Respiratory Diseases

Respiratory diseases and illness, such as asthma, bronchitis, pneumonia, allergic rhinitis, and sinusitis, can greatly impair a child's ability to function and are an important cause of missed school days and limitations of activities. Symptoms associated with both mild and more severe manifestations of these respiratory conditions, such as cough, wheeze, congestion, chest pain, shortness of breath, respiratory distress, and death in the most extreme cases, are responsible for substantial morbidity and a large cost burden to families and society.

Outdoor and indoor air pollution can adversely affect children's respiratory health.[1-7] Studies have shown that air pollution can exacerbate existing respiratory conditions such as asthma and upper airway allergies.[1,8-10] Increasing evidence suggests that exposure to certain air pollutants may contribute to the onset of asthma in children, although studies relating to the exacerbation of pre-existing asthma are more prevalent because they are easier to conduct.[11-13] Air pollution also increases a child's risk of developing respiratory infections, most likely by causing inflammation and/or impaired immune response.[14-16]

EPA sets health-based National Ambient Air Quality Standards for six air pollutants.[17] These pollutants, referred to as criteria air pollutants, are particulate matter (PM), ground-level ozone, nitrogen oxides, sulfur oxides, carbon monoxide (CO), and lead. Four of these pollutants have extensive evidence linking them to respiratory diseases in children (PM, ground-level ozone, nitrogen oxides, and sulfur oxides). The evidence for respiratory effects is weaker for CO, and lead has not been linked to adverse respiratory outcomes.

PM is associated with significant respiratory problems in children, including aggravated asthma; exacerbation of allergic symptoms; reduced growth of lung function; and increased hospital admissions, emergency room visits, and doctor visits for respiratory diseases, especially in children with lung diseases such as asthma.[6] Particulate air pollution has also been associated with respiratory-related infant mortality, even at relatively low PM levels that are commonly experienced in the United States.[18,19]

Short-term exposure to ground-level ozone can cause a variety of respiratory health effects, including airway inflammation; reduced lung function; increased susceptibility to respiratory infection; and respiratory symptoms such as cough, wheezing, chest pain, and shortness of breath.[3,20,21] Ozone exposure can decrease the capacity to perform exercise and has been associated with the aggravation of respiratory illnesses such as asthma and bronchitis, leading to increased use of medication, absences from school, doctor and emergency department visits, and hospital admissions.[3] Studies have also found that long-term ozone exposure may contribute to the development of asthma, especially among children with certain genetic susceptibilities and children who frequently exercise outdoors.[22-24]

Nitrogen dioxide (NO_2) is an odorless gas that can irritate the eyes, nose, and throat, and can cause shortness of breath. EPA has concluded that exposure to NO_2 can lead to increased

respiratory illnesses and symptoms, more severe asthma symptoms, and an increase in the number of emergency department visits and hospital admissions for respiratory causes, especially asthma.[4]

Short-term exposures of persons with asthma to elevated levels of sulfur dioxide (SO_2) while exercising at a moderate level may result in breathing difficulties, accompanied by symptoms such as wheezing, chest tightness, or shortness of breath. Studies also provide consistent evidence of an association between short-term SO_2 exposure and increased respiratory symptoms in children, especially those with asthma or chronic respiratory symptoms. Short-term exposures to SO_2 have also been associated with respiratory-related emergency department visits and hospital admissions, particularly for children.[5]

Exposure to CO reduces the capacity of the blood to carry oxygen, thereby decreasing the supply of oxygen to tissues and organs such as the heart. Research suggests correlations between CO exposure and the exacerbation of asthma; however, CO levels are highly correlated with other combustion-related pollutants, especially in locations near roads. Few analyses clearly distinguish the contributions of CO from those of the larger traffic-related air pollutant mixture, thus it is uncertain whether the observed health effects are truly attributable to CO or whether they are due to other co-occurring air pollutants.[7,10,25]

In addition to the criteria air pollutants, EPA regulates 187 hazardous air pollutants (HAPs) that are known or suspected to cause serious health effects or adverse environmental effects. For many of these pollutants, information on health effects is scarce. HAPs that may be of particular concern for the induction and exacerbation of asthma include acrolein, formaldehyde, nickel, and chromium.[26] Acrolein has been identified as a HAP of particular concern for possible respiratory effects at levels commonly found in outdoor air in the United States.[27-29] Acrolein can cause respiratory irritation in individuals who do not have asthma.[30]

Pollution from traffic-related sources, a mix of criteria air pollutants and HAPs, appears to pose particular threats to a child's respiratory system. Many studies have found a correlation between proximity to traffic (or to traffic-related pollutants) and occurrence of new asthma cases or exacerbation of existing asthma and other respiratory symptoms, including reduced growth of lung function during childhood.[11-13,31-36] A report by the Health Effects Institute concluded that living close to busy roads appears to be an independent risk factor for the onset of childhood asthma. The same report also concluded that the evidence was "sufficient" to infer a causal association between exposure to traffic-related pollution and exacerbations of asthma in children.[37] Some studies have suggested that traffic-related pollutants may contribute to the development of allergic disease, either by affecting the immune response directly or by increasing the concentration or biological activity of the allergens themselves.[38-40]

Children can also be exposed to air pollution inside homes, schools, and other buildings. Indoor air pollutants from biological sources such as mold; dust mites; pet dander (skin flakes); and droppings and body parts from cockroaches, rodents, and other pests or insects, can lead to allergic reactions, exacerbate existing asthma, and have been associated with the development

of respiratory symptoms.[1,41,42] Furthermore, the Institute of Medicine concluded that exposure to dust mites can cause asthma in susceptible children, and exposure to cockroaches may cause asthma in young children.[1]

PM and NO_2, discussed previously as outdoor air pollutants, also pollute indoor air when they are emitted from gas stoves, gas or oil furnaces, fireplaces, wood stoves, and kerosene or gas space heaters. Indoor concentrations of these combustion byproducts can reach very high levels in developing countries where solid fuels are used extensively for cooking and home heating, but may also affect the respiratory health of children in developed countries, especially during the winter when use of fireplaces and space heaters is more common.[43] Environmental tobacco smoke (ETS), also known as secondhand smoke, is an air pollutant mixture that includes particles and NO_2 as well as thousands of other chemicals. The Surgeon General has concluded that exposure to ETS causes sudden infant death syndrome (SIDS), acute lower respiratory infection, ear problems, and more severe asthma in children. Smoking by parents causes respiratory symptoms and slows lung growth in their children.[2]

A number of air pollutants emitted indoors by a variety of household items such as building materials and home furnishings, recently dry-cleaned clothes, cleaning supplies, and room deodorizers, have been associated with respiratory symptoms and may play a role in the exacerbation or development of childhood asthma.[44,45] A recent systematic review of seven studies concluded that there is a significant association between exposure to formaldehyde—a chemical released from particle board, insulation, carpet, and furniture—and self-reported or diagnosed asthma in children.[46]

Air pollutants can enter the bloodstream of pregnant women and cross the placenta to reach the developing fetus; thus the period of fetal development may be a window of special vulnerability for respiratory effects of some air pollutants. Studies indicate that prenatal exposure to ETS may increase the risk of developing asthma during childhood and/or lead to impaired lung function, especially among children with asthma.[2,47-50] Studies have also found that prenatal exposure to polycyclic aromatic hydrocarbons (hazardous air pollutants found in diesel exhaust, ETS, and smoke from burning organic materials) is associated with childhood respiratory illnesses and the development of asthma, particularly when in combination with prenatal or postnatal exposure to ETS.[51-53] Limited studies of prenatal exposure to criteria air pollutants have found that exposure to PM, CO, and oxides of nitrogen and sulfur may increase the risk of developing asthma as well as worsen respiratory outcomes among those children who do develop asthma.[11,54,55] However, it is difficult to distinguish the effects of prenatal and early childhood exposure because exposure to air pollutants is often very similar during both periods.

