

Report on the Environment

<https://www.epa.gov/report-environment>

Serum Cotinine

Secondhand smoke, also referred to as environmental tobacco smoke, contains a mixture of toxic chemicals, including known human carcinogens. The U.S. Surgeon General has concluded that secondhand smoke causes a range of adverse health outcomes in adults, ranging from nasal irritation to increased risk of coronary heart disease to lung cancer. In children, the Surgeon General has concluded that secondhand smoke causes lower respiratory illnesses, adverse effects on lung function, onset of wheezing, asthma, middle ear disease, and sudden infant death syndrome (HHS, 2006). Household secondhand smoke exposure is an important issue because many people, especially young children, spend much time inside their homes. Infants and younger children are more susceptible and vulnerable to the effects of secondhand smoke than are older children because they are still developing physically, have higher breathing rates than adults, and have little control over their indoor environments (HHS, 2006; U.S. EPA, 2021).

Exposure to secondhand smoke leaves traces of specific chemicals in people's serum, urine, saliva, and hair. Cotinine is a chemical that forms inside the body following exposure to nicotine, an ingredient in all tobacco products and a component of secondhand smoke. Following nicotine exposures, cotinine can usually be detected in serum for at least 1 or 2 days (Pirkle et al., 1996). Active smokers almost always have serum cotinine levels higher than 10 nanograms per milliliter (ng/mL), while non-smokers exposed to typical levels of secondhand smoke have serum concentrations less than 1 ng/mL. Following heavy exposure to secondhand smoke, non-smokers can have serum cotinine levels between 1 and 10 ng/mL (CDC, 2015, 2017).

The purpose of this indicator is to track exposure to secondhand smoke among the non-smoking U.S. population. Cotinine is considered the best biomarker for tracking exposure among non-smokers to secondhand smoke. Accordingly, this indicator reflects serum cotinine concentrations in ng/mL among non-smokers for a representative sample of the U.S. population, age 3 years and older, as measured in the 1988-1994, 1999-2000, 2001-2002, 2003-2004, 2005-2006, 2007-2008, 2009-2010, 2011-2012, 2013-2014, 2015-2016, and 2017-2018 National Health and Nutrition Examination Survey (NHANES). NHANES is a series of surveys conducted by the Centers for Disease Control and Prevention's (CDC's) National Center for Health Statistics, designed to collect data on the health and nutritional status of the civilian, non-institutionalized U.S. population using a complex, stratified, multistage, probability-cluster design. Serum cotinine also was monitored in individuals age 4 years and older as part of NHANES III, between 1988 and 1994. CDC's National Center for Environmental Health conducted the laboratory analyses for the biomonitoring samples. Beginning in 1999, NHANES became a continuous and annual national survey. The continuous NHANES does not include cotinine data for children from birth to 3 years of age, the group reported to be the most vulnerable to the effects of secondhand smoke.

What the Data Show

The results of NHANES III (1988-1994) and continuous NHANES (1999-2018) are presented here for the different survey periods by sex (Exhibit 1), race and ethnicity (Exhibit 2), and age (Exhibit 3). During the 1988-1994 survey period, the median (50th percentile) serum cotinine level among

non-smokers in the general U.S. population was 0.176 ng/mL. In 1999-2000, the estimated median serum cotinine level among non-smokers nationwide had decreased to 0.060 ng/mL. During the most recent survey period (2017-2018), the estimated median serum cotinine level for the U.S. population was 0.016 ng/mL (see Exhibit 1). This marks a greater than 70 percent decrease from levels measured in 1999-2000 and a 90 percent decline since NHANES III (1988-1994)—a consistent reduction over time that suggests a marked decrease in exposure to secondhand smoke. Similar decreasing trends in serum cotinine levels are observed between NHANES III (1988-1994) and the most recent 2017-2018 survey across sex, race/ethnicity, and age groups. However, 38.2 percent of children age 3 to 11 years still had "detectable" cotinine in their serum (defined as serum cotinine levels of 0.05 to 10 ng/mL) in 2017-2018 (CDC, 2022a; data not shown).

