America's Children and the Environment, Third Edition

DRAFT Indicators

Environments and Contaminants: Climate Change

EPA is preparing the third edition of *America's Children and the Environment* (ACE3), following the previous editions published in December 2000 and February 2003. ACE is EPA's compilation of children's environmental health indicators and related information, drawing on the best national data sources available for characterizing important aspects of the relationship between environmental contaminants and children's health. ACE includes four sections: Environments and Contaminants, Biomonitoring, Health, and Special Features.

EPA has prepared draft indicator documents for ACE3 representing 23 children's environmental health topics and presenting a total of 42 proposed children's environmental health indicators. This document presents the draft text, indicator, and documentation for the climate change topic in the Environments and Contaminants section.

THIS INFORMATION IS DISTRIBUTED SOLELY FOR THE PURPOSE OF PRE-DISSEMINATION PEER REVIEW UNDER APPLICABLE INFORMATION QUALITY GUIDELINES. IT HAS NOT BEEN FORMALLY DISSEMINATED BY EPA. IT DOES NOT REPRESENT AND SHOULD NOT BE CONSTRUED TO REPRESENT ANY AGENCY DETERMINATION OR POLICY.

For more information on America's Children and the Environment, please visit www.epa.gov/ace. For instructions on how to submit comments on the draft ACE3 indicators, please visit www.epa.gov/ace/ace3drafts/.

Climate Change and Children's Health

The term "climate change" refers to any major change in measures of climate, including temperature, precipitation, or wind, that lasts for decades or longer. Both human activities and natural factors contribute to climate change. Human activities, such as burning fossil fuels, cutting down forests, and developing land for farms, cities, and roads, release heat-trapping greenhouse gases into the atmosphere. Natural causes, such as changes in the Earth's orbit, the sun's intensity, the circulation of the ocean and the atmosphere, and volcanic activity, contribute to climate change in a variety of ways.[1]

Climate change may affect children's health in a number of direct and indirect ways. It is important to note that climate change will likely result in a mix of both positive and negative health impacts. The effects of climate change will also vary from one location to another and will likely change over time as climate change continues.[2,3] Furthermore, the human health risks from climate change may be strongly affected by changes in health care advances and accessibility, public health infrastructure, and technology.[2,4,5]

Direct effects of extreme temperatures are one area of concern, as climate change is expected to increase the number and intensity of hot days, hot nights, and heat waves in the United States.[5-7] Heat exposure can result in heat rashes, heat stroke, heat exhaustion, and even death; children may be especially at risk because they often spend more time outside than adults do.[2,8] Many factors can modify the impact of heat exposure, including income level and the magnitude of the urban heat-island effect.[9] A higher income allows families to adapt more easily to meet the challenges of climate change compared with lower-income families, because they can afford the use of air conditioners and other cooling methods to create a more ideal and comfortable environment.

The term "urban heat island" refers to urban areas that are hotter than surrounding rural areas because the buildings, roads, and other infrastructure of the urban areas have replaced open land and vegetation with impervious surfaces, thereby removing permeable and moist land.[10] Warmer winters may have the effect of decreasing the number of cold-related deaths and injuries.[2,9] It is difficult to estimate the net changes in mortality due to climate change; however, a recent assessment by the United States Global Change Research Program concluded that increases in heat-related mortality due to climate change are unlikely to be compensated by decreases in cold-related mortality.[7]

High temperatures, heat waves, and associated stagnant air masses can increase levels of air pollution, specifically ground level ozone, fine particulate matter ($PM_{2.5}$), nitrogen oxides, and sulfur oxides.[2,7,8] These air pollutants can be harmful for children: they may contribute to the development of new cases of asthma, aggravate preexisting cases of asthma, cause decrements to lung function, increase respiratory symptoms such as coughing and wheezing, and increase hospital admissions and emergency room visits for respiratory diseases.[11-26] Because children may spend a lot of time outdoors, often while exerting themselves for sports or play, they can be especially vulnerable to the impacts of poor air quality.[7]

Climate change is likely to change the timing, frequency, and intensity of extreme weather events, including tornados, hurricanes, floods, droughts, and tropical storms.[5,8] These events can cause traumatic injury and death, as well as emotional trauma. Extreme weather events are also associated with increased risk of food- and water-borne illnesses as sanitation, hygiene, and safe food and water supplies are often compromised after these types of events. Flooding may also lead to contamination of water with dangerous chemicals, heavy metals, or other hazardous substances from storage containers or from preexisting chemical contamination already in the environment.[2] Elevated temperatures and low precipitation are also projected to increase the size and severity of wildfires. This can lead to increased eye and respiratory illnesses and injuries, which include burns and smoke inhalation.[2] Extreme weather events can be especially dangerous for children because they are dependent on adults for care and protection.[6]

