were calculated by dividing the number of events by US population estimates obtained from the US Census for children 0-17 years for the specified race group, except for asthma attack prevalence estimates which were based on NHIS survey weights. For ED visit rates and hospitalizations, PBRs were calculated using the US civilian population. For asthma deaths,

PBRs were calculated using the US resident population. We calculated ARRs by dividing the number of persons or events by the estimated number of children with current asthma obtained from NHIS.

Standard errors

For estimates obtained from surveys with complex sampling designs (NHIS, NHAMCS, and NHDS), SUDAAN software was used to calculate the standard error to account for the clustered sampling. For mortality data that are based on complete counts (NVSS), standard errors were calculated assuming a Poisson distribution where the standard error of the number of deaths is equal to the square root of the number of deaths.(17)

For PBRs, the standard error of the numerator was used to calculate the standard error of the rate. That is, we assumed there was no sampling error associated with US Census population estimates. For ARR standard errors, the standard error of both the numerator and denominator were taken into account using the formula for the standard error of a ratio.

Trends

Joinpoint software (National Cancer Institute)(18) was used to estimate the average annual percent change (APC) with weighted log-linear regression for the 2001-2010 trend for each race group and to determine if there was a change in trend for any of the analyzed series. If no change in trend was identified, Joinpoint fit a straight line based on a simple log-linear model over the entire period. A straight line was in fact the optimal model identified by Joinpoint in all cases except for the hospitalization PBR, where a change in trend was identified at 2003. However, for simplicity, the straight-line model was presented in this case because the overall average annual percent change based on a single estimated slope over the entire period is still a valid calculation.(19) To determine if the trend for each race group was significantly different than zero, we used the Joinpoint confidence interval calculation of the APC, which is based on a t-distribution.(19)

Disparities

We estimated whether trends in PBRs and ARRs for each race group were converging, diverging or not changing to assess whether disparities were changing over the observed period. We used the Joinpoint comparability test which determines whether two trends are identical (coincident), parallel, or nonparallel (diverging or converging) based on the regression line for the trend for each race. No pairs of trends were coincident. For those pairs of trends that were parallel, we report the APC for each trend as well as the combined APC. For those pairs of trends that were not parallel, we report the APC for each trend and note that the difference is statistically significant (i.e., that the black/white disparity has changed over time).(20;21) As a sensitivity analysis, we also used the criteria outlined in the Agency for Healthcare Research and Quality (AHRQ) 2012 National Healthcare Disparities Report(22)which identify a change in disparity if: (1) a difference in the annual rate of change between two groups is greater than 1 percentage point (or less than −1 percentage point) and (2) while the AHRQ use a p-value <0.10 for the z-statistic comparing the annual rate of change between the two groups, we chose a p-value of <0.05 to maintain the same significance criteria throughout our analyses. We used HD*Calc to generate estimates of

black/white rate ratios for PBRs and ARRs in 2010 to present the magnitude of disparity at the end of the period.(23) HD*Calc uses the standard errors associated with the underlying rates to estimate 95% confidence intervals of rate ratios.

RESULTS

In 2001, an estimated 4.4 million white children had asthma, and in 2010, there was no statistically significant change in that estimate (4.5 million). In 2001, an estimated 1.2 million black children had asthma, and in 2010, an estimated 1.7 million were affected. From 2001 to 2010 (Figure 1), the difference in current asthma prevalence rates between black and white children increased (p-value<0.01). Among white children, the APC in the percent with current asthma from 2001 to 2010 was not statistically different from zero, indicating no trend over the period in current asthma prevalence (asthma prevalence during the period ranged between 7.4% and 8.2%). In contrast, current asthma prevalence among black children increased by an average of 3.6% per year from 2001 to 2010 (range 11.4% to 16.8%). The black/white rate ratio of asthma prevalence increased from 1.4 in 2001 to 2.0 from 2007 onward. The increased racial disparity in asthma prevalence among children impacts interpretation of disparities in outcome rates, as subsequent analyses show.

Figure 2 shows asthma attack prevalence PBRs and ARRs from 2001 to 2010 (see also Table I). The PBR is higher for black children than white children and did not change significantly for either black or white children from 2001 to 2010. There was also no change in the disparity between black and white children in PBR asthma attack prevalence over the period. In contrast, the ARR for asthma attack prevalence was initially similar for white and black children, and then declined significantly for both black and white children. Because the ARR declined more rapidly among black children (−2.3% per year) than among white children (−1.2% per year), white children had higher rates compared to black children at the end of the period and the disparity increased significantly.