Asthma

Asthma is a chronic inflammatory disease of the airways. When children with asthma are exposed to an asthma trigger, the airway walls become inflamed and secrete more mucus, and the muscles around the airways tighten. This exaggerates the normal airway constriction that occurs on exhalation, trapping air in the lungs and compromising normal oxygen exchange.

These physiological changes can result in wheezing, coughing, difficulty in breathing, chest tightness, and pain.

Asthma is one of the most common chronic diseases among children: in the year 2009, it affected 7.1 million (or about 10% of) children in the United States.[56] It is costly in both human and monetary terms: estimated national costs of asthma in 2007 were $56 billion.[57] The percentage of children with asthma increased substantially from 1980–1996 and remains high.[58] Researchers do not completely understand why children develop asthma or why the prevalence has increased.

Asthma is a complex disease with many factors, including genetic factors and environmental factors, that interact to influence its development and severity. The percentage of children reported to have current asthma differs by age, family history of asthma and allergies, racial and ethnic group, and family income. Children of color and children of lower-income families are more likely to be diagnosed with asthma. Because minority populations are more likely to be of low socioeconomic status, it is difficult to establish whether racial/ethnic group is an independent risk factor for the development of asthma. While some research has suggested that variations in asthma prevalence among racial groups can be explained by socioeconomic factors,[59,60] another study suggested that the difference persists even after accounting for socioeconomic factors.[61] Other researchers have proposed that the greater prevalence of asthma among Black children can be explained by their disproportionate presence in urban environments.[62]

Children living in poverty are more likely to have poorly maintained housing, which can present risk factors for asthma development and exacerbation. The Institute of Medicine concluded that exposure to dust mites causes asthma in susceptible children, and that cockroaches may cause asthma in young children.[1] Research suggests that lower-income children are more likely to live in homes with high levels of cockroach allergens and homes where someone smokes regularly.[63-66] A nationally representative survey of allergens in U.S. housing reported higher levels of dust mite allergen in bedding from lower-income families.[67] Household mouse allergen was also found at higher concentrations in low-income homes, mobile homes, and older homes.[68] In addition, total dust weight itself has been found to contribute to respiratory symptoms, including asthma and wheeze. Households with lower income, older homes, household pets, a smoker in the house, and less frequent cleaning are more likely to have higher dust weight levels.[69] Furthermore, children living in poverty may also face barriers to medical care, have less access to routine medical care and instructions for asthma management, or may be less likely to use asthma control medications.[70-76] These factors may increase asthma morbidity, as evidenced by increased asthma symptoms among those diagnosed with the disease.

Asthma indicators provide data on the percentage of children who have asthma as well as health outcomes for children with asthma. Indicators H1 and H2 focus on the prevalence of asthma among children. Indicator H1 provides the best nationally representative data available on prevalence of asthma over time among children ages 0 to 17 years. It provides two

measures of asthma prevalence by year, from 1997–2013: current asthma prevalence and asthma attack prevalence. While the former measure reports on the percentage of children who have asthma each year, the latter measure presents data on children who had asthma attacks in the past year, and thus represents outcomes for children with asthma by identifying the proportion of children with ongoing or uncontrolled symptoms. Indicator H2 provides the best nationally representative data available to compare the prevalence of current asthma among children 0 to 17 years by race/ethnicity and family income for the years 2010–2013.[i] Indicators H1 and H2 have been updated since the publication of the *America's Children and the Environment, Third Edition* (January 2013) to include data through 2013 and to use updated census data.

Emergency Room Visits and Hospitalizations for Respiratory Diseases

Children who visit emergency rooms or are hospitalized for respiratory diseases (including asthma and upper and lower respiratory infections such as bronchiolitis and pneumonia) usually represent the most severe cases of respiratory disease. Although only a fraction of children with respiratory diseases are admitted to the hospital, asthma is the third leading cause of hospitalization for children in the United States and bronchiolitis is the leading cause of acute illness and hospitalization in infants.[77,78]

Emergency room visits and hospital admissions for respiratory diseases can be related to a number of factors. These factors include exposure to asthma triggers, lack of access to primary health care, lack of or inadequate insurance, inadequate instructions for asthma management, or inadequate compliance with given instructions.[79-83] Changes in emergency room visits and hospital admissions over time may also reflect changes in medical practices, asthma therapy, and access to and use of care.[84,85]

For children with existing respiratory conditions, exposure to air pollution from indoor and outdoor sources can trigger the onset of symptoms and lead to difficulty in breathing, increased use of medication, school absenteeism, visits to the doctor's office, and respiratory-related hospitalizations and trips to the emergency room.[3-6]

Studies have suggested that exacerbation of asthma from exposure to air pollution can be more severe among people with low income compared with other populations,[86,87] and that the gap between Black and White children in both hospitalizations and deaths from asthma appears to be growing.[88-90] The asthma death rate among Black non-Hispanic children with asthma was 4.9 times higher than the rate for White non-Hispanic children with asthma in 2004–2005.[88] Asthma is the leading cause of emergency room visits, hospitalizations, and missed school days in New York City's poorest neighborhoods.[91] In Maryland, the rate of children's emergency room visits for asthma is twice as high for Baltimore City (an area with a relatively high percentage of lower income and Black children) than for any other jurisdiction.[92]

[i] State-specific asthma information can be found in the CDC report, *The State of Childhood Asthma, United States, 1980–2005*, located at http://www.cdc.gov/nchs/data/ad/ad381.pdf.

Indicator H3 provides the best nationally representative data available on the frequency with which children experienced asthma or respiratory symptoms resulting in an emergency room visit or hospitalization for the years 1996–2010. This indicator highlights the most severe cases of respiratory illness among children ages 0 to 17 years. Indicator H3 includes further information on health outcomes for children with asthma, in addition to the asthma attack prevalence information in Indicator H1, by reporting on trends in children's hospitalizations and emergency room visits due to asthma. Indicator H3 has been updated since the publication of the *America's Children and the Environment, Third Edition* (January 2013) to include data through 2010 and to use updated census data.

Indicator H1: Percentage of children ages 0 to 17 years with asthma, 1997–2013

Indicator H2: Percentage of children ages 0 to 17 years reported to have current asthma, by race/ethnicity and family income, 2010–2013

About the Indicators: Indicators H1 and H2 present the percentage of children ages 0 to 17 years with asthma. The data are from a national survey that collects health information from a representative sample of the population each year. Indicator H1 shows how children's asthma rates have changed over time. Indicator H2 shows how children's asthma rates vary by race/ethnicity and family income level.

National Health Interview Survey

The National Health Interview Survey (NHIS) provides nationally representative data on the prevalence of childhood asthma in the United States each year. NHIS is a large-scale household interview survey of a representative sample of the civilian noninstitutionalized U.S. population, conducted by the National Center for Health Statistics (NCHS). The interviews are conducted in person at the participants' homes. From 1997–2005, interviews were conducted for approximately 12,000–14,000 children annually. From 2006–2008, interviews were conducted for approximately 9,000–10,000 children per year. From 2009-2013, interviews were conducted for approximately 11,000-13,000 children per year.

