Drinking Water Contaminants

Drinking water sources may contain a variety of contaminants that, at elevated levels, have been associated with increased risk of a range of diseases in children, including acute diseases such as gastrointestinal illness, developmental effects such as learning disorders, endocrine disruption, and cancer.[1-3] Because children tend to take in more water relative to their body weight than adults do, children are likely to have higher exposure to drinking water contaminants.

Drinking water sources include surface water, such as rivers, lakes, and reservoirs;[4] and groundwater aquifers, which are subsurface layers of porous soil and rock that contain large collections of water.[5] Groundwater and surface water are not isolated systems and are continually recharged by each other as well as by rain and other natural precipitation.[6]

Several types of drinking water contaminants may be of concern for children's health. Examples include microorganisms, (e.g., *E. coli*, *Giardia*, and noroviruses), inorganic chemicals (e.g., lead, arsenic, nitrates, and nitrites), organic chemicals (e.g., atrazine, glyphosate, trichloroethylene, and tetrachloroethylene), and disinfection byproducts (e.g., chloroform). EPA and the Food and Drug Administration (FDA) are both responsible for the safety of drinking water. FDA regulates bottled drinking water, while EPA regulates drinking water provided by public water systems. EPA sets enforceable drinking water standards for public water systems, and unless otherwise specified, the term "drinking water" in this text refers to water provided by these systems. The drinking water standards include maximum contaminant levels and treatment technique requirements for more than 90 chemical, radiological, and microbial contaminants, designed to protect people, including sensitive populations such as children, against adverse health effects.[2,7] Microbial contaminants, lead, nitrates and nitrites, arsenic, disinfection byproducts, pesticides, and solvents are among the contaminants for which EPA has set health-based standards.

Microbial contaminants include bacteria, viruses, and protozoa that may cause severe gastrointestinal illness.[2] Children are particularly sensitive to microbial contaminants, such as *Giardia*, *Cryptosporidium*, *E. coli*, and noroviruses, because their immune systems are less developed than those of most adults.[8-14]

Drinking water is a known source of lead exposure among children in the United States, particularly from corrosion of pipes and other elements of the drinking water distribution systems.[15-17] Exposure to lead via drinking water may be particularly high among very young children who consume baby formula prepared with drinking water that is contaminated by leaching lead pipes.[15] The National Toxicology Program has concluded that childhood lead exposure is associated with reduced cognitive function, reduced academic achievement, and increased attention-related behavioral problems.[18]

Fertilizer, livestock manure, and human sewage can be significant contributors of nitrates and nitrites in groundwater sources of drinking water.[19,20] High levels of nitrates and nitrites can cause the blood disorder methemoglobinemia (blue baby syndrome)[21-23] and have been associated with thyroid dysfunction in children[24,25] and pregnant women.[24,26,27] Moderate deficits in maternal thyroid hormone levels during early pregnancy have been linked to reduced childhood IQ scores and other neurodevelopmental effects, as well as unsuccessful or complicated pregnancies.[28]

Arsenic enters drinking water sources from natural deposits in the earth, which vary widely from one region to another, or from agricultural and industrial sources where it is used as a wood preservative and a component of fertilizers, animal feed, and a variety of industrial products.[29] Population studies of health effects associated with arsenic exposure have been conducted primarily in countries such as Bangladesh, Taiwan, and Chile, where arsenic levels in drinking water are generally much higher than in the United States due to high levels of naturally occurring arsenic in groundwater.[30] Long-term consumption of arsenic-contaminated water has been associated with the development of skin conditions and circulatory system problems, as well as increased risk of cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate.[29,31] In many cases, long-term exposure to arsenic begins during prenatal development or childhood, which increases the risk of mortality and morbidity among young adults exposed to arsenic long-term.[32] A review of the literature concluded that epidemiological studies of associations between exposure to arsenic and some adverse health outcomes pertinent to children's health have mixed findings. These include studies of associations between high levels of exposure to arsenic and abnormal pregnancy outcomes, such as spontaneous abortion, still-births, reduced birth weight, and infant mortality, as well as associations between early-life exposure to arsenic and increased incidence of childhood cancer and reduced cognitive function.[33]