For both PBR and ARR rates, black children had higher rates of ED visits compared to white children (Figure 3, Table I). Over the period, there were no significant changes in ED visit PBR trends for black or white children, and there was no change in the black/white disparity. In contrast, the ARR for asthma ED visits decreased significantly among black children, and the black/white disparity in ED asthma visit ARRs also decreased. When we performed a sensitivity analysis excluding records with imputed race, the results were similar with one exception. While there was a significant decline in the black/white disparity in ED visits ARRs in the main analysis, there was no significant change detected by the sensitivity analysis using the Joinpoint analysis. However, when AHRQ criteria were applied, the decline in the black/white disparity in ARRs was significant (see Online Repository for more detailed results).

Rates of hospitalization decreased among black and white children from 2001 to 2010 for both PBRs and ARRs (Figure 4, Table I)). There was no statistically significant change in disparity between black and white PBRs. In contrast, the black/white disparity in hospitalization ARRs decreased. In a sensitivity analysis, we estimated the most conservative (smallest) black/white disparity by assigning records with unknown race to the

"white" category. The results were the same: all trends were in the same direction with the same statistical significance, and the same patterns in disparity trends were observed (see Online Repository).

For asthma deaths, PBRs did not change significantly for either black (insignificant increase) or white children (insignificant decrease). However, the trend for the racial disparity in PBRs increased significantly (Figure 5, Table I). In contrast, the ARR declined for both groups, by 3.4% per year for white children and by 3.6% per year for black children, but there was no change in racial disparity in ARR for asthma deaths over the period.

We used the AHRQ criteria to assess changing disparities over time as a sensitivity analysis. The results were the same as those presented above with the one exception already noted for the sensitivity analysis for unknown race for ED visits (see Online Repository).

The magnitude of disparities in 2010 in asthma outcomes are shown in Figure 6 as black/white rate ratios for PBRs and ARRs. For all 4 outcomes, the rate ratios for ARRs are lower than those for PBRs, although the 95% confidence intervals generally overlap. Among the general population, black children were 1.7 times more likely (95% CI 1.4, 2.1) to have ≥1 asthma attack in the past 12 months compared to white children. In comparison, the rate ratio for ARRs was 0.9 (95% CI 0.7, 1.2) showing a similar likelihood for black and white children with asthma to have ≥1 asthma attack. For asthma ED visits, the black/white rate ratio for PBRs was 4.9 (95% CI 2.9, 8.2) versus 2.6 (95% CI 1.5, 4.4) for ARRs. For asthma hospitalizations, the rate ratios were 3.3 (95% CI 1.2, 8.9) for PBRs versus 1.7 (95% CI 0.6, 4.7) for ARRs. The magnitude of disparities remains highest for asthma deaths: comparing the PBRs, black children were 7.1 times more likely to die from asthma than white children (5.2, 9.7) and when comparing the ARRs, black children were 4.1 more likely to die compared to white children (95% CI, 2.9, 5.8).

DISCUSSION

Different pictures of trends in racial disparities in childhood asthma are presented by PBRs, which reflect the general burden of a condition in a population group, and ARRs, which show the impact only among those at risk for the outcomes (Table II). The racial disparity in asthma prevalence increased in the early 2000s, and there are few broad, effective interventions to prevent asthma from developing. Although new research is identifying diverse areas to design primary prevention efforts,(24) and the Federal Action Plan to Reduce Racial and Ethnic Asthma Disparities included as one of the four main strategies: "accelerate efforts to identify and test interventions that may prevent the onset of asthma among ethnic and racial and minority children,"(10) most existing asthma prevention interventions are designed to decrease severity and improve control among those with asthma. Examination of ARRs may provide a more specific perspective of group differences in the effectiveness of those interventions than do PBRs. When racial differences in asthma prevalence are accounted for with ARRs, the racial disparities picture appears more favorable although disparities remain in 2010 for asthma ED visits and deaths regardless.