With a major survey redesign implemented in 1997, the measurement of childhood asthma prevalence in NHIS was changed to reporting the percentage of children ever diagnosed with asthma (lifetime asthma prevalence) and children ever diagnosed with asthma that also had an asthma attack in the previous 12 months (asthma attack prevalence). The data are obtained by asking a parent or other knowledgeable household adult questions regarding the child's health status. NHIS asks "Has a doctor or other health professional ever told you that your child has asthma?" If the answer is YES to this question, NHIS then asks (1) "Does your child still have asthma?" and (2) "during the past 12 months, has your child had an episode of asthma or an asthma attack?" The question "Does your child still have asthma?" was introduced in 2001 and identifies children who were previously diagnosed with asthma and who currently have asthma (current asthma prevalence). Some children may have asthma when they are young and experience fewer symptoms as they get older, or their asthma may be well controlled through medication and by avoiding triggers of asthma attacks. In such cases, children may currently have asthma but may not have experienced any attacks in the previous year.

Data Presented in the Indicators

Indicator H1 presents two different measures of asthma prevalence using data from the NHIS: current asthma and asthma attack prevalence. Indicator H1 provides the annual estimates of asthma prevalence for all children 0 to 17 years of age for the years 1997–2013. Indicator H2 reports on the percentage of children ages 0 to 17 years reported to have current asthma, by

race/ethnicity and family income, in 2010–2013. NHIS is also the source of data for this indicator. The 2010, 2011, 2012 and 2013 data are combined for this indicator in order to increase the statistical reliability of the estimates for each race/ethnicity and income group. Both indicators have been updated since the publication of the *America's Children and the Environment, Third Edition* (January 2013) to include data from 2010-2013.

For Indicator H2, five race/ethnicity groups are presented: White non-Hispanic, Black non-Hispanic, Asian non-Hispanic, Hispanic, and "All Other Races." The "All Others Races" category includes all other races not specified, together with those individuals who report more than one race. The limits of the sample design and sample size often prevent statistically reliable estimates for smaller race/ethnicity groups. The data are also tabulated for three income groups: all incomes, below the poverty level, and greater than or equal to the poverty level. These prevalence data are based on a survey respondent reporting that asthma has been diagnosed by a health care provider. Accuracy of responses and access to health care providers may vary among population groups.[93,94]

In addition to the data shown in Indicator H1, a supplemental table shows data for the percentage of children who had asthma in the past 12 months (asthma period prevalence), for the years 1980–1996. Estimates for asthma period prevalence are not directly comparable to any of the three prevalence estimates collected since 1997 because of changes in the NHIS survey questions. The data table for Indicator H2 shows the prevalence of current asthma for an expanded set of race/ethnicity categories, including Mexican-American and Puerto Rican. A supplemental data table shows the prevalence of current asthma by age and sex for the years 2010-2013.

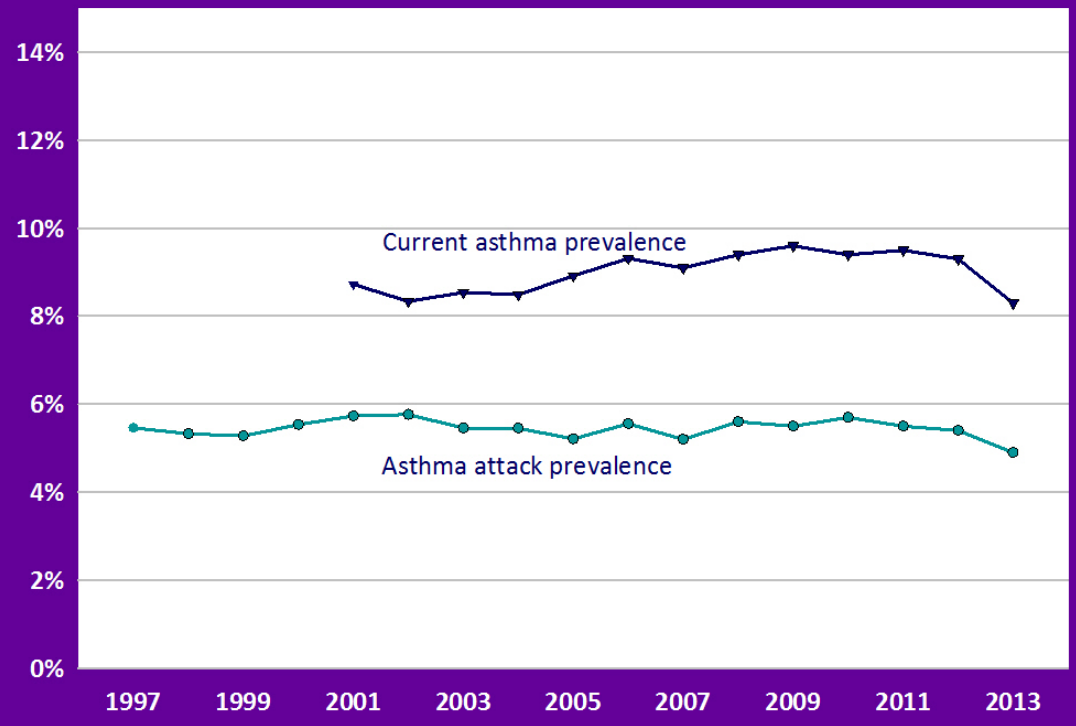
Please see the Introduction to the Health section for discussion of statistical significance testing applied to these indicators.

Other Estimates of Asthma Prevalence

In addition to NHIS, other NCHS surveys provide data on asthma prevalence. A telephone-based survey conducted in 2007 by NCHS along with state and local governments found that 11% of high school students currently had asthma.[95] The 2007 National Survey of Children's Health (NSCH) found that nationwide 9.0% of children ages 0 to 17 years currently had asthma, which is very similar to the estimate from NHIS for 2007. The 2007 NSCH also provides information at the state level: South Dakota has the lowest asthma rates, with only 5.2% of children currently having asthma. The District of Columbia has the highest asthma rates, with 14.4% of children currently having asthma.[96]

Indicator H1

Percentage of children ages 0 to 17 years with asthma, 1997-2013



Data: Centers for Disease Control and Prevention, National Center for Health Statistics, National Health Interview Survey

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Data characterization

- Data for this indicator are obtained from an ongoing annual survey conducted by the National Center for Health Statistics.
- Survey data are representative of the U.S. civilian noninstitutionalized population.
- A parent or other knowledgeable adult in each sampled household is asked questions regarding the child's health status, including if they have ever been told the child has asthma, if the child has had an asthma attack in the past year, and if the child currently has asthma.

