Serum Cotinine

Environmental tobacco smoke (ETS) contains a mixture of toxic chemicals, including known human carcinogens. The U.S. Surgeon General has concluded that ETS 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 ETS causes lower respiratory illnesses, adverse effects on lung function, onset of wheezing, asthma, middle ear disease, and Sudden Infant Death Syndrome (HHS, 2006). Household ETS 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 ETS 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, 2011).

Exposure to ETS 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 ETS. 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 low levels of ETS typically have serum concentrations less than 1 ng/mL. Following heavy exposure to ETS, non-smokers can have serum cotinine levels between 1 and 10 ng/mL (CDC, 2009, 2015a).

The purpose of this indicator is to track exposure to ETS, or secondhand smoke, among the non-smoking U.S. population. Cotinine is considered the best biomarker for tracking exposure among non-smokers to ETS. 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, and 2011-2012 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 non-smokers 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. 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 ETS.

What the Data Show

The results of NHANES III (1988-1994) and continuous NHANES (1999-2012) 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 serum cotinine level (50th percentile) among non-smokers in the general U.S. population was 0.176 ng/mL. In 1999-2000, the estimated median serum (50th percentile) cotinine level among non-smokers nationwide had decreased to 0.060 ng/mL. During the most recent survey period (2011-2012), the estimated median serum cotinine level for the U.S. population was 0.020 ng/mL (see Exhibit 1). This marks a greater than 65 percent

decrease from levels measured in 1999-2000 and a nearly 90 percent decline since NHANES III (1988-1994)—a consistent reduction over time that suggests a marked decrease in exposure to ETS. Similar decreasing trends in serum cotinine levels are observed between NHANES III (1988-1994) and the most recent 2011-2012 survey across sex, race/ethnicity, and age groups (CDC, 2014). However, CDC reports that 40.6 percent of children age 3 to 11 years still had detectable cotinine in their serum in 2011-2012 (CDC, 2015a).

These data reveal three additional observations: (1) non-smoking males have slightly higher cotinine levels than females across survey periods (Exhibit 1); (2) of the ethnic groups presented, non-Hispanic blacks had 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 children between the ages of 3 and 17 with specified serum cotinine levels, for the total age group and by selected race and ethnicity breakdowns. Among the three subgroup populations presented, Mexican American children had the lowest percentage of serum cotinine levels greater than 1.0 ng/mL; this was evident for all time periods displayed. Between 1988-1994 and 1999-2000, black, non-Hispanic children had the largest absolute decline in the percentage of serum cotinine levels greater than 1.0 ng/mL, but that population also started off with the highest percentage above 1.0 ng/mL (33.7 percent). In 2011-2012, the percent of children with serum cotinine levels greater than 1.0 ng/mL decreased by 6.2, 3.5, and 11.8 percent among non-Hispanic blacks, Mexican Americans, and non-Hispanic whites, respectively, compared to 1999-2000.

Limitations

- The relatively small number of samples collected in a two-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 (1999-2012) data used for Exhibits 1 through 3 of this indicator were obtained directly from CDC's Fourth National Report on Human Exposure to Environmental Chemicals, Updated Tables, August 2014 (CDC, 2014a). NHANES III (1988-1994) data for Exhibits 1 through 4 were generated with Stata statistical software using NHANES laboratory data files available online (CDC 2014b, 2015b). Continuous NHANES (1999-2012) data used for Exhibit 4 also were generated with Stata statistical software using NHANES data files available online in SAS® transport file format (CDC, 2015b).

References

CDC (Centers for Disease Control and Prevention). 2015a. Vital Signs: Disparities in nonsmokers' exposure to secondhand smoke—United States, 1999–2012. MMWR 64(04):103-108. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6404a7.htm?s_cid=mm6404a7_w.

CDC. 2015b. National Center for Health Statistics, National Health and Nutrition Examination Survey. Accessed March 2015. http://www.cdc.gov/nchs/nhanes/nhanes_questionnaires.htm.

CDC. 2014a. Fourth national report on human exposure to environmental chemicals, updated tables, August. http://www.cdc.gov/exposurereport/pdf/fourthreport_updatedtables_aug2014.pdf (PDF)

(514 pp, 27.6MB).