The one area where white children with asthma fared worse than black children was controlling symptoms, with ARRs showing a greater proportion of white children with ≥1 asthma attack in the past 12 months and a widening disparity over time. This pattern does not translate into greater rates of severe outcomes among white children, and it could be related to the observation in previous studies that among children with asthma, white children have higher outpatient visit rates.(1) During these encounters, milder symptoms might be recognized and treated before escalating into exacerbations requiring emergency care. Similarly, children in minority ethnic groups, low socioeconomic groups, and with greater disease severity have been shown to have lower accuracy in asthma symptom perception compared to referent groups.(25;26)

While ARRs account for different asthma prevalence between black and white children, they do not necessarily account for differences in asthma severity. Though we were unable to assess severity in this analysis, there is reason to believe that severity may differ by race. In addition to higher rates of poor asthma management among minority groups (e.g., underuse of preventive asthma medications),(27-31) past research suggests that black children on average have more severe underlying disease,(31;32) including a study of children of middle-class socioeconomic status.(33) Another study found that among children hospitalized for asthma, black children were in more severe condition, even after controlling for other demographic differences.(34) Furthermore, differential response to preventive asthma medications by race group has also been reported, including decreased responsiveness to glucocorticoids among black patients with asthma.(35;36)

This analysis has additional limitations. Asthma prevalence is based on proxy report of a history of an asthma diagnosis and if a child still has asthma. Although the questions are based on surveillance recommendations from the Council of State and Territorial Epidemiologists,(37) the performance of the questions has not been validated against medical records, and recall bias for a history of diagnosis may vary over the age range 0-17 years. Some asthma outcomes, particularly healthcare utilization measures, are dependent on factors other than need for care, including access to care, characteristics of the health delivery and financing systems, and perceived need. It is not clear from the available data how changes in any of these factors may have contributed to the patterns observed in this analysis. Race has a high rate of missingness in the NHAMCS and NHDS. Missing race was singly imputed for the NHAMCS by NCHS. Although these imputations are based on extensive methodological work, single imputation may underestimate variance compared to multiple imputation methods. No missing race values were imputed for the NHDS. An analysis of 1994 data concluded that hospitalizations with missing race were most likely to be for white patients.(16) If this pattern still holds, the disparities reported here may be overestimated. However, because no analysis of patterns by diagnosis was done, it is unknown whether underreporting of race varies by diagnosis. We performed a sensitivity analysis assessing the most conservative assumption that all hospitalizations with unknown race were for white children. The overall conclusions did not change. Finally, data on Hispanic ethnicity is either not available in the data sources used or has high rates of missing. Examining disparities by Hispanic ethnicity is important: asthma prevalence varies widely between Hispanic subgroups with Puerto Rican children having among the highest rates of asthma prevalence and Mexican children among the lowest.(4) While health surveys

oversample Hispanic populations to obtain estimates on reported health outcomes, in healthcare utilization data sets, information on Hispanic ethnicity is missing to an even greater extent than race. Furthermore, although ethnicity has been imputed for emergency department visit data from 2003 onward, information is not available for Hispanic subgroups. Finally, mortality data is available by Hispanic subgroup, but the number of asthma deaths in these subgroups is generally too low among children to yield reliable estimates of annual death rates.

This analysis demonstrates the impact of racial differences in asthma prevalence on measured disparities in asthma outcomes. It is encouraging that asthma ED visit and hospitalization disparities based on ARRs have decreased, and that disparities in asthma deaths have not increased. These improved racial disparity results were observed during a period of decreasing adverse outcome rates for both black and white children with asthma. Nonetheless, concerns remain. Prevalence continued to increase among black children, and even after accounting for this factor, racial disparities remain in asthma ED visit and death rates.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Abbreviations

APC	average annual percent change
AHRQ	Agency for Healthcare Research and Quality
ARR	at risk rate
ED	emergency department
OMB	Office of Management and Budget
NCHS	National Center for Health Statistics
NHAMCS	National Hospital Ambulatory Medical Care Survey
NHDS	National Hospital Discharge Survey
NHIS	National Health Interview Survey
NVSS	National Vital Statistics System
PBR	population-based rate

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Key Messages

- Asthma prevalence increased among black but not white children since 2001
- Accounting for prevalence differences with at-risk rates reveals different patterns in disparity trends
- Population-based rates show stable or increasing asthma outcome disparities
- At-risk rates show stable or decreasing disparities