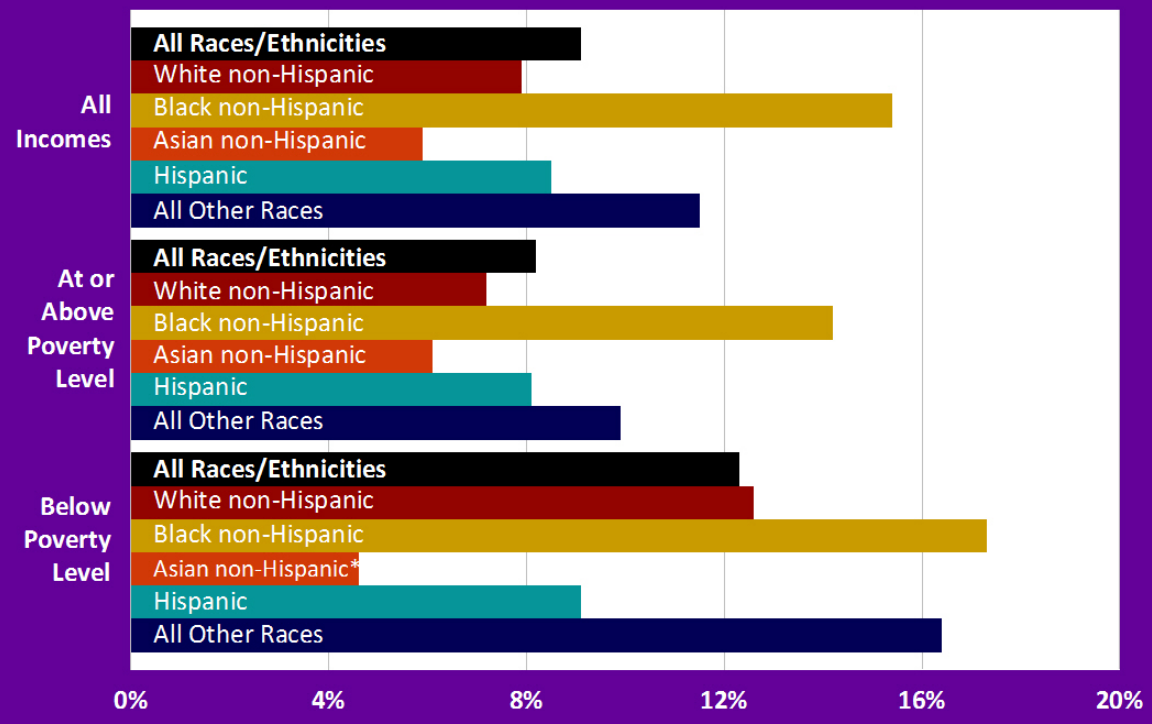
- The proportion of children reported to currently have asthma increased from 8.7% in 2001 to 9.3% in 2012 but then decreased to 8.3% in 2013. The increasing trend from 2001 to 2013 was statistically significant, as was the year-to-year decrease from 2012 to 2013.

- In 1997, 5.5% of all children were reported to have had one or more asthma attacks in the previous 12 months. There was little change in this rate between 1997 and 2012. In 2013, the rate decreased to 4.9%.
- In 2001, 61.7% of children with current asthma had one or more asthma attacks in the previous 12 months, and by 2013 this figure had declined to 57.9%.[ii] The decreasing trend from 2001 to 2013 was statistically significant. (See Table H1c.)
- Between 1980 and 1995 the percentage of children who had asthma in the past 12 months increased from 3.6% in 1980 to 7.5% in 1995. Methods for measurement of childhood asthma changed in 1997, so earlier data cannot be compared to the data from 1997–2010. (See Table H1b.)

[ii] See indicator H3 for further information on outcomes for children with asthma.

Indicator H2

Percentage of children ages 0 to 17 years reported to have current asthma, by race/ethnicity and family income, 2010-2013



Data: Centers for Disease Control and Prevention, National Center for Health Statistics, National Health Interview Survey

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* The estimate should be interpreted with caution because the standard error of the estimate is relatively large: the relative standard error, RSE, is at least 30% but is less than 40% (RSE = standard error divided by the estimate).

Data characterization

- Data for this indicator are obtained from an ongoing annual survey conducted by the National Center for Health Statistics.
- Survey data are representative of the U.S. civilian noninstitutionalized population.
- A parent or other knowledgeable adult in each sampled household is asked questions regarding the child's health status, including if they have ever been told the child has asthma, if the child has had an asthma attack in the past year, and if the child currently has asthma.

- In 2010–2013, 9.1% of all children were reported to currently have asthma.

- Among children living in families with incomes below the poverty level, 12.3% were reported to currently have asthma. Among children living in families with incomes at the poverty level and higher, 8.2% were reported to currently have asthma. This difference was statistically significant.
- In 2010–2013, the percentages of Black non-Hispanic children and children of "All Other Races" reported to currently have asthma, 15.4% and 11.5% respectively, were greater than for Hispanic children (8.5%), White non-Hispanic children (7.9%), , and Asian non-Hispanic children (5.9%).
  - The differences in current asthma prevalence among Black non-Hispanic or "All Other Races" children, compared with current asthma prevalence among Hispanic, White non-Hispanic, or Asian non-Hispanic children, were statistically significant. These differences by race/ethnicity are also significant when considering only children below poverty level, except for the comparison between "All Other Races" children and White non-Hispanic children. These differences by race/ethnicity are also significant when considering only children at or above poverty level, except for the comparison between "All Other Races" children and Hispanic children.
- Among Hispanic children, about 1 in 4 Puerto Rican children (25.2%) living in families with incomes below the poverty level were reported to currently have asthma. The rate of reported current asthma for Mexican-American children living in families with incomes below the poverty level is 6.9%. This difference was statistically significant. (See Table H2.)
- Among boys, 10.0% were reported to have current asthma compared with 8.2% of girls. This difference was statistically significant. (See Table H2a.)
- Among children ages 0 to 5 years, 6.4% were reported to have current asthma compared with 10.1% of children ages 6 to 10 years and 10.8% of children ages 11 to 17 years. The difference in current asthma by age group was statistically significant. (See Table H2a.)

Indicator H3: Children's emergency room visits and hospitalizations for asthma and other respiratory causes, ages 0 to 17 years, 1996–2010

About the Indicator: Indicator H3 presents information about the number of children's emergency room visits and hospitalizations for asthma and other respiratory causes. The data are from two national surveys that collect information from hospitals each year. Indicator H3 shows how the rates of children's emergency room visits and hospitalizations for respiratory causes have changed over time.

National Hospital Ambulatory Medical Care Survey and National Hospital Discharge Survey

The National Hospital Ambulatory Medical Care Survey (NHAMCS) and the National Hospital Discharge Survey (NHDS), conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention, provide national data on emergency room visits and hospitalizations. The NHAMCS has collected data for physician diagnoses for visits to hospital emergency rooms and outpatient departments beginning in the year 1992, while the NHDS reports physician diagnoses for discharges from hospitals beginning in the year 1965. The diagnoses in both surveys include asthma and a number of other respiratory conditions. Both surveys exclude federal and military hospitals and report patient demographic information.