A number of infectious diseases may be affected by climate change. The combined effects of increased temperature and precipitation are projected to cause increases in water-, food-, and vector-borne illnesses. In general, increased temperature results in higher replication, transmission, persistence, habitat range, and survival of bacterial pathogens (the effect on viral pathogens is less clear), and produces a greater number of water- and food-borne parasitic infections.[5,7] Climate change is also expected to expand or shift the habitat and range of disease-carrying organisms, such as mosquitoes, ticks, and rodents.[5] The distribution of vector-borne diseases may be altered, causing formerly prevalent diseases such as malaria to re-emerge, or allowing the introduction and spread of other diseases, such as West Nile virus and Dengue fever.[5]

Climate change, including changes in carbon dioxide (CO_2) concentrations and temperature, may affect the growth and distribution of allergen-producing vegetation such as weeds, grasses, and trees. Climate change has already caused an earlier onset of the U.S. spring pollen season.[9] The aeroallergens (e.g., pollen) themselves might be changed in terms of production, distribution, dispersion, and allergic potency.[2,9]

Changes in temperature, rainfall, and crop practices related to climate change are likely to affect use of and exposure to pathogens, pesticides, and other chemicals in a number of ways. Broader geographic distribution of pests and increased growth of invasive weeds will likely lead to greater use of pesticides.[7] Increased precipitation and increased variability in precipitation are likely to increase contaminant levels in lakes and other surface waters.[2,27] The distribution of chemicals in the environment is likely to change: for example, an increase in ice melts caused by a warming climate may release some past emissions of globally transported chemicals, such as PCBs and mercury, that have been trapped in polar ice.[28,29] Increasing concentrations of these chemicals in the atmosphere, and subsequent deposition to land and water, have the potential to increase concentrations of these chemicals in fish and other foods derived from animals. Warmer water temperatures may also increase the release of chemical contaminants from sediments, increasing their uptake in fish.[2]

Children are expected to be especially sensitive to the effects of climate change for a number of reasons. First, children's small ratio of body mass to surface area makes them vulnerable to heat-related illness and death.[30] Compared with adults, children have higher breathing rates, spend more time outside, and have less developed respiratory tracts—all making children more sensitive to air pollutants. Additionally, children have immature immune systems, meaning that they can experience more serious impacts from infectious diseases.[7] The greatest impacts are likely to fall on the poor, who lack the resources, such as adequate shelter and access to air conditioning, to cope with climate change.[7]

Indicator CL1 shows the trend in the percentage of children living in counties where unusually high temperatures were experienced one or more days per summer, between 1977 and 2008. While climate change may lead to an array of direct and indirect human health impacts, Indicator CL1 focuses on temperature alone and does not represent any of the potential indirect effects due to climate change, such as potential increases in air pollution, infectious diseases, allergens and extreme weather events. Furthermore, it is not well known which temperature-related metric may best represent the health consequences associated with high temperatures. Examples of other potential temperature-related metrics include rising overnight low temperatures, unseasonal high temperature days occurring in spring, consecutive hot days (heat waves), or a metric that combines temperature and humidity.[31]

Indicator CL1: Percentage of children ages 0 to 17 years living in counties with unusually high temperatures on three or more summer days, 1977–2008

Overview

Indicator CL1 presents information about the percentage of children living in counties with unusually high summer temperatures. The data come from the National Climatic Data Center 3200 Meteorological Dataset, which includes maximum and minimum daily temperatures measured by weather stations located throughout the country. Indicator CL1 shows how the percentage of children exposed to unusually high temperatures on three or more days per summer has changed over time.

National Climatic Data Center 3200 Meteorological Dataset

Daily temperature data for this indicator come from the National Climatic Data Center 3200 Meteorological Dataset: Surface Land Daily Cooperative Summary of the Day. For the years 1977–2008, the 3200 Meteorological Dataset has data for 2,311 counties, although completeness of the data varies by month and year. Sufficient data to assess maximum temperatures for all three summer months in all years 1977–2008 were available for 1,596 counties; about 70% of children in the United States lived in these counties in 2008.

Defining Unusually High Summer Temperatures

To define which children were exposed to unusually high temperatures, the following steps were taken. First, daily maximum temperatures at each weather station for a period of 11 years, from 1977–1987, were combined to establish a baseline. For each summer month, a cutoff point for unusually high heat was established as the daily maximum temperature that was reached by the hottest 1% of days from the approximately 330 values (11 years times 30 days per month) for each summer month in 1977–1987. This cutoff point represents an "unusually high temperature" and was defined independently for each county. From the mid 1930s to the mid 1970s, U.S. average temperatures decreased slightly.[32] Using 1977–1987 as a baseline therefore focuses on the more recent years without unduly influencing the baseline with lower temperatures from the period prior to 1977. An alternate analysis using 1960–1980 as the baseline yielded results very similar to those obtained using the 1977–1987 baseline.