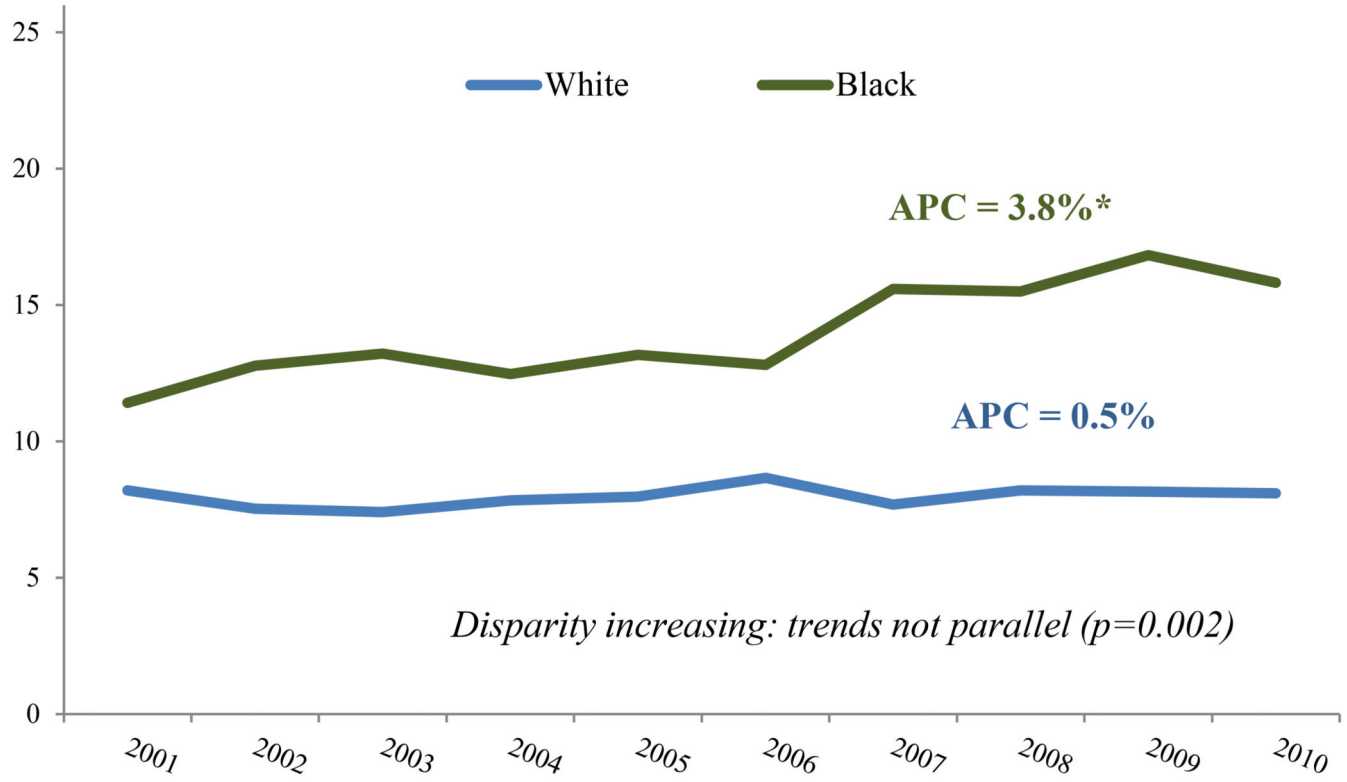

Figure 1.

Current asthma prevalence and average annual percent change (APC) among children ages 0-17 years