Water can contain microorganisms such as parasites, viruses, and bacteria; the disinfection of drinking water to reduce water-borne infectious disease is one of the major public health advances of the 20th century.[34] The method by which infectious agents are removed or chemically inactivated depends on the type and quality of the drinking water source and the volume of water to be treated. Surface water systems are more exposed than groundwater systems to weather and runoff; therefore, they may be more susceptible to contamination.[4,35] Surface and groundwater systems use filtration and other treatment methods to physically remove particles. Disinfectants, such as chlorine and chloramine, ultraviolet radiation, and ozone are added to drinking water provided by public water systems to kill or neutralize microbial contaminants.[36] However, this process can produce disinfection byproducts, which form when chemical disinfectants react with naturally occurring organic matter in water.[37] The most common of these disinfection byproducts are chloroform and other trihalomethanes. Consumption of drinking water from systems in the United States and other industrialized countries with relatively high levels of disinfection byproducts has been associated with bladder cancer and developmental effects in some studies.[38-41] Some individual epidemiological studies have reported associations between the presence of disinfection byproducts in drinking water and increased risk of birth defects, especially neural tube defects and oral clefts; however, recent articles reviewing the body of literature determined that the evidence is too limited to make conclusions about a possible association between exposure to disinfection byproducts and birth defects.[38,42-45]

Some of the most widely used agricultural pesticides in the United States, such as atrazine and glyphosate, are also drinking water contaminants.[46,47] Pesticides can enter drinking water sources as runoff from crop production in agricultural areas and enter groundwater through abandoned wells on farms.[48] Some epidemiological studies have reported associations between prenatal exposure to atrazine and reduced fetal growth.[49-52]

The use of glyphosate, an herbicide used to kill weeds, has increased dramatically in recent years because of the growing popularity of crops genetically modified to survive glyphosate treatment.[53] Previous safety assessments have concluded that glyphosate does not affect fertility or reproduction in laboratory animal studies.[54,55] However, more recent studies in laboratory animals have found that male rats exposed to high levels of glyphosate, either during prenatal or pubertal development, may suffer from reproductive problems, such as delayed puberty, decreased sperm production, and decreased testosterone production.[56,57] Very few epidemiological human studies have investigated effects of glyphosate exposure on reproductive endpoints. In contrast to the results of animal studies, one such epidemiological study of women living in regions with different levels of exposure to glyphosate found no associations between glyphosate exposure and delayed time to pregnancy.[58]

A variety of other chemical contaminants can enter the water supply after use in industry.[47] Examples include trichloroethylene and tetrachloroethylene (also known as perchloroethylene), which are solvents widely used in industry as degreasers, dry cleaning agents, paint removers, chemical extractors, and components of adhesives and lubricants.[59-61] Potential health concerns from exposure to trichloroethylene, based on limited epidemiological data and evidence from animal studies, include decreased fetal growth and birth defects, particularly cardiac birth defects.[61] A study conducted in Massachusetts reported associations between birth defects and maternal exposure to drinking water contaminated with high levels of tetrachloroethylene around the time of conception.[62] An additional study reported that older mothers or mothers who had previously miscarried, and who were exposed to high levels of tetrachloroethylene in contaminated drinking water, had a higher risk of delivering a baby with reduced birth weight.[63] However, other studies did not find associations between maternal exposure to tetrachloroethylene and pregnancy loss, gestational age, or birth weight.[64,65] Studies in laboratory animals indicate that mothers exposed to high levels of tetrachloroethylene can have spontaneous abortion, and their fetuses can suffer from altered growth and birth defects.[60]

EPA has not determined whether standards are necessary for some drinking water contaminants, such as personal care products. Personal care products, such as cosmetics, sunscreens, and fragrances; and pharmaceuticals, including prescription, over-the-the counter, and veterinary medications, can enter water systems after use by humans or domestic animals[66] and have been measured at very low levels in drinking water sources.[67] Many concentrated animal feeding operations treat livestock with hormones and antibiotics, and can be one significant source of pharmaceuticals in water.[35] Other major sources of pharmaceuticals in water are human waste, manufacturing plants and hospitals, and other human activities such as showering and swimming.[66] Any potential health implications of long-term exposure to levels of pharmaceuticals and personal care products found in drinking water are unclear.