Data Presented in the Indicators

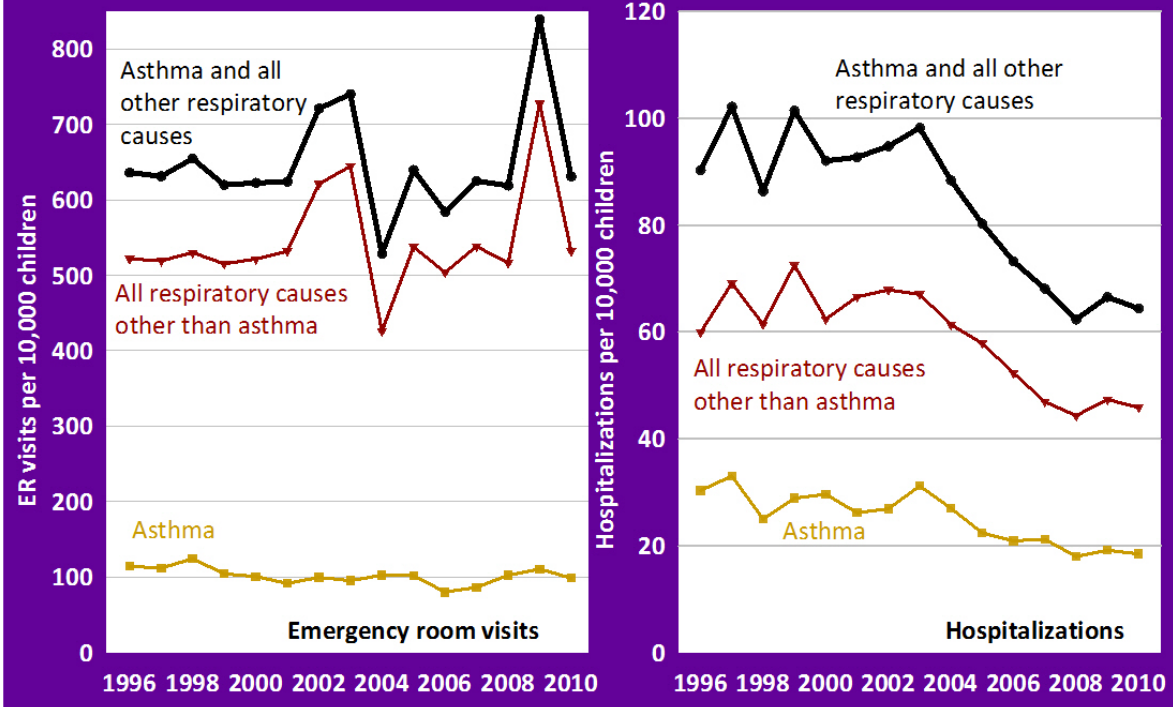
Indicator H3 uses data from NHAMCS and NHDS to display emergency room visits and hospitalizations for asthma and other respiratory conditions including bronchitis, pneumonia, and influenza. The top line in each graph represents the total number of children's emergency room visits or hospitalizations for asthma and all other respiratory causes, followed by lines for asthma and for all respiratory causes other than asthma. Indicator H3 presents annual survey results from 1996–2010. 1996 was selected as the initial year for the indicator because not all of the needed hospitalization data for earlier years are available online This indicator has been updated since the publication of the *America's Children and the Environment, Third Edition* (January 2013) to include data from 2009-2010 and to use updated census data.

In addition to the data shown in the Indicator H3 graph, supplemental tables show the annual average rates of children's emergency room visits and hospitalizations for asthma and all other respiratory causes, asthma, and all respiratory causes other than asthma (composed of the following subcategories: upper respiratory conditions, pneumonia or influenza, and other lower respiratory conditions besides asthma) by age and race/ethnicity for the years 2007–2010. For emergency room visits, five race/ethnicity groups are presented: White non-Hispanic, Black non-Hispanic, American Indian/Alaska Native non-Hispanic, Asian and Pacific Islander non-Hispanic, and Hispanic. For hospitalizations, race only is reported; the two groups presented are White and Black. The supplemental tables do not include income data, since neither of these surveys includes the patient's income or family income.

Please see the Introduction to the Health section for discussion of statistical significance testing applied to these indicators.

Indicator H3

Children's emergency room visits and hospitalizations for asthma and other respiratory causes, ages 0 to 17 years, 1996-2010



Data: Centers for Disease Control and Prevention, National Center for Health Statistics, National Hospital Ambulatory Medical Care Survey (emergency room visits) and National Hospital Discharge Survey (hospitalizations)

America's Children and the Environment, Third Edition, Updated October 2015

Data characterization

- Data for this indicator are obtained from two ongoing annual surveys conducted by the National Center for Health Statistics.
- Survey data are representative of U.S. population visits to emergency rooms and stays at non-federal hospitals.
- The surveys collect data on physician diagnoses of patients in sampled hospitals, including diagnoses of asthma and other respiratory conditions.

Emergency Room Visits

- In 2010, the rate of emergency room visits for asthma and all other respiratory causes was 631 visits per 10,000 children. The rate of emergency room visits for asthma alone was 99 visits per 10,000 children, and the rate for all respiratory causes other than asthma was 532 visits per 10,000 children.

- The rate of emergency room visits for asthma decreased from 114 visits per 10,000 children in 1996 to 99 visits per 10,000 children in 2010. This decreasing trend was statistically significant, after adjusting for sex and race/ethnicity.
- Children's emergency room visits for asthma and all other respiratory causes vary widely by race/ethnicity. For the years 2007–2010, Black non-Hispanic children had a rate of 1,316 emergency room visits per 10,000 children, while Hispanic children had a rate of 760 emergency room visits per 10,000 children, American Indian/Alaska Native non-Hispanic children had a rate of 594 emergency room visits per 10,000 children, White non-Hispanic children had a rate of 540 emergency room visits per 10,000 children, and Asian and Pacific Islander non-Hispanic children had a rate of 387 emergency room visits per 10,000 children. (See Table H3a.)
  - The difference in rates of emergency room visits between Black non-Hispanic children and emergency room visits for each of the other race/ethnicity groups was statistically significant.
- Children's emergency room visits for asthma and all other respiratory causes vary widely by age. For the years 2007–2010, infants less than 12 months of age had a rate of 2,265 emergency room visits per 10,000 children, while children 16 to 17 years of age had a rate of 361 emergency room visits per 10,000 children. The differences between age groups were statistically significant. (See Table H3b.)

Hospitalizations

- Between 1996 and 2010, hospitalizations for asthma and all other respiratory causes decreased from 90 hospitalizations per 10,000 children to 64 hospitalizations per 10,000 children. Between 1996 and 2010, hospitalizations for asthma alone decreased from 30 per 10,000 children to 19 per 10,000 children, and hospitalizations for all other respiratory causes decreased from 60 per 10,000 children to 46 per 10,000 children. These decreasing trends were statistically significant.
- Children's hospitalizations for asthma and all other respiratory causes vary widely by race. For the years 2007–2010, Black children had a rate of 78 hospitalizations for asthma and other respiratory causes per 10,000 children, while White children had a rate of 43 hospitalizations per 10,000 children. This difference was statistically significant. (See Table H3c.)
- Children's hospitalizations for asthma and all other respiratory causes vary widely by age. For the years 2007–2010, infants less than 12 months of age had a rate of 370 hospitalizations per 10,000 children, while children 16 to 17 years of age had a rate of 16 hospitalizations per 10,000 children. The differences between age groups were statistically significant. (See Table H3d.)

Respiratory Diseases

1. Institute of Medicine. 2000. *Clearing the Air: Asthma and Indoor Air Exposures*. Washington DC: National Academy Press. http://books.nap.edu/catalog/9610.html.

2. U.S. Department of Health and Human Services. 2006. *The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General*. Atlanta, GA: Centers for Disease Control and Prevention, Coordinating Center for Health Promotion, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health. http://www.surgeongeneral.gov/library/secondhandsmoke/report/index.html.

3. U.S. Environmental Protection Agency. 2006. *Air Quality Criteria for Ozone and Related Photochemical Oxidants*. Washington, DC: U.S. EPA. EPA/600/R-05/004aF. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=149923.

4. U.S. Environmental Protection Agency. 2008. *Integrated Science Assessment for Oxides of Nitrogen – Health Criteria (Final Report)*. Washington, DC: U.S. EPA, Office of Research and Development. http://oaspub.epa.gov/eims/eimscomm.getfile?p_download_id=475020.

5. U.S. Environmental Protection Agency. 2008. *Integrated Science Assessment for Sulfur Oxides - Health Criteria (Final Report)*. Washington, DC: U.S. EPA. EPA/600/R-08/047F. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=198843.

6. U.S. Environmental Protection Agency. 2009. *Integrated Science Assessment for Particulate Matter (Final Report)*. Washington, DC: U.S. EPA. EPA/600/R-08/139F. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=216546.

7. U.S. Environmental Protection Agency. 2010. *Integrated Science Assessment for Carbon Monoxide (Final Report)*. Washington, DC: U.S. Environmental Protection Agency. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=218686.