Data Presented in this Indicator

The following indicator displays the trend in the percentage of children exposed to unusually high temperatures more than three days per summer (June, July, and August). The indicator was calculated by comparing the daily maximum temperatures to the unusually high temperature cutoff point for each year from 1977–2008. For each county, the number of days where the daily maximum temperature exceeded the cutoff value was calculated for each month. Then these monthly exceedances were summed across summer months to create a season total.

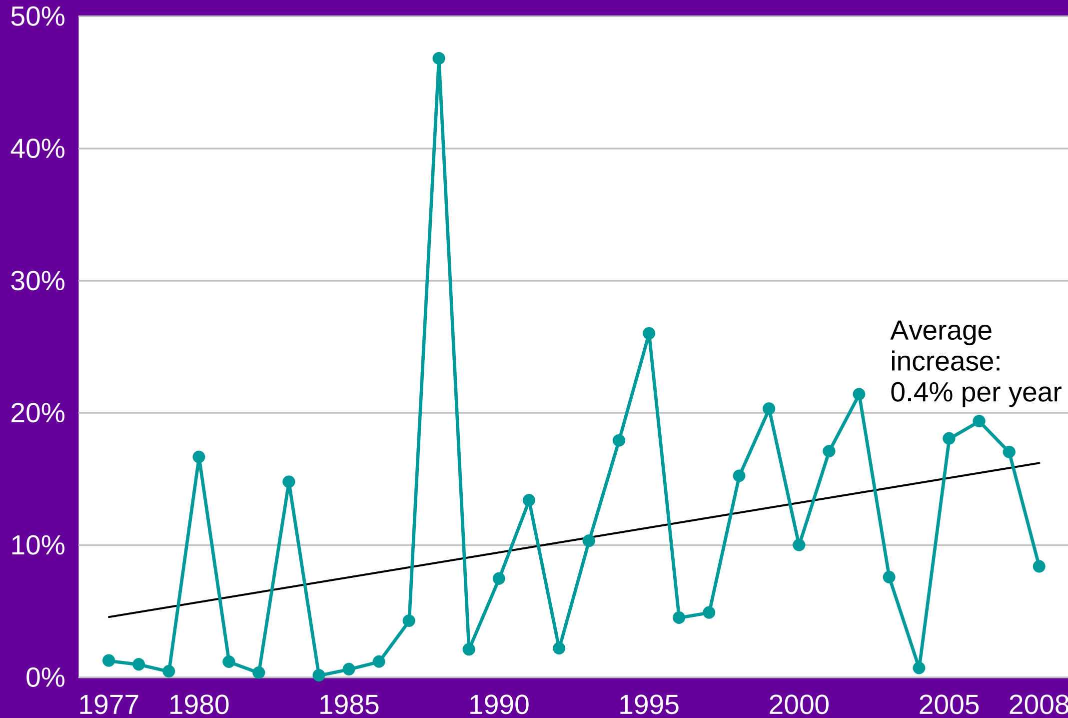
A county is considered to have experienced unusually high temperatures if the county exceeded the cutoff point on three or more days per summer. The number of children living in all such counties was summed up for each year, and divided by the total number of children living in counties with daily maximum temperatures in this data set. The indicator includes all children ages 0 to 17 years; however, it is important to note that infants (under 1 year) are especially vulnerable to heat events.[33]

The general approach used in calculating this indicator could be applied in several different ways. For example, the indicator could be calculated using temperature data year-round, or for particular seasons as it is done here. It could also be applied using different choices for what constitutes an unusually hot day (e.g., the hottest 1% or 5% of baseline days), and different choices for the number of days in a year or season exceeding that cutoff point. The approach taken here focuses on the hottest days during the hottest months of the year, the days where heat-related health effects may be most expected.

This indicator highlights only one aspect of climate change: increased temperatures. Of all the possible direct and indirect impacts of climate change, the relationship to adverse health impacts is most established for increased temperatures. Higher temperatures are related to air quality degradation, so the same children who are exposed to unusually high temperatures may also be exposed to higher levels of air pollution, and may also be more likely to experience other indirect effects of climate change.

Indicator CL1

Percentage of children ages 0 to 17 years living in counties with unusually high temperatures on three or more summer days, 1977-2008



DRAFT Indicator for Third Edition of America's Children and the Environment

DATA: National Climatic Data Center, 3200 Meteorological Dataset, Surface Land Daily Cooperative Summary of the Day

- Between 1977 and 2008, the percentage of children living in counties with unusually high temperatures on three or more summer days increased by an average of 0.4% per year, or 4% every 10 years.