Source: National Health Interview Survey, CDC/NCHS

*Average annual percentage change is significantly different than zero

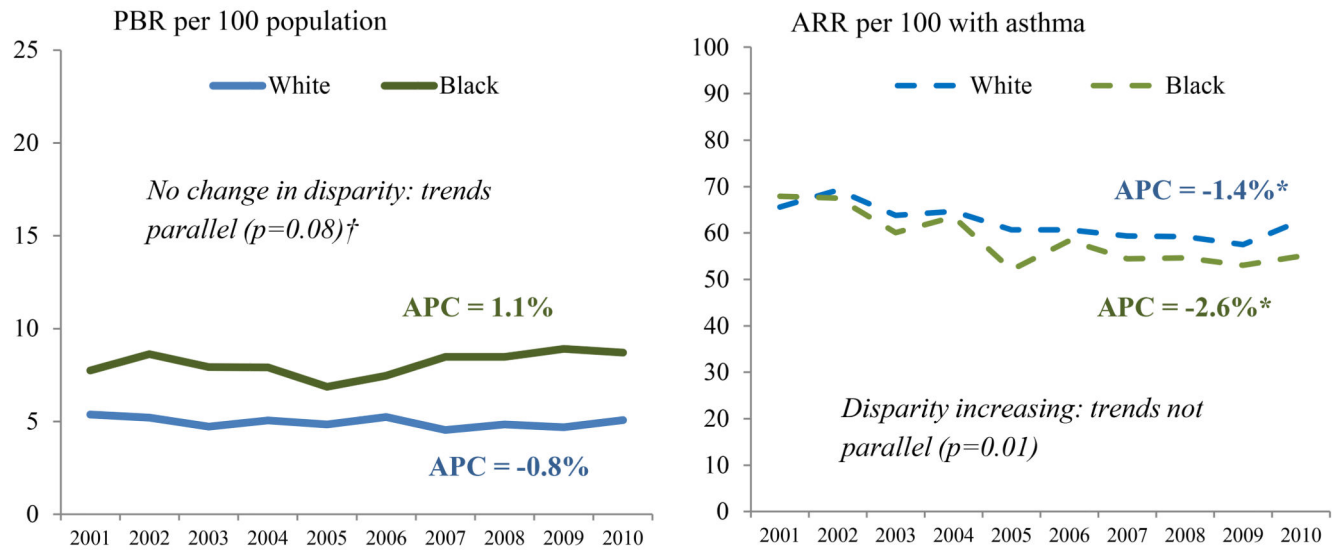

Figure 2.

Population-based rates and at risk rates for asthma attack prevalence, and average annual percent change (APC) among children 0-17 years

Source: National Health Interview Survey

*Annual percentage change is significantly different than zero

† The combined APC for black and white children was 1.0%

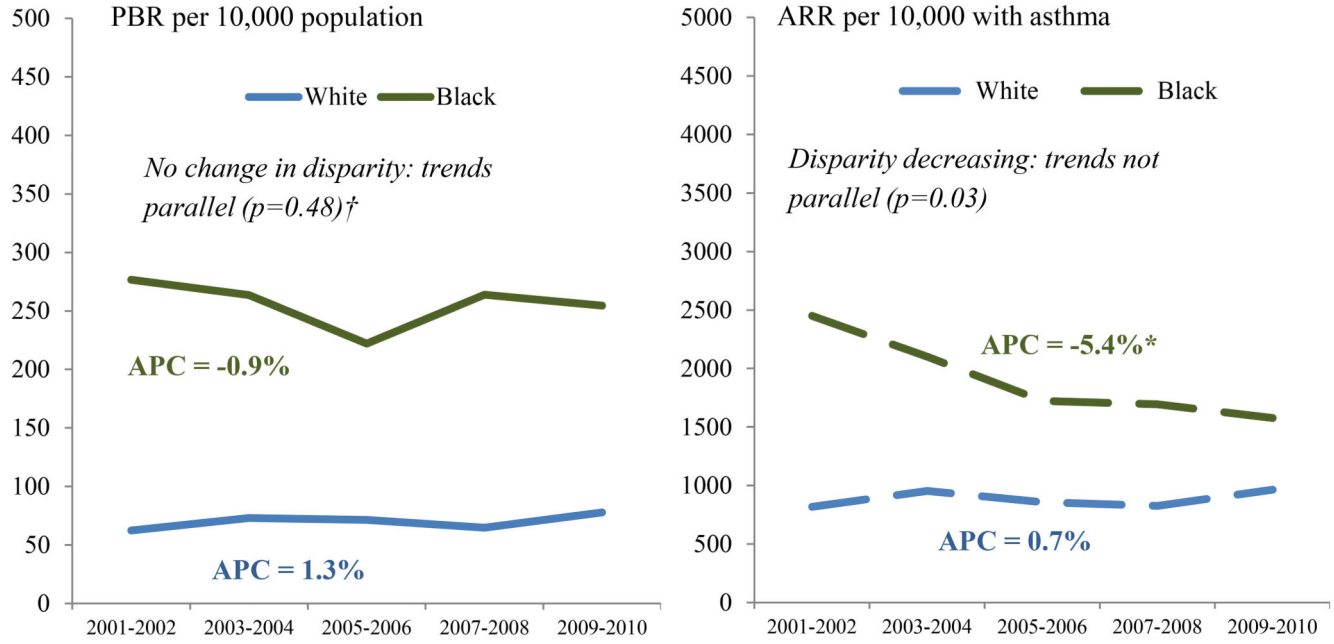

Figure 3.