Other observations include: (1) non-smoking males have slightly higher cotinine levels than females across survey periods (Exhibit 1); (2) of the race/ethnicity groups presented, non-Hispanic blacks generally have the highest cotinine levels (Exhibit 2); and (3) in general, people below the age of 20 have higher serum cotinine levels than people age 20 years and older (Exhibit 3).

Exhibit 4 shows the percentage of non-smokers aged 3 to 17 years with serum cotinine levels more than 0.05 ng/mL and less than or equal to 10 ng/mL (the standard range for classifying secondhand smoke exposure) for the total age group and by selected race and ethnicity breakdowns. Among the five subgroup populations presented, Mexican American children had the lowest percentage of serum cotinine levels greater than 1.0 ng/mL and less than or equal to 10 ng/mL for all time periods displayed except for 2011-2012 and 2015-2016 when the lowest percentages were observed among Asian and all Hispanic children, respectively.

Serum cotinine levels greater than 1.0 ng/mL and less than or equal to 10 ng/mL declined for non-Hispanic blacks, Mexican Americans, and non-Hispanic whites between 1999-2000 and 2017-2018, with an absolute decrease of 7.9, 0.3, and 10.9 percent, respectively. The percentage of all Hispanic children with serum cotinine levels greater than 1.0 ng/mL and less than or equal to 10 ng/mL increased by 2.9 percent from 2011-2012 to 2017-2018 and by 4.7 percent among Asian children from 2011-2012 and 2013-2014 (the years with available data).

Limitations

- The relatively small number of samples collected in a 2-year cycle (e.g., 1999-2000 or 2001-2002) may, in some cases, result in measures of central tendency that are unstable from one survey period to the next.

Data Sources

Continuous NHANES data from 1999-2018 in Exhibits 1 through 3 of this indicator were obtained directly from CDC's National Report on Human Exposure to Environmental Chemicals: Analysis of whole blood, serum, and urine samples, NHANES 1999-2018, which was updated in March 2022 (CDC, 2022b). NHANES III (1988-1994) data for Exhibits 1 through 3, as well as all data used for Exhibit 4, were generated with Stata statistical software using NHANES laboratory data files available online in SAS[®] transport file format (CDC, 2022a).

References

CDC (Centers for Disease Control and Prevention). 2022a. National Center for Health Statistics, National Health and Nutrition Examination Survey. Second Laboratory 2A files (1988-1994);

Cadmium, lead, mercury, cotinine & nutritional biochemistries (1999-2000, 2001-2002); Cotinine (2003-2004, 2005-2006, 2007-2008, 2009-2010, 2011-2012); Cotinine and hydroxycotinine (2013-2014, 2015-2016, 2017-2018). Accessed April 19, 2022.
<https://wwwn.cdc.gov/nchs/nhanes/default.aspx>.

CDC. 2022b. National report on human exposure to environmental chemicals: Analysis of whole blood, serum, and urine samples, NHANES 1999-2018. Updated March 2022. Accessed May 25, 2022. https://www.cdc.gov/exposurereport/data_tables.html.

CDC. 2017. National Biomonitoring Program, biomonitoring summary for cotinine. Last reviewed April 7, 2017. Accessed August 3, 2022.
https://www.cdc.gov/biomonitoring/Cotinine_BiomonitoringSummary.html.