- During the baseline period of 1977–1987, an average of 3.8% of children lived in counties with unusually high temperatures on three or more summer days. During the 11-year baseline period, four years exceeded this average, while during the most recent 11-year period for which data are available (1998–2008), 10 years exceeded this average.

Data Table

Table CL1. Percentage of children ages 0 to 17 years living in counties with unusually high temperatures on three or more summer days, 1977-2008

1977-1981				
1977	**1978**	**1979**	**1980**	**1981**
1.2%	1.0%	0.4%	16.6%	1.2%
1982-1986				
1982	**1983**	**1984**	**1985**	**1986**
0.3%	14.8%	0.1%	0.6%	1.2%
1987-1991				
1987	**1988**	**1989**	**1990**	**1991**
4.3%	46.8%	2.1%	7.4%	13.4%
1992-1996				
1992	**1993**	**1994**	**1995**	**1996**
2.2%	10.3%	17.9%	26.0%	4.5%
1997-2001				
1997	**1998**	**1999**	**2000**	**2001**
4.9%	15.2%	20.3%	10.0%	17.1%
2002-2006				
2002	**2003**	**2004**	**2005**	**2006**
21.4%	7.6%	0.7%	18.0%	19.4%
2007-2008				
2007	**2008**			
17.0%	8.4%			

DATA: National Climatic Data Center, 3200 Meteorological Dataset, Surface Land Daily Cooperative Summary of the Day

References

1. U.S. Environmental Protection Agency. 2010. *Climate Change Science Facts* Washington, DC: U.S. EPA, Office of Air and Radiation. EPA 430-F-10-002. http://www.epa.gov/climatechange/downloads/Climate_Change_Science_Facts.pdf.

2. U.S. Environmental Protection Agency. 2009. *Technical Support Document for Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202 (a) of the Clean Air Act*. Washington, DC: U.S. EPA, Office of Atmospheric Programs, Climate Change Division. http://www.epa.gov/climatechange/endangerment/downloads/Endangerment%20TSD.pdf.

3. U.S. Global Change Research Program. 2008. *Analyses of the Effects of Global Change on Human Health and Welfare and Human Systems (SAP 4.6)*. Washington, DC: U.S. Environmental Protection Agency. http://downloads.climatescience.gov/sap/sap4-6/sap4-6-final-report-all.pdf.

4. Field, C.B., L.D. Mortsch, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running, and M.J. Scott. 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Edited by M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson. Cambridge, UK: Cambridge University Press.

5. National Research Council. 2010. Advancing the Science of Climate Change. In *America's Climate Choices*. Washington, DC: The National Academies Press.

6. U.S. Environmental Protection Agency. 2009. *Climate Change and Children's Health*. Washington, DC: U.S. EPA, Office of Children's Health Protection. EPA-100-K-09-008. http://yosemite.epa.gov/ochp/ochpweb.nsf/content/OCHP_Climate_Brochure.htm/$File/OCHP_Climate_Brochure.pdf.

7. U.S. Global Change Research Program. 2009. *Global Climate Change Impacts in the United States*. Edited by T. R. Karl, J. M. Melillo and T. C. Peterson. Cambridge, UK: Cambridge University Press. http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf.

8. Shea, K.M. 2007. Global climate change and children's health. *Pediatrics* 120 (5):1149-52.

9. Confalonieri, U., B. Menne, R. Akhtar, K.L. Ebi, M. Hauengue, R.S. Kovats, B. Revich, and A. Woodward. 2007. Human Health. In *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. v. d. Linden and C. E. Hanson. Cambridge, UK: Cambridge University Press.

10. U.S. Environmental Protection Agency. 2010. *Heat Island Effect*. Retrieved June 1, 2010 from http://www.epa.gov/hiri/.

11. Andersen, Z.J., P. Wahlin, O. Raaschou-Nielsen, T. Scheike, and S. Loft. 2007. Ambient particle source apportionment and daily hospital admissions among children and elderly in Copenhagen. *Journal of Exposure Science and Environmental Epidemiology* 17 (7):625-36.

12. Annesi-Maesano, I., D. Moreau, D. Caillaud, F. Lavaud, Y. Le Moullec, A. Taytard, G. Pauli, and D. Charpin. 2007. Residential proximity fine particles related to allergic sensitisation and asthma in primary school children. *Respiratory Medicine* 101 (8):1721-9.

13. Gauderman, W.J., G.F. Gilliland, H. Vora, E. Avol, D. Stram, R. McConnell, D. Thomas, F. Lurmann, H.G. Margolis, E.B. Rappaport, K. Berhane, and J.M. Peters. 2002. Association between air pollution and lung function

growth in southern California children: results from a second cohort. *American Journal of Respiratory and Critical Care Medicine* 166 (1):76-84.

14. 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.