Population-based rates and at risk rates for asthma emergency department visits, and average annual percent change (APC) among children 0-17 years

Source: National Hospital Ambulatory Medical Care Survey

† The combined APC for black and white children was 0.3%

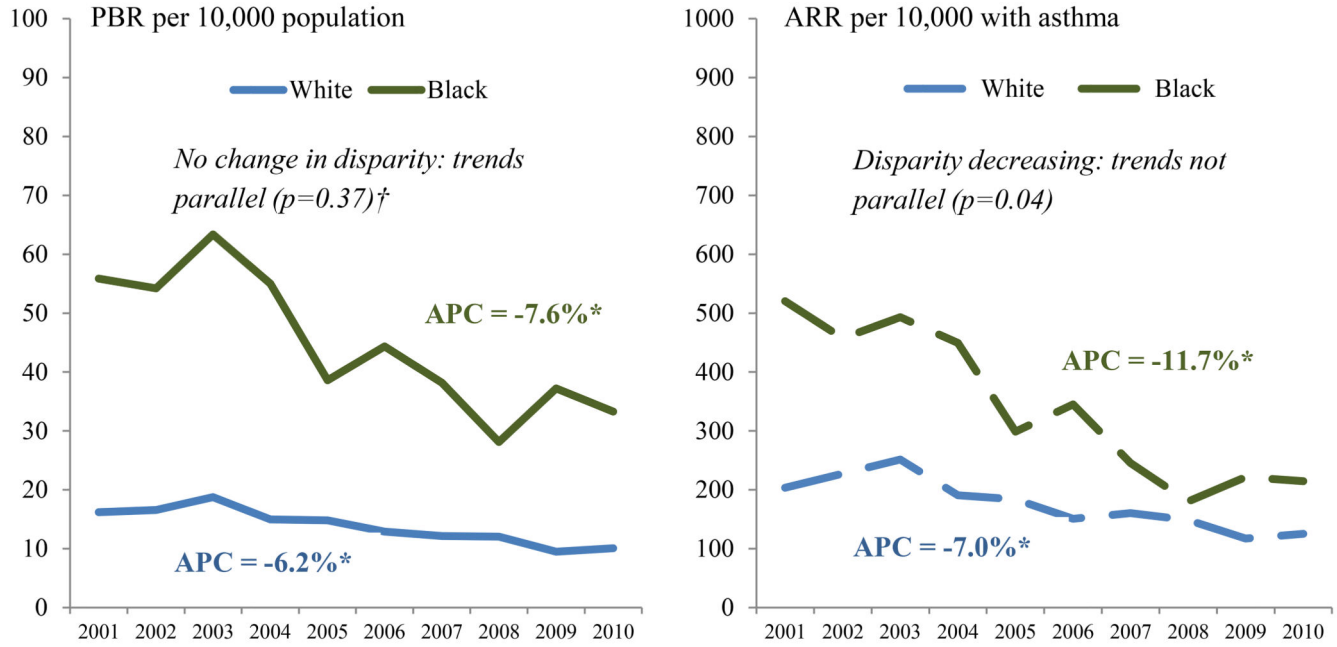

Figure 4.

Population-based rates and at risk rates for asthma hospitalizations, and average annual percent change (APC) among children 0-17 years