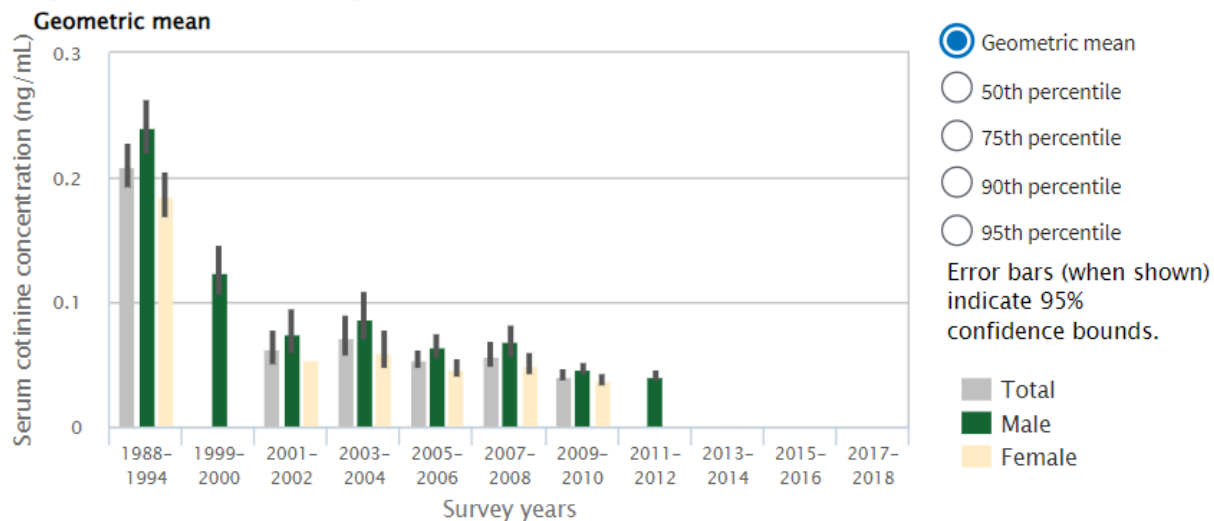
CDC. 2015. Vital Signs: Disparities in nonsmokers' exposure to secondhand smoke—United States, 1999–2012. MMWR 64(04):103-108. Accessed August 3, 2022.
https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6404a7.htm?s_cid=mm6404a7_w.

HHS (U.S. Department of Health and Human Services). 2006. The health consequences of involuntary exposure to tobacco smoke: A report of the surgeon general. O2NLM: WA 754 H4325 2006. Atlanta, GA: U.S. Department of Health and Human Services, 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. Accessed August 3, 2022.
<https://www.ncbi.nlm.nih.gov/books/NBK44324/>.

Pirkle, J.L., K.M. Flegal, J.T. Bernert, D.J. Brody, R.A. Etzel, and K.R. Maurer. 1996. Exposure of the U.S. population to environmental tobacco smoke: The third national health and nutrition examination survey, 1988 to 1991. J. Amer. Med. Assoc. 275:1233-1240.

U.S. EPA (United States Environmental Protection Agency). 2021. Secondhand smoke and smoke-free homes. Last updated October 5, 2021. Accessed August 3, 2022.
<https://www.epa.gov/indoor-air-quality-iaq/secondhand-tobacco-smoke-and-smoke-free-homes>.

Exhibit 1. Serum cotinine concentrations for the non-smoking U.S. population age 3 years and older by sex, 1988–2018



1988–1994 data are for age 4 years and older.