15. Norris, G., S.N. YoungPong, J.Q. Koenig, T.V. Larson, L. Sheppard, and J.W. Stout. 1999. An association between fine particles and asthma emergency department visits for children in Seattle. *Environmental Health Perspectives* 107 (6):489-93.

16. Ostro, B., L. Roth, B. Malig, and M. Marty. 2009. The effects of fine particle components on respiratory hospital admissions in children. *Environmental Health Perspectives* 117 (3):475-80.

17. Romieu, I., F. Meneses, S. Ruiz, J.J. Sienra, J. Huerta, M.C. White, and R.A. Etzel. 1996. Effects of air pollution on the respiratory health of asthmatic children living in Mexico City. *American Journal of Respiratory and Critical Care Medicine* 154 (2 Pt 1):300-7.

18. Tang, C.S., L.T. Chang, H.C. Lee, and C.C. Chan. 2007. Effects of personal particulate matter on peak expiratory flow rate of asthmatic children. *The Science of the Total Environment* 382 (1):43-51.

19. U.S. Environmental Protection Agency. 2004. *Air Quality Criteria for Particulate Matter*. Research Triangle Park, NC: U.S. EPA, National Center for Environmental Assessment. EPA/600/P-99/002aF, EPA/600/P-99/002bF. http://cfpub2.epa.gov/ncea/cfm/recordisplay.cfm?deid=87903.

20. 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.

21. Agency for Toxic Substances and Disease Registry (ATSDR). 1998. *Toxicological Profile for Sulfur Dioxide*. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service,. www.atsdr.cdc.gov/toxprofiles/tp116-c2.pdf.

22. Gent, J.F., E.W. Triche, T.R. Holford, K. Belanger, M.B. Bracken, W.S. Beckett, and B.P. Leaderer. 2003. Association of low-level ozone and fine particles with respiratory symptoms in children with asthma. *Journal of the American Medical Association* 290 (14):1859-67.

23. 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.

24. McConnell, R., T. Islam, K. Shankardass, M. Jerrett, F. Lurmann, F. Gilliland, J. Gauderman, E. Avol, N. Kuenzli, L. Yao, J. Peters, and K. Berhane. 2010. Childhood Incident Asthma and Traffic-Related Air Pollution at Home and School. *Environmental Health Perspectives* 118:1021-26.

25. U.S. Environmental Protection Agency. 2006. *Air Quality Criteria for Ozone and Related Photochemical Oxidants*. Research Triangle Park, NC: U.S. EPA, National Center for Environmental Assessment. EPA/600/R-05/004aF. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=149923.

26. U.S. Environmental Protection Agency. 2008. *Integrated Science Assessment for Oxides of Nitrogen- Health Criteria*. Research Triangle Park, NC: U.S. EPA. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=194645.

27. U.S. Environmental Protection Agency. 2009. *Climate Change: Water Resources*. U.S. EPA, Climate Change Division. Retrieved February 11, 2011 from http://www.epa.gov/climatechange/effects/water/index.html.

28. Bogdal, C., P. Schmid, M. Zennegg, F.S. Anselmetti, M. Scheringer, and K. Hungerbuhler. 2009. Blast from the past: melting glaciers as a relevant source for persistent organic pollutants. *Environmental Science and Technology* 43 (21):8173-7.

29. Carrie, J., F. Wang, H. Sanei, R.W. Macdonald, P.M. Outridge, and G.A. Stern. 2010. Increasing Contaminant Burdens in an Arctic Fish, Burbot (Lota lota), in a Warming Climate. *Environmental Science and Technology* 44 (1):316-322.

30. U.S. Environmental Protection Agency. 2010. *Climate Change and the Health of Children*. U.S. EPA, Office of Children's Health Protection. Retrieved December 22, 2010 from http://yosemite.epa.gov/ochp/ochpweb.nsf/content/climate.htm.

31. U.S. Environmental Protection Agency. 2010. *Climate Change Indicators in the United States*. Washington, DC: U.S. EPA, Office of Air and Radiation, Climate Change Division. EPA 430-R-10-007. http://www.epa.gov/climatechange/indicators/pdfs/ClimateIndicators_full.pdf.

32. Menne, M.J., C.N. Williams, and R.S. Vose. 2010. The United States Historical Climatology Network Monthly Temperature Data - Version 2. *Bulletin of the American Meteorological Society* 90:993-1107.

33. U.S. Environmental Protection Agency. 2006. *Excessive Heat Events Guidebook*. Washington, DC: U.S. EPA, Office of Atmospheric Programs. EPA 430-B-06-005. http://www.epa.gov/heatisld/about/pdf/EHEguide_final.pdf.