8. Fauroux, B., M. Sampil, P. Quénel, and Y. Lemoullec. 2000. Ozone: a trigger for hospital pediatric asthma emergency room visits. *Pediatric Pulmonology* 30 (1):41-6.

9. Parker, J.D., L.J. Akinbami, and T.J. Woodruff. 2009. Air pollution and childhood respiratory allergies in the United States. *Environmental Health Perspectives* 117 (1):140-147.

10. Schildcrout, J.S., L. Sheppard, T. Lumley, J.C. Slaughter, J.Q. Koenig, and G.G. Shapiro. 2006. Ambient air pollution and asthma exacerbations in children: an eight-city analysis. *American Journal of Epidemiology* 164 (6):505-17.

11. Clark, N.A., P.A. Demers, C.J. Karr, M. Koehoorn, C. Lencar, L. Tamburic, and M. Brauer. 2010. Effect of early life exposure to air pollution on development of childhood asthma. *Environmental Health Perspectives* 118 (2):284-90.

12. Gehring, U., A.H. Wijga, M. Brauer, P. Fischer, J.C. de Jongste, M. Kerkhof, M. Oldenwening, H.A. Smit, and B. Brunekreef. 2010. Traffic-related air pollution and the development of asthma and allergies during the first 8 years of life. *American Journal of Respiratory and Critical Care Medicine* 181 (6):596-603.

13. McConnell, R., T. Islam, K. Shankardass, M. Jerrett, F. Lurmann, F. Gilliland, J. Gauderman, E. Avol, N. Kuenzli, L. Yao, et al. 2010. Childhood incident asthma and traffic-related air pollution at home and school. *Environmental Health Perspectives* 118 (7):1021-6.

14. Chauhan, A.J., and S.L. Johnston. 2003. Air pollution and infection in respiratory illness. *British Medical Bulletin* 68:95-112.

15. Ciencewicki, J., and I. Jaspers. 2007. Air pollution and respiratory viral infection. *Inhalation Toxicology* 19 (14):1135-46.

16. Dherani, M., D. Pope, M. Mascarenhas, K.R. Smith, M. Weber, and N. Bruce. 2008. Indoor air pollution from unprocessed solid fuel use and pneumonia risk in children aged under five years: a systematic review and meta-analysis. *Bulletin of the World Health Organization* 86 (5):390-398C.

17. U.S. Environmental Protection Agency. 2010. *National Ambient Air Quality Standards (NAAQS)*. U.S. EPA, Office of Air and Radiation. Retrieved October 20, 2010 from http://www.epa.gov/air/criteria.html.

18. Glinianaia, S.V., J. Rankin, R. Bell, T. Pless-Mulloli, and D. Howel. 2004. Does particulate air pollution contribute to infant death? A systematic review. *Environmental Health Perspectives* 112 (14):1365-71.

19. Woodruff, T.J., J.D. Parker, and K.C. Schoendorf. 2006. Fine particulate matter (PM2.5) air pollution and selected causes of postneonatal infant mortality in California. *Environmental Health Perspectives* 114 (5):786-90.

20. Kajekar, R. 2007. Environmental factors and developmental outcomes in the lung. *Pharmacology & Therapeutics* 114 (2):129-45.

21. Wigle, D.T., T.E. Arbuckle, M. Walker, M.G. Wade, S. Liu, and D. Krewski. 2007. Environmental hazards: evidence for effects on child health. *Toxicology and Environmental Health Part B: Critical Reviews* 10 (1-2):3-39.

22. Islam, T., K. Berhane, R. McConnell, W.J. Gauderman, E. Avol, J.M. Peters, and F.D. Gilliland. 2009. Glutathione-S-transferase (GST) P1, GSTM1, exercise, ozone and asthma incidence in school children. *Thorax* 64 (3):197-202.

23. Islam, T., R. McConnell, W.J. Gauderman, E. Avol, J.M. Peters, and F.D. Gilliland. 2008. Ozone, oxidant defense genes, and risk of asthma during adolescence. *American Journal of Respiratory and Critical Care Medicine* 177 (4):388-95.

24. McConnell, R., K. Berhane, F. Gilliland, S.J. London, T. Islam, W.J. Gauderman, E. Avol, H.G. Margolis, and J.M. Peters. 2002. Asthma in exercising children exposed to ozone: a cohort study. *Lancet* 359 (9304):386-91.

25. Villeneuve, P.J., L. Chen, B.H. Rowe, and F. Coates. 2007. Outdoor air pollution and emergency department visits for asthma among children and adults: a case-crossover study in northern Alberta, Canada. *Environmental Health* 6:40.

26. Leikauf, G.D. 2002. Hazardous air pollutants and asthma. *Environmental Health Perspectives* 110 Suppl 4:505-26.

27. Cook, R., M. Strum, J.S. Touma, T. Palma, J. Thurman, D. Ensley, and R. Smith. 2007. Inhalation exposure and risk from mobile source air toxics in future years. *Journal of Exposure Science and Environmental Epidemiology* 17 (1):95-105.

28. U.S. Environmental Protection Agency. 2003. *Toxicological Review of Acrolein (CAS No. 107-02-8)*. Washington, DC: U.S. EPA, National Center for Environmental Assessment. EPA/635/R-03/003. http://www.epa.gov/iris/toxreviews/0364tr.pdf.

29. Woodruff, T.J., D.A. Axelrad, J. Caldwell, R. Morello-Frosch, and A. Rosenbaum. 1998. Public health implications of 1990 air toxics concentrations across the United States. *Environmental Health Perspectives* 106 (5):245-51.

30. Faroon, O., N. Roney, J. Taylor, A. Ashizawa, M.H. Lumpkin, and D.J. Plewak. 2008. Acrolein health effects. *Toxicology and Industrial Health* 24 (7):447-90.

31. Gauderman, W.J., H. Vora, R. McConnell, K. Berhane, F. Gilliland, D. Thomas, F. Lurmann, E. Avol, N. Kunzli, M. Jerrett, et al. 2007. Effect of exposure to traffic on lung development from 10 to 18 years of age: a cohort study. *Lancet* 369 (9561):571-7.

32. Jerrett, M., K. Shankardass, K. Berhane, W.J. Gauderman, N. Künzli, E. Avol, F. Gilliland, F. Lurmann, J.N. Molitor, J.T. Molitor, et al. 2008. Traffic-related air pollution and asthma onset in children: a prospective cohort study with individual exposure measurement. *Environmental Health Perspectives* 116 (10):1433-38.

33. Karr, C.J., P.A. Demers, M.W. Koehoorn, C.C. Lencar, L. Tamburic, and M. Brauer. 2009. Influence of ambient air pollutant sources on clinical encounters for infant bronchiolitis. *American Journal of Respiratory and Critical Care Medicine* 180 (10):995-1001.

34. McConnell, R., K. Berhane, L. Yao, M. Jerrett, F. Lurmann, F. Gilliland, N. Kunzli, J. Gauderman, E. Avol, D. Thomas, et al. 2006. Traffic, susceptibility, and childhood asthma. *Environmental Health Perspectives* 114 (5):766-72.

35. Morgenstern, V., A. Zutavern, J. Cyrys, I. Brockow, U. Gehring, S. Koletzko, C.P. Bauer, D. Reinhardt, H.E. Wichmann, and J. Heinrich. 2007. Respiratory health and individual estimated exposure to traffic-related air pollutants in a cohort of young children. *Occupational and Environmental Medicine* 64 (1):8-16.