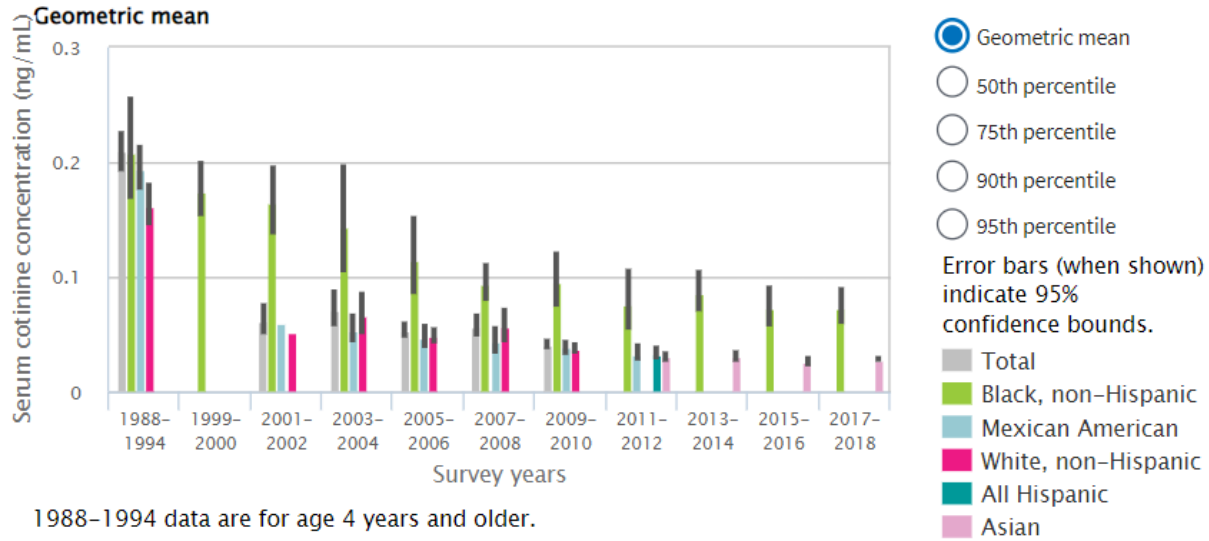
Geometric means are not calculated or displayed in cases where the proportion of results below the limit of detection was too high to provide a valid result. Neither are error bars where the lower bound is below the limit of detection. The limit of detection for cotinine was 0.05 ng/mL in 1999–2000; 0.05 ng/mL and 0.015 ng/mL in 2001–2002; and 0.015 ng/mL in 2003–2018.

Information on the statistical significance of the trends in this exhibit is not presented here. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: CDC, 2022a,b

Visit <https://www.epa.gov/roe> to see the full exhibit.

Exhibit 2. Serum cotinine concentrations for the non-smoking U.S. population age 3 years and older by race and ethnicity, 1988–2018



1988–1994 data are for age 4 years and older.

Geometric means are not calculated or displayed in cases where the proportion of results below the limit of detection was too high to provide a valid result. Neither are error bars where the lower bound is below the limit of detection. The limit of detection for cotinine was 0.05 ng/mL in 1999–2000; 0.05 ng/mL and 0.015 ng/mL in 2001–2002; and 0.015 ng/mL in 2003–2018.

Other racial and ethnic groups are included in the "total" only.

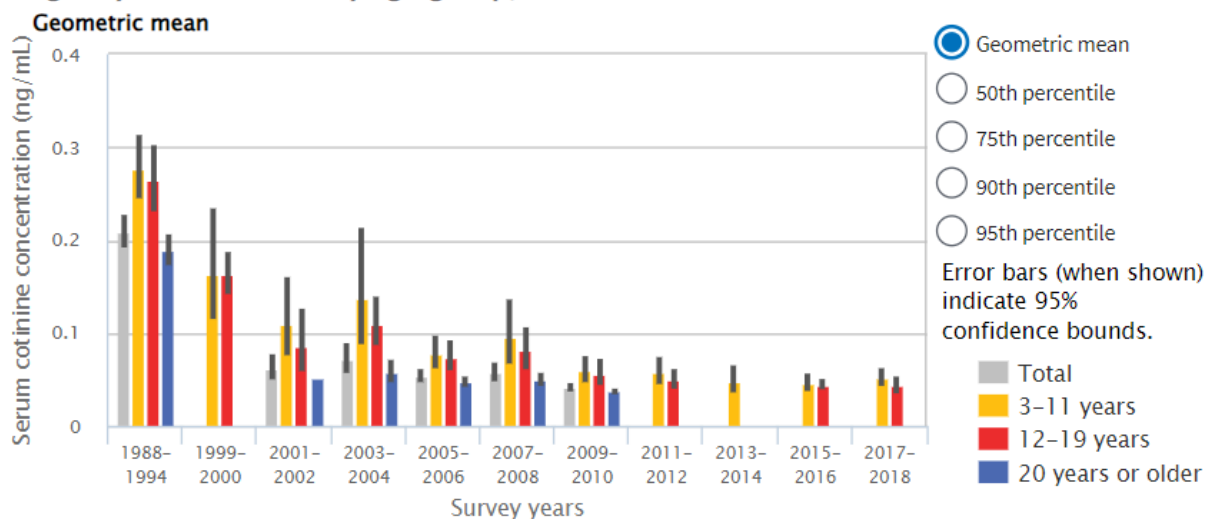
NHANES data for All Hispanics and Asians were available starting with the 2011–2012 survey period.