Metadata

Metadata for	National Climatic Data Center, 3200 Meteorological Dataset, Surface Land Daily Cooperative Summary of the Day
Brief description of the data set	The 3200 Meteorological Dataset from the National Climatic Data Center contains various weather parameters, including maximum and minimum daily temperatures, snowfall, and 24-hour precipitation totals.
Who provides the data set?	U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center.
How are the data gathered?	Data are collected from weather stations located throughout the country. Currently, there are 8,000 active weather stations.
What documentation is available describing data collection procedures?	See http://www1.ncdc.noaa.gov/pub/data/documentlibrary/tddoc/td3200.pdf for documentation on data collection procedures as well as information on the weather stations.
What types of data relevant for children's environmental health indicators are available from this database?	Maximum and minimum daily temperatures.
What is the spatial representation of the database (national or other)?	National.
Are raw data (individual measurements or survey responses) available?	Individual daily records are available for each weather station.
How are database files obtained?	All meteorological data can be downloaded from the ftp server provided by National Climatic Data Center at: ftp://ftp3.ncdc.noaa.gov/pub/data/.
Are there any known data quality or data analysis concerns?	No: the documentation for the data set includes this statement: "The data have received a high measure of quality control through computer and manual edits. The data are subjected to internal consistency checks, compared against climatological limits, checked serially, and evaluated against surrounding stations... In November 1993 the entire historical period of record was processed through a stringent quality control.

Metadata for	**National Climatic Data Center, 3200 Meteorological Dataset, Surface Land Daily Cooperative Summary of the Day**
	Another round of quality control in November 2000 increased the data set's quality still more."
What documentation is available describing QA procedures?	The above statement, and other details on the data set, come from this document: Data Documentation for Data Set 3200 (DSI-3200) - Surface Land Daily Cooperative Summary of the Day. National Climatic Data Center, July 27, 2009.
For what years are data available?	Some limited data are available starting as far back as the 1850s. Most states began collecting data during 1948, but some began in 1946. For the purpose of this analysis, only data for the years 1977-2008 were used.
What is the frequency of data collection?	Data are collected on a daily basis.
What is the frequency of data release?	Data are released on a regular basis throughout the year. The initial release of data for any month is marked "preliminary;" when quality control is complete, the "preliminary" designation is removed.
Are the data comparable across time and space?	There are uniform instructions for national weather stations on proper observing and reporting of weather data, available at: http://www.ofcm.gov/fmh-1/fmh1.htm.
Can the data be stratified by race/ethnicity, income, and location (region, state, county or other geographic unit)?	Data can be stratified by location using latitude and longitude recordings, which can be downloaded at: http://www.ncdc.noaa.gov/oa/climate/surfaceinventories.html#inventories.

Methods

Indicator

CL1. Percentage of children ages 0 to 17 years living in counties with unusually high temperatures on three or more summer days, 1977-2008.

Summary

Beginning as far back as the 1850s, the National Climatic Data Center, in the U.S. Department of Commerce, has been recording daily meteorological data at weather stations throughout the United States. Currently, there are approximately 8,000 active weather stations. Indicator CL1 uses daily maximum temperature measurements to identify counties where unusually high temperatures were experienced three or more days in the summer months (June, July, and August) of each year. The indicator is calculated by summing up the number of children living in those counties, then dividing by the number of children living in all counties with weather stations with complete data.

Overview of Data Files

The following files are needed to calculate this indicator.

- National Climatic Data Center: 3200 Meteorological Dataset, Surface Land Daily Cooperative Summary of the Day. Contains the cooperative station ID (COOPID), date (DATE), year (YEAR), month (MONTH), day of the month (DAY), and daily maximum temperature (TMAX).

- National Climatic Data Center: Historical cooperative station index. Includes data for each weather station, including station numbers, call letters, country, state, county, time zone, station name, latitude (degrees-minutes-seconds, north=positive, south=negative), longitude (degrees-minutes-seconds, east=positive, west=negative), and elevation (in feet).

- Census data. This file contains the state and county Federal Information Processing Standard (FIPS) codes, year, and children's population.

  For 1977-1979, we obtained this information from the U.S. Census Bureau files:

    Estimates of the Population of Counties in the United States by Age, Sex, and Race: July 1, 1970 through July 1, 1979. File: co-asr-7079.csv
    Source: U.S. Census Bureau, Population Division. Internet Release date: October 22, 2004.
    http://www.census.gov/popest/archives/pre-1980/co-asr-7079.html

Intercensal Estimates of the Resident Population of States 1970 to 1980.
http://www.census.gov/popest/archives/pre-1980/e7080sta.txt

For 1980-1989, we obtained this information from the U.S. Census Bureau files:

Intercensal County Estimates by Age, Sex, Race: 1980-1989.
http://www.census.gov/popest/archives/1980s/PE-02.html