CDC. 2014b. National Center for Health Statistics, National Health and Nutrition Examination Survey. Accessed November 2014. http://www.cdc.gov/nchs/nhanes/nhanes_questionnaires.htm.

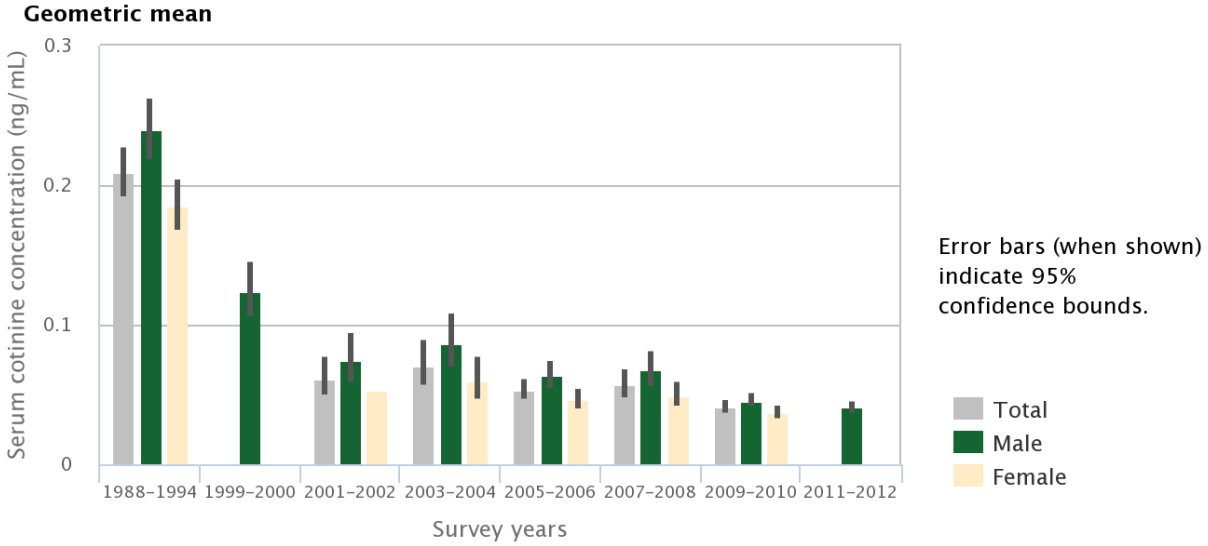
CDC. 2009. Fourth national report on human exposure to environmental chemicals. http://www.cdc.gov/exposurereport.

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. http://www.surgeongeneral.gov/library/reports/secondhandsmoke/report-index.html.

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. 2015. Secondhand tobacco smoke and smoke-free homes. Last updated November 16, 2015. http://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, 1988-2012



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

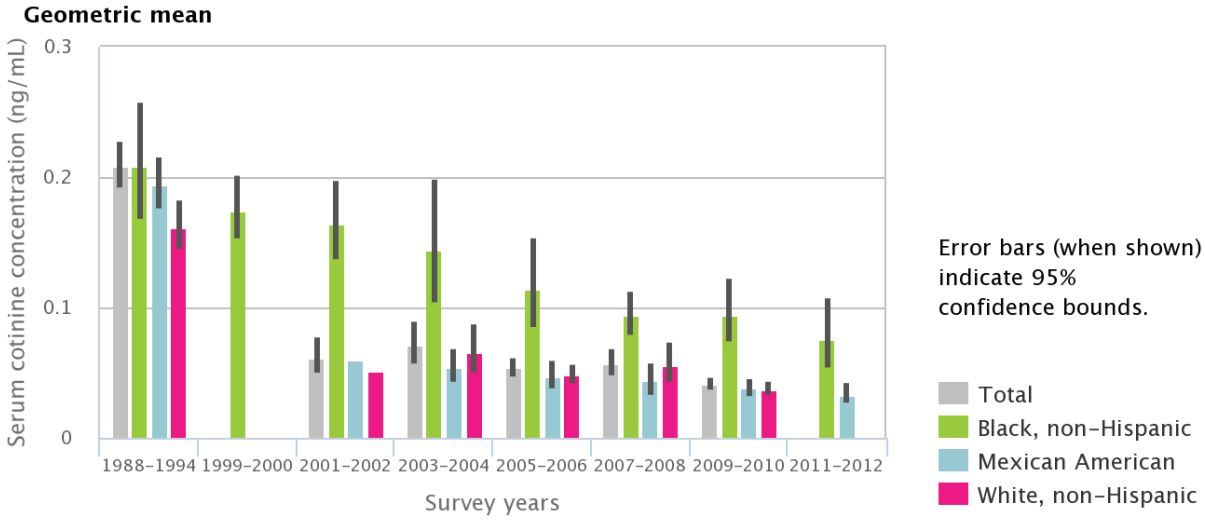
Geometric means are not calculated or displayed in cases where the proportion of results below the limit of detection was too high to provide a valid result. Neither are error bars where the lower bound is below the limit of detection. The limit of detection for cotinine was 0.05 ng/mL in 1999-2000; 0.05 ng/mL and 0.015 ng/mL in 2001-2002; and 0.015 ng/mL in 2003-2012.