36. Salam, M.T., T. Islam, and F.D. Gilliland. 2008. Recent evidence for adverse effects of residential proximity to traffic sources on asthma. *Current Opinion in Pulmonary Medicine* 14 (1):3-8.

37. Health Effects Institute. 2010. *HEI Panel on the Health Effects of Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects*. Boston, MA. HEI Special Report 17. http://pubs.healtheffects.org/view.php?id=334

38. Bartra, J., J. Mullol, A. del Cuvillo, I. Davila, M. Ferrer, I. Jauregui, J. Montoro, J. Sastre, and A. Valero. 2007. Air pollution and allergens. *Journal of Investigational Allergology and Clinical Immunology* 17 Suppl 2:3-8.

39. Bråbäck, L., and B. Forsberg. 2009. Does traffic exhaust contribute to the development of asthma and allergic sensitization in children: findings from recent cohort studies. *Environmental Health* 8:17.

40. Krzyzanowski, M., B. Kuna-Dibbert, and J. Schneider, eds. 2005. *Health Effects of Transport-Related Air Pollution*. Copenhagen, Denmark: World Health Organization, Europe.

41. Dales, R., L. Liu, A.J. Wheeler, and N.L. Gilbert. 2008. Quality of indoor residential air and health. *Canadian Medical Association Journal* 179 (2):147-52.

42. Seltzer, J.M., and M.J. Fedoruk. 2007. Health effects of mold in children. *Pediatric Clinics of North America* 54 (2):309-33, viii-ix.

43. Perez-Padilla, R., A. Schilmann, and H. Riojas-Rodriguez. 2010. Respiratory health effects of indoor air pollution. *The International Journal of Tuberculosis and Lung Disease* 14 (9):1079-86.

44. Dales, R., and M. Raizenne. 2004. Residential exposure to volatile organic compounds and asthma. *Journal of Asthma* 41 (3):259-70.

45. Fuentes-Leonarte, V., J.M. Tenias, and F. Ballester. 2009. Levels of pollutants in indoor air and respiratory health in preschool children: a systematic review. *Pediatric Pulmonology* 44 (3):231-43.

46. McGwin, G., J. Lienert, and J.I. Kennedy. 2010. Formaldehyde exposure and asthma in children: a systematic review. *Environmental Health Perspectives* 118 (3):313-7.

47. Cheraghi, M., and S. Salvi. 2009. Environmental tobacco smoke (ETS) and respiratory health in children. *European Journal of Pediatrics* 168 (8):897-905.

48. Li, Y.F., F.D. Gilliland, K. Berhane, R. McConnell, W.J. Gauderman, E.B. Rappaport, and J.M. Peters. 2000. Effects of in utero and environmental tobacco smoke exposure on lung function in boys and girls with and without asthma. *American Journal of Respiratory and Critical Care Medicine* 162 (6):2097-104.

49. Wang, L., and K.E. Pinkerton. 2008. Detrimental effects of tobacco smoke exposure during development on postnatal lung function and asthma. *Birth Defects Research Part C: Embryo Today* 84 (1):54-60.

50. Xepapadaki, P., Y. Manios, T. Liarigkovinos, E. Grammatikaki, N. Douladiris, C. Kortsalioudaki, and N.G. Papadopoulos. 2009. Association of passive exposure of pregnant women to environmental tobacco smoke with asthma symptoms in children. *Pediatric Allergy and Immunology* 20 (5):423-9.

51. Jedrychowski, W., A. Galas, A. Pac, E. Flak, D. Camman, V. Rauh, and F. Perera. 2005. Prenatal ambient air exposure to polycyclic aromatic hydrocarbons and the occurrence of respiratory symptoms over the first year of life. *European Journal of Epidemiology* 20 (9):775-82.

52. Miller, R.L., R. Garfinkel, M. Horton, D. Camann, F.P. Perera, R.M. Whyatt, and P.L. Kinney. 2004. Polycyclic aromatic hydrocarbons, environmental tobacco smoke, and respiratory symptoms in an inner-city birth cohort. *Chest* 126 (4):1071-8.

53. Rosa, M.J., K.H. Jung, M.S. Perzanowski, E.A. Kelvin, K.W. Darling, D.E. Camann, S.N. Chillrud, R.M. Whyatt, P.L. Kinney, F.P. Perera, et al. 2011. Prenatal exposure to polycyclic aromatic hydrocarbons, environmental tobacco smoke and asthma. *Respiratory Medicine* 105 (6):869-76.

54. Mortimer, K., R. Neugebauer, F. Lurmann, S. Alcorn, J. Balmes, and I. Tager. 2008. Air pollution and pulmonary function in asthmatic children: effects of prenatal and lifetime exposures. *Epidemiology* 19 (4):550-7.

55. Mortimer, K., R. Neugebauer, F. Lurmann, S. Alcorn, J. Balmes, and I. Tager. 2008. Early-lifetime exposure to air pollution and allergic sensitization in children with asthma. *Journal of Asthma* 45 (10):874-81.

56. Bloom, B., R.A. Cohen, and G. Freeman. 2010. Summary health statistics for U.S. children: National Health Interview Survey, 2009. *Vital and Health Statistics* 10 (247):1-89.

57. Barnett, S.B., and T.A. Nurmagambetov. 2011. Costs of asthma in the United States: 2002-2007. *The Journal of Allergy and Clinical Immunology* 127 (1):145-52.

58. Rudd, R.A., and J.E. Moorman. 2007. Asthma incidence: data from the National Health Interview Survey, 1980-1996. *Journal of Asthma* 44 (1):65-70.

59. Litonjua, A.A., V.J. Carey, S.T. Weiss, and D.R. Gold. 1999. Race, socioeconomic factors, and area of residence are associated with asthma prevalence. *Pediatric Pulmonology* 28 (6):394-401.

60. Panico, L., M. Bartley, M. Marmot, J.Y. Nazroo, A. Sacker, and Y.J. Kelly. 2007. Ethnic variation in childhood asthma and wheezing illnesses: findings from the Millennium Cohort Study. *International Journal of Epidemiology* 36 (5):1093-102.

61. Pearlman, D.N., S. Zierler, S. Meersman, H.K. Kim, S.I. Viner-Brown, and C. Caron. 2006. Race disparities in childhood asthma: does where you live matter? *Journal of the National Medical Association* 98 (2):239-47.

62. Aligne, C.A., P. Auinger, R.S. Byrd, and M. Weitzman. 2000. Risk factors for pediatric asthma. Contributions of poverty, race, and urban residence. *American Journal of Respiratory and Critical Care Medicine* 162 (3 Pt 1):873-7.

63. Crain, E.F., M. Walter, G.T. O'Connor, H. Mitchell, R.S. Gruchalla, M. Kattan, G.S. Malindzak, P. Enright, R. Evans, 3rd, W. Morgan, et al. 2002. Home and allergic characteristics of children with asthma in seven U.S. urban communities and design of an environmental intervention: the Inner-City Asthma Study. *Environmental Health Perspectives* 110 (9):939-45.

64. Kitch, B.T., G. Chew, H.A. Burge, M.L. Muilenberg, S.T. Weiss, T.A. Platts-Mills, G. O'Connor, and D.R. Gold. 2000. Socioeconomic predictors of high allergen levels in homes in the greater Boston area. *Environmental Health Perspectives* 108 (4):301-7.

65. Leaderer, B.P., K. Belanger, E. Triche, T. Holford, D.R. Gold, Y. Kim, T. Jankun, P. Ren, J.E. McSharry, T.A. Platts-Mills, et al. 2002. Dust mite, cockroach, cat, and dog allergen concentrations in homes of asthmatic children in the northeastern United States: impact of socioeconomic factors and population density. *Environmental Health Perspectives* 110 (4):419-25.