Source: National Hospital Discharge Survey

*Annual percentage change is significantly different than zero

† The combined APC for black and white children was 6.8%

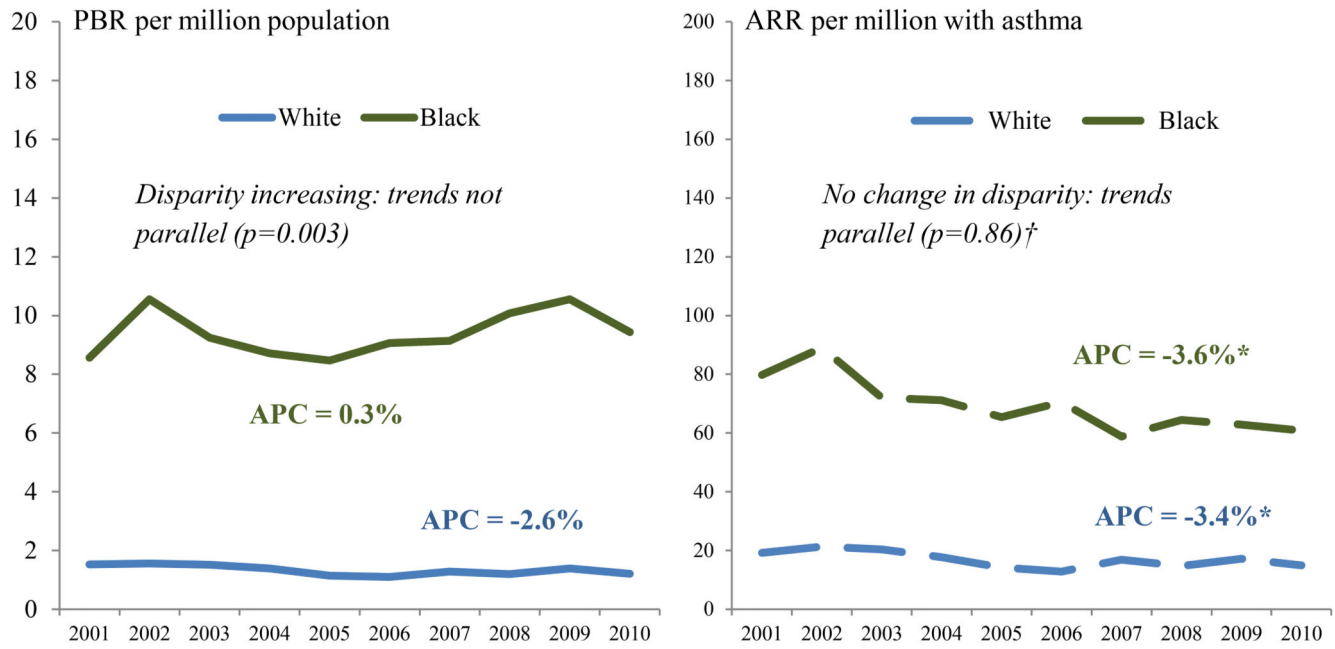

Figure 5.

Population-based rates and at risk rates for asthma deaths, and average annual percent change (APC) among children 0-17 years