Historical Annual Time Series of State Population Estimates and Demographic Components of Change 1980 to 1990, by Single Year of Age and Sex.
http://www.census.gov/popest/archives/1980s/80s_st_age_sex.html

For 1990-1999, we obtained this information from the U.S. Census Bureau files:

Estimates of the Population of Counties by Age and Sex: 1990-1999, August 30, 2000. The file headers were "(C0-99-9) Population Estimates for Counties by Age and Sex: Annual Time Series July 1, 1990 to July 1, 1999."
http:/www.census.gov/popest/archives/1990s/CO-99-09.html

For 2000-2008, we obtained this information from the bridged-race Vintage 2008 postcensal population file:

National Center for Health Statistics. Postcensal estimates of the resident population of the United States for July 1, 2000-July 1, 2008, by year, county, age, bridged race, Hispanic origin, and sex (Vintage 2008). Prepared under a collaborative arrangement with the U.S. Census Bureau; released May 14, 2009. Available from: http://www.cdc.gov/nchs/nvss/bridged_race.htm as of September 2, 2009.

Weather Station Data

The National Climatic Data Center Historical Cooperative Station Index provides the exact location of each climate monitor. Of the 3,140 counties or county-equivalent administrative units listed by the U.S. Census Bureau, 1,596 counties (wherein approximately 70% of children resided in 2008) had climate monitor data for all three summer months.[i]

Daily TMAX values were recorded for each weather station in the 3200 Meteorological Dataset. FIPS codes were assigned to the 3200 Meteorological Dataset county names for ease of data linkage. For counties containing multiple weather stations, a mean daily TMAX was calculated for all the stations in the county.

Census Data

[i] U.S. Census Bureau. USA Counties. [cited 2010 Aug 10]; Available from: http://censtats.census.gov/usa/usainfo.shtml.

The census data used for the analyses were obtained from the U.S. Census Bureau. The files are listed above.

For the years 1990-1999, census intercensal files provide annual populations by county, age, and sex. For the years 2000-2008, the bridged race Vintage 2008 postcensal population files provide annual populations by county, age, bridged race, Hispanic origin, and sex. In both cases, children's populations by county and year were calculated by summing the county annual populations over all the subgroups for children ages 0 to 17 years.

For the years 1977-1989, the census archive files provide annual estimates by county, sex, and five-year age groups. At the state level, the census archive files provide annual estimates by state by year and age. The state-level data were used to estimate the proportions of the age 15-17 county population in the five-year age group 15-19, which were used to estimate annual county populations for children ages 0 to 17 years. A further reallocation was used to adjust county populations for changes in the county geographical areas. The detailed calculations were performed as follows:

Step 1. The intercensal estimates by county and five-year age group for the years 1970-1979 and 1980-1989 were obtained from the http://www.census.gov archives files detailed above. These files give annual population estimates from the age groups 0-4, 5-9, 10-14, 15-19, and other five-year age groups not used for these analyses. Populations are stratified into various race and sex groups. For these analyses, the county populations were summed across all the race and sex groups. This gives county populations for the age groups 0-4, 5-9, 10-14, and 15-19.

Step 2. To estimate the county populations for the age group 15-17, the county populations for ages 15-19 were multiplied by the corresponding state's proportion of ages 15-17 among ages 15-19. The intercensal estimates by state and age for the years 1970-1979 and 1980-1989 include estimates of state populations by year and age for ages 15 to 19 years. In step 2, for each state and year, the ratio of the population of ages 15-17 to the population of ages 15-19 was calculated. These ratios ranged from 0.4777 to 0.6493.

Ratio = State Population (15-17) / State Population (15-19)

Step 3. To estimate the county populations of children ages 0 to 17 years by year, the results of Steps 1 and 2 were combined. The estimated population of children in each county is given by

County Population (0-17) =
County Population (0-4) + County Population (5-9) + County Population (10-14)
+ Ratio × County Population (15-19)

The ratio (for the state containing that county) is calculated in Step 2.

Step 4. This step accounts for FIPS code changes due to changes in geographic areas as detailed in the "Census Data Summary" document:

United States Department of Commerce, U.S. Census Bureau, Population Division; Census Population 1970-2000 for Public Health Research, CDC WONDER Online Database, March 2003. "Census Data Summary."

http://wonder.cdc.gov/wonder/help/Census1970-2000.html#Source

The result was a set of estimates for the same set of 3141 county FIPS codes used from 1990 onward. The calculations used are approximations.

The following adjustment method was applied for each of the geographic area changes that were either made beginning in 1980 (including changes made retroactively) or made beginning in 1990. Briefly, the county children's populations for a set of FIPS codes in one decade are reallocated in proportion to the children's county populations for the realigned set of FIPS codes at the beginning of the next decade.