66. Federal Interagency Forum on Child and Family Statistics. 2009. *America's Children: Key National Indicators of Well-Being, 2009: Outdoor and Indoor Air Quality*. Washington, DC: U.S. Government Printing Office. http://childstats.gov/americaschildren09/phenviro1.asp.

67. Arbes, S.J., R.D.Cohn, M. Yin, M.L. Muilenberg, H.A. Burge, W. Friedman, and D.C. Zeldin. 2003. House dust mite allergen in U.S. beds: results from the first national survey of lead and allergens in housing. *Journal of Allergy and Clinical Immunology* 111 (2):408-14.

68. Cohn, R.D., S.J. Arbes, Jr., M. Yin, R. Jaramillo, and D.C. Zeldin. 2004. National prevalence and exposure risk for mouse allergen in US households. *The Journal of Allergy and Clinical Immunology* 113 (6):1167-71.

69. Elliott, L., S.J. Arbes, E.S. Harvey, R.C. Lee, P.M. Salo, R.D. Cohn, S.J. London, and D.C. Zeldin. 2007. Dust weight and asthma prevalence in the National Survey of Lead and Allergens in Housing (NSLAH). *Environmental Health Perspectives* 115 (2):215-20.

70. Farber, H.J., C. Johnson, and R.C. Beckerman. 1998. Young inner-city children visiting the emergency room (ER) for asthma: risk factors and chronic care behaviors. *Journal of Asthma* 35 (7):547-52.

71. Halfon, N., and P.W. Newacheck. 1993. Childhood asthma and poverty: differential impacts and utilization of health services. *Pediatrics* 91 (1):56-61.

72. Lozano, P., J.A. Finkelstein, J. Hecht, R. Shulruff, and K.B. Weiss. 2003. Asthma medication use and disease burden in children in a primary care population. *Archives of Pediatrics and Adolescent Medicine* 157 (1):81-8.

73. Price, M.R., J.M. Norris, B. Bucher Bartleson, L.A. Gavin, and M.D. Klinnert. 1999. An investigation of the medical care utilization of children with severe asthma according to their type of insurance. *Journal of Asthma* 36 (3):271-9.

74. Rosenbach, M.L., C. Irvin, and R.F. Coulam. 1999. Access for low-income children: is health insurance enough? *Pediatrics* 103 (6 Pt 1):1167-74.

75. Stanton, M.S., and D. Dougherty. 2005. Chronic Care for Low-Income Children with Asthma: Strategies for Improvement. In *Research in Action Issue 18*. Rockville, MD: Agency for Healthcare Research and Quality.

76. Yoos, H.L., H. Kitzman, and A. McMullen. 2003. Barriers to anti-inflammatory medication use in childhood asthma. *Ambulatory Pediatrics* 3 (4):181-90.

77. Eder, W., M.J. Ege, and E. von Mutius. 2006. The asthma epidemic. *New England Journal of Medicine* 355 (21):2226-35.

78. Zorc, J.J., and C.B. Hall. 2010. Bronchiolitis: recent evidence on diagnosis and management. *Pediatrics* 125 (2):342-9.

79. Coffman, J.M., M.D. Cabana, H.A. Halpin, and E.H. Yelin. 2008. Effects of asthma education on children's use of acute care services: a meta-analysis. *Pediatrics* 121 (3):575-86.

80. Flores, G., M. Abreu, S. Tomany-Korman, and J. Meurer. 2005. Keeping children with asthma out of hospitals: parents' and physicians' perspectives on how pediatric asthma hospitalizations can be prevented. *Pediatrics* 116 (4):957-65.

81. Flores, G., C. Snowden-Bridon, S. Torres, R. Perez, T. Walter, J. Brotanek, H. Lin, and S. Tomany-Korman. 2009. Urban minority children with asthma: substantial morbidity, compromised quality and access to specialists, and the importance of poverty and specialty care. *The Journal of Asthma* 46 (4):392-8.

82. Fox, P., P.G. Porter, S.H. Lob, J.H. Boer, D.A. Rocha, and J.W. Adelson. 2007. Improving asthma-related health outcomes among low-income, multiethnic, school-aged children: results of a demonstration project that combined continuous quality improvement and community health worker strategies. *Pediatrics* 120 (4):e902-11.

83. U.S. Department of Health and Human Services. 2007. *Guidelines for the Diagnosis and Management of Asthma*. Bethesda, MD: National Heart, Lung, and Blood Institute, National Asthma Education and Prevention Program. NIH Publication Number 08-5846. http://www.nhlbi.nih.gov/guidelines/asthma/asthsumm.pdf.

84. Homer, C.J., P. Szilagyi, L. Rodewald, S.R. Bloom, P. Greenspan, S. Yazdgerdi, J.M. Leventhal, D. Finkelstein, and J.M. Perrin. 1996. Does quality of care affect rates of hospitalization for childhood asthma? *Pediatrics* 98 (1):18-23.

85. Russo, M.J., K.M. McConnochie, J.T. McBride, P.G. Szilagyi, A.M. Brooks, and K.J. Roghmann. 1999. Increase in admission threshold explains stable asthma hospitalization rates. *Pediatrics* 104 (3 Pt. 1):454-62.

86. Gwynn, R.C., and G.D. Thurston. 2001. The burden of air pollution: impacts among racial minorities. *Environmental Health Perspectives* 109 (Suppl. 4):501-6.

87. Nauenberg, E., and K. Basu. 1999. Effect of insurance coverage on the relationship between asthma hospitalizations and exposure to air pollution. *Public Health Reports* 114 (2):135-48.

88. Akinbami, L.J., J.E. Moorman, P.L. Garbe, and E.J. Sondik. 2009. Status of childhood asthma in the United States, 1980-2007. *Pediatrics* 123 Suppl 3:S131-45.

89. Gupta, R.S., V. Carrion-Carire, and K.B. Weiss. 2006. The widening black/white gap in asthma hospitalizations and mortality. *The Journal of Allergy and Clinical Immunology* 117 (2):351-8.

90. McDaniel, M., C. Paxson, and J. Waldfogel. 2006. Racial disparities in childhood asthma in the United States: evidence from the National Health Interview Survey, 1997 to 2003. *Pediatrics* 117 (5):e868-77.

91. Corburn, J., J. Osleeb, and M. Porter. 2006. Urban asthma and the neighbourhood environment in New York City. *Health & Place* 12 (2):167-79.

92. Maryland Department of Health and Mental Hygiene, and Maryland Department of the Environment. 2008. *Maryland's Children and the Environment*. http://www.dhmh.state.md.us/reports/pdf/MDChildrenEnv08.pdf.

93. Chan, K.S., E. Keeler, M. Schonlau, M. Rosen, and R. Mangione-Smith. 2005. How do ethnicity and primary language spoken at home affect management practices and outcomes in children and adolescents with asthma? *Archives of Pediatrics and Adolescent Medicine* 159 (3):283-9.

94. Scott, G., and H. Ni. 2004. Access to health care among Hispanic/Latino children: United States, 1998-2001. *Advance Data from Vital and Health Statistics* (344):1-20.

95. Centers for Disease Control and Prevention. 2008. Youth risk behavior surveillance — United States, 2007. *Morbidity and Mortality Weekly Report* 57 (SS-4).

96. Child and Adolescent Health Measurement Initiative. 2009. *2007 National Survey of Children's Health*. Child and Adolescent Health Measurement Initiative, Data Resource Center for Child and Adolescent Health. Retrieved June 16, 2009 from www.nschdata.org.