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, 2014a,b

Visit http://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, 1988-2012



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 2003-2012.

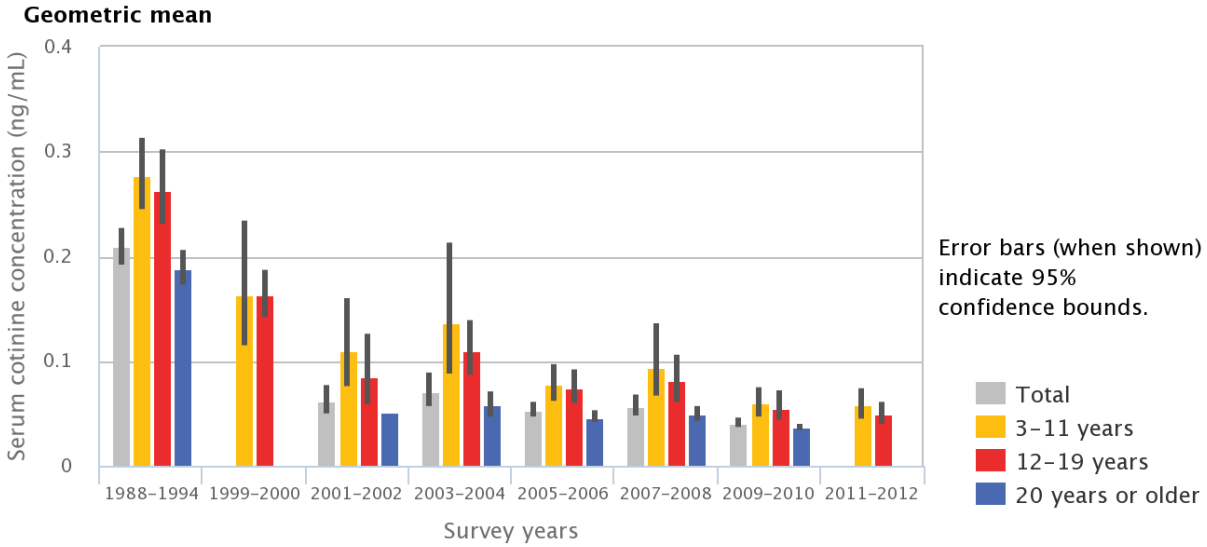
Other racial and ethnic groups are included in the "total" only.

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, 2014a,b

Visit http://www.epa.gov/roe to see the full exhibit.

Exhibit 3. Serum cotinine concentrations for the non-smoking U.S. population age 3 years and older by age group, 1988-2012



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 2003-2012.

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, 2014a,b

Visit http://www.epa.gov/roe to see the full exhibit.

Exhibit 4. Serum cotinine concentrations in U.S. children age 3 to 17 years by race and ethnicity, 1988–2012

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

Cotinine concentrations are reported for "non-smoking" children only.

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, 2015b

Visit http://www.epa.gov/roe to see the full exhibit.