To illustrate the approach, consider the "Census Data Summary" items 12, 14, 15, 17, 18, and 19 for 1970-1979. These six items show that the 1970s populations of FIPS code 02160 were added to either FIPS code 02050 or 02290; the 1970s populations of FIPS code 02250 were added to either FIPS code 02240 or 02290; and the 1970s populations of FIPS codes 02080 and 02260 and part of 02240 were combined into the 1980s FIPS code 02261. Thus the set of 1970s FIPS codes 02050, 02080, 02160, 02240, 02250, 02260, and 02290 were moved to the set of 1980s FIPS codes 02050, 02290, and 02240. These six items have to be considered together so that the sets of 1970s codes that are moved do not overlap, and the sets of 1980s codes that they are moved to do not overlap.

Table 1. Revisions of 1977 populations for selected FIPS based on 1970-1989 geographical area changes.

FIPS Code (1)	**Children's Population 1977 per 1970-1979 Intercensal estimates (2)**	**Children's Population 1980 per 1980-1989 Intercensal estimates (3)**	**1980 Percentage (4) [(3) divided by Total of (3)]**	**Revised Children's Population 1977 (5) [(Total of 2)×(4)]**
02050	4,190	4,453	38%	4,786
02080	685	0	0%	FIPS deleted
02160	1,091	0	0%	FIPS deleted
02240	1,831	2,016	17%	2,167*
02250	567	0	0%	FIPS deleted
02260	2,382	0	0%	FIPS deleted
02261	FIPS added	2,592	22%	2,786
02290	1,875	2,681	23%	2,882*
Total (may not equal column total due to rounding)	**12,621**	**11,742**	**100%**	**12,621**

*The final 1977 population estimates for FIPS codes 02240 and 02290 are different from the values in this table because of the subsequent realignment of FIPS codes for 1990-1999.

Table 1 shows the calculations for this example. The second column shows the original population estimates for 1977 for the 1970s FIPS codes, which sum to 12,621. The third column shows the populations in 1980 for the new set of 1980s FIPS codes, which exclude 02080, 02160, 02250, and 02260, and add the new code 02261. The fourth column shows these 1980 children's populations as percentages of the total, 11742, for those four FIPS codes. For example, FIPS code 02050 had 38% of the children's population among those four FIPS codes in 1980. As an approximation, we estimate that the children's population for 1977 that would have moved to the FIPS code 02050 will also be 38% of the original 1977 population; i.e., 38% of 12,621 = 4,786, as shown in the fifth column. Thus we reallocated the 1977 total population for the original seven FIPS to the four 1980s FIPS using the distribution of the population in 1980. The old FIPS codes 02080, 02160, 02250, and 02260 were then deleted. The same calculation was applied to the other years 1978 and 1979.

The same approach was applied for each of the population changes beginning in 1980 as identified in the "Census Data Summary" (for 1970-1979 and 1980-1989). Finally, a similar approach was applied for the FIPS changes from 1980-1989 to 1990 described in the "Census Data Summary," based on 1990 children's populations percentages.

Calculation of Indicator

In order to determine the number of children living in counties with unusually high temperatures, it was first necessary to establish a baseline for comparison. For the purpose of this analysis, the baseline was established for the years 1977-1987.[ii]

Baseline norms were established for each county separately. The National Climatic Data Center Historical Cooperative Station Index provides the exact location of each climate monitor. Of the 3,140 counties or county-equivalent administrative units listed by the U.S. Census Bureau, 1,596 counties (wherein approximately 70% of children resided in 2008) had climate monitor data for all three summer months.[iii] The daily maximum temperatures were considered separately for each month. Over the entire baseline period, there were approximately 330 values for each month (11 years times 30 days per month). Using those 330 values, the 99th percentile daily maximum temperature was established for each month.

Once the baseline was established, the indicator was calculated using each year between 1977 and 2008. For each year, in each county, the number of days in June, July, and August when the maximum temperature exceeds the month-specific 99th percentile maximum daily temperature were counted.

[ii] An analysis using 1960-1980 as the baseline yielded results very similar to those obtained using the 1977-1987 baseline.
[iii] U.S. Census Bureau. USA Counties. [cited August 10, 2010]; Available from: http://censtats.census.gov/usa/usainfo.shtml.

Counties with three or more days in June, July, and August exceeding the 99th percentile maximum daily temperature were identified for each year. U.S. Census child population estimates (ages 0 to 17 years) for each county were used to determine the number of children living in the identified counties. This number was then divided by the total number of children living in all 2,311 counties with weather stations in the data set to determine the percentage of children living in counties where the maximum daily temperature exceeded the 99th percentile three or more days during the summer months.

Questions and Comments

Questions regarding these methods, and suggestions to improve the description of the methods, are welcome. Please use the “Contact Us” link at the bottom of any page in the America’s Children and the Environment website.