Source: National Vital Statistics System

*Annual percentage change is significantly different than zero

† The combined APC for black and white children was −3.5%

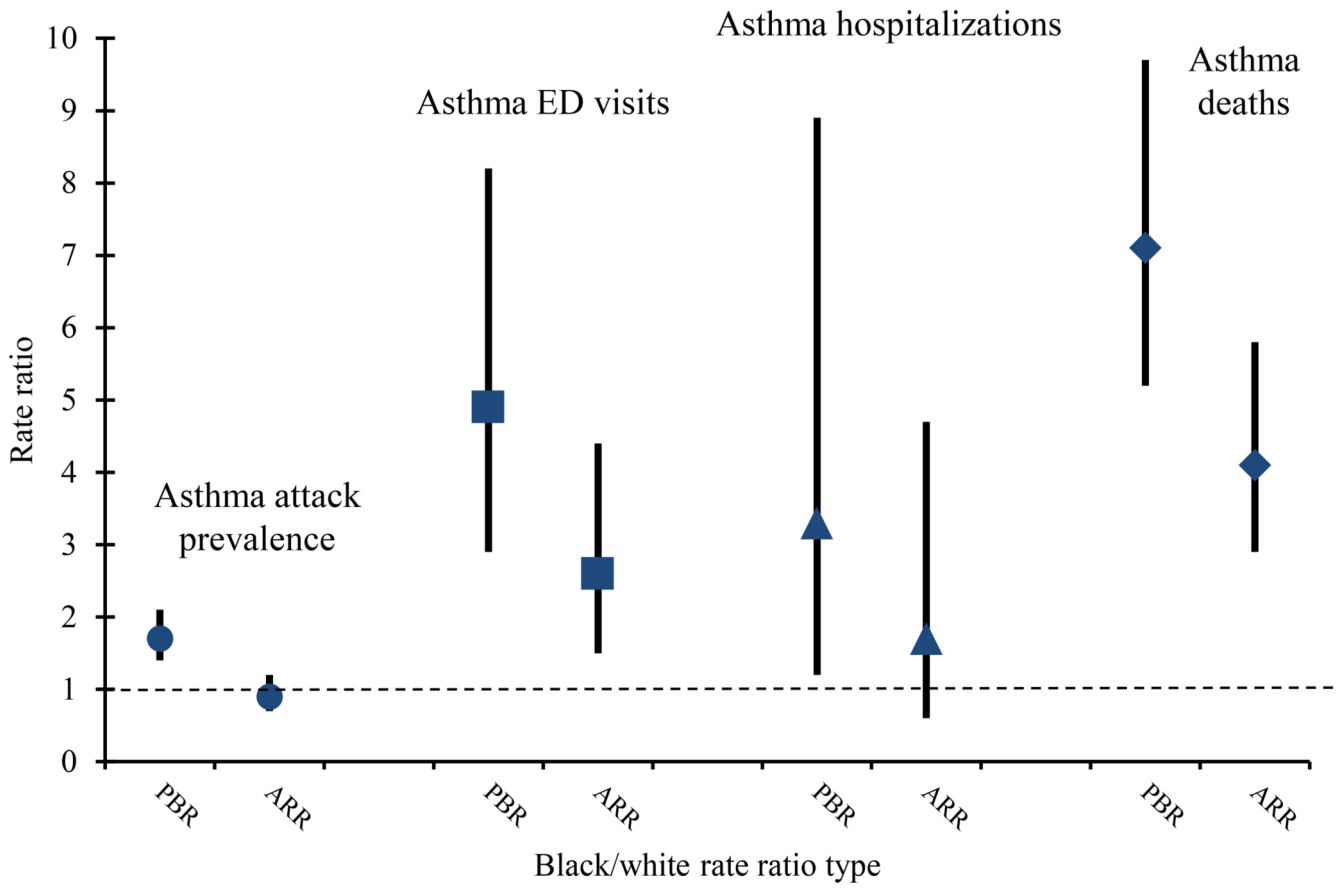

Figure 6.

Black/white rate ratios for population-based rates (PBR) and at-risk rates (ARR) of asthma outcomes among children 0-17 years, 2010

Source: National Health Interview Survey, National Hospital Ambulatory Medical Care Survey, National Hospital Discharge Survey, National Vital Statistics System

Note: The dotted line at the value of 1.0 denotes no black/white disparity in outcome rate

Table I

Number, population-based rate, at-risk rate and for asthma outcomes among children 0-17 years, 2001 and 2010

	Asthma attack prevalence		ED visits*		Hospitalization		Deaths	
	2001	**2010**	**2001-2002**	**2009-2010**	**2001**	**2010**	**2001**	**2010**
Number								
Black	826,000	958,800	313,900	286,600	63,200	37,400	97	106
White	2,902,000	2,848,300	348,300	438,200	90,200	56,900	85	68
Population-based rate								
	Per 100 (SE)		Per 10,000 (SE)		Per 10,000 (SE)		Per million (SE)	
Black	7.7 (0.7)	8.7 (0.8)	276.7 (38.0)	254.4 (38.4)	55.8 (12.5)	33.3 (12.9)	8.2 (0.8)	8.6 (0.8)
White	5.4 (0.3)	5.1 (0.3)	62.5 (9.3)	77.9 (9.6)	16.2 (2.8)	10.1 (3.4)	1.5 (0.2)	1.2 (0.2)
At-risk rates								
	Per 100 (SE)		Per 10,000 (SE)		Per 10,000 (SE)		Per million (SE)	
Black	67.9 (8.8)	55.1 (6.6)	2449.1 (266.4)	1576.7 (254.7)	520.0 (124.5)	214.7 (84.5)	79.8 (10.6)	60.9 (7.3)
White	65.6 (4.7)	62.7 (5.0)	819.4 (124.9)	964.5 (123.5)	203.9 (36.1)	125.1 (41.9)	19.2 (2.3)	15.0 (2.0)

Note: All numbers except those for deaths are rounded to the nearest hundred; SE=standard error

*Average annual rates for 2001-2002 and 2009-2010

Table II

Summary of disparity trends

	Population-based rates	At-risk rates
Asthma attack prevalence	No change in disparity	↑ W/B disparity (i.e., higher rates among white children)
ED visits	No change in disparity	↓ B/W disparity
Hospitalizations	No change in disparity	↓ B/W disparity
Deaths	↑ B/W disparity	No change in disparity