Manganese is a naturally occurring mineral that can enter drinking water sources from rocks and soil or from human activities.[68] While manganese is an essential nutrient at low doses, chronic exposure to high doses may be harmful, particularly to the nervous system. Many of the reports on adverse effects from manganese exposure are based on inhalation exposures in occupational settings. Fewer studies have examined health effects associated with oral exposure to manganese.[68] However, some recent epidemiological studies have reported associations between long-term exposure to high levels of manganese in drinking water during prenatal development or childhood and intellectual impairment; decreased non-verbal memory, attention, and motor skills; hyperactivity; and other behavioral effects.[69-73] Most studies on the health effects of manganese have been conducted in countries where manganese exposure is generally higher than in the United States. However, two individual studies conducted in specific areas of relatively high manganese contamination in the United States reported associations between prenatal or childhood manganese exposure and problems with general intelligence, memory, and behavior.[74,75] Although there is no health-based regulatory standard for manganese in drinking water, EPA has set a voluntary standard for manganese as a guideline to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color and odor.[7]

Perchlorate is a naturally occurring and man-made chemical that has been found in surface and groundwater in the United States.[76-78] Perchlorate is used in the manufacture of fireworks, explosives, flares, and rocket fuel.[78] Perchlorate was detected in just over 4% of public water systems in a nationally representative monitoring study conducted from 2001–2005.[78] Some infant formulas have been found to contain perchlorate, and the perchlorate content of the formula is increased if it is prepared with perchlorate-contaminated water.[79-82] Exposure to elevated levels of perchlorate can inhibit iodide uptake into the thyroid gland, possibly disrupting the function of the thyroid and potentially leading to a reduction in the production of thyroid hormone.[83,84] As noted above, thyroid hormones are particularly important for growth and development of the central nervous system in fetuses and infants.

In January 2009, EPA issued an interim health advisory level to help state and local officials manage local perchlorate contamination issues in a health-protective manner, in advance of a final EPA regulatory determination.[78,85] In February 2011, EPA decided to develop a federal drinking water standard for perchlorate, based on the concern for effects on thyroid hormones and the development and growth of fetuses, infants, and children.[78] The process for developing the standard will include receiving input from key stakeholders as well as submitting any formal rule to a public comment process.

The two indicators that follow use the best nationally representative data currently available to characterize the performance of water systems in meeting EPA's health-based drinking water standards and in reporting monitoring results over time. Indicator E7 estimates the percentage of children served by community water systems that did not meet all applicable health-based drinking water standards. Indicator E8 estimates the percentage of children served by systems with violations of drinking water monitoring and reporting requirements. Monitoring and reporting violations occur when a water system does not monitor, does not report monitoring results, or was late in reporting results.[86] Such violations in monitoring and reporting may mean that some health-based violations were not reported; this could cause the percentages shown in Indicator E7 to be underestimated.

Indicator E7: Estimated percentage of children ages 0 to 17 years served by community water systems that did not meet all applicable health-based drinking water standards, 1993–2009

Indicator E8: Estimated percentage of children ages 0 to 17 years served by community water systems with violations of drinking water monitoring and reporting requirements, 1993–2009

About the Indicators: Indicators E7 and E8 estimate the percentage of children served by community water systems that did not meet all health-based drinking water standards or failed to adhere to monitoring and reporting requirements. The data are from an EPA database that compiles drinking water violations reported by public water systems. Indicator E7 shows the estimated percentage of children served by community water systems that did not meet health-based drinking water standards in each year from 1993 to 2009. Indicator E8 shows the estimated percentage of children served by community water systems that did not adhere to monitoring and reporting requirements in each year.

SDWIS/FED

EPA's Safe Drinking Water Information System, Federal Version (SDWIS/FED) provides information on violations of drinking water standards. Public drinking water systems in the United States are required to monitor the presence of certain individual contaminants at specific time intervals and locations to assess whether they are complying with drinking water standards. These standards include Maximum Contaminant Levels (MCLs), which are numerical limits on how much of a contaminant may be present in drinking water; as well as mandatory treatment techniques and processes, such as those intended to prevent microbial contamination of drinking water. When a violation of a drinking water standard is detected, the public water system is required to report the violation to the state, which in turn reports to the federal government. All health-based violations are compiled in SDWIS/FED. SDWIS/FED was created in 1995 and includes data from various precursor database systems that have violation and inventory data going back to 1976. SDWIS/FED also reports the number of people served by each water system.

Health-Based Drinking Water Standard Violations

Indicator E7 presents statistics on violations of drinking water standards grouped into several categories:

- The "Surface water treatment" category includes violations of requirements in the Surface Water Treatment Rule and Interim Enhanced Surface Water Treatment Rule that specify the type of treatment and maintenance activities that systems must use to prevent microbial contamination of drinking water.

- The "Chemical and radionuclide" category includes violations of the MCLs for organic and inorganic chemicals, such as atrazine, glyphosate, trichloroethylene, tetrachloroethylene, arsenic, cadmium, and mercury, in addition to radionuclide contaminants, such as radium and uranium.
- The "Lead and copper" category includes violations of treatment technique requirements for