Information on the statistical significance of the trends in this exhibit is not presented here. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: CDC, 2022a,b

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Exhibit 3. Serum cotinine concentrations for the non-smoking U.S. population age 3 years and older by age group, 1988–2018



1988–1994 data are for age 4 years and older.

Geometric means are not calculated or displayed in cases where the proportion of results below the limit of detection was too high to provide a valid result. Neither are error bars where the lower bound is below the limit of detection. The limit of detection for cotinine was 0.05 ng/mL in 1999–2000; 0.05 ng/mL and 0.015 ng/mL in 2001–2002; and 0.015 ng/mL in 2003–2018.

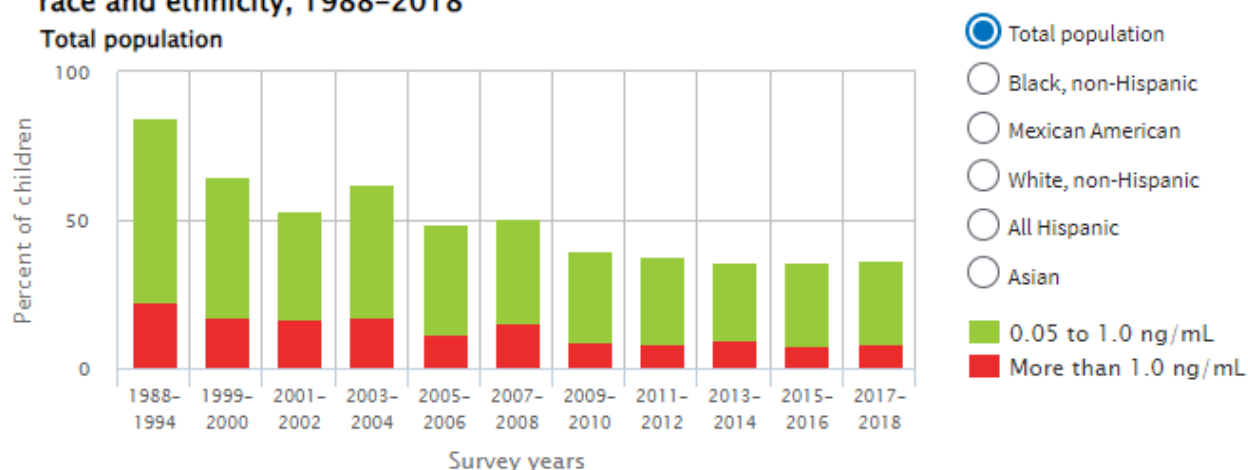
Information on the statistical significance of the trends in this exhibit is not presented here. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: CDC, 2022a,b

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Exhibit 4. Serum cotinine concentrations in U.S. children age 3 to 17 years by race and ethnicity, 1988–2018

Total population



1988–1994 data are for age 4 to 17 years.

Cotinine concentrations are reported for "non-smoking" children only, defined as having serum cotinine concentrations less than or equal to 10.0 ng/mL.

Concentrations below 0.05 ng/mL are not presented here because this was the detection limit for many of the pre-2002 samples.

Other racial and ethnic groups are included in the "total" only.

Information on the statistical significance of the trends in this exhibit is not presented here. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: CDC, 2022a

Visit <https://www.epa.gov/roe> to see the full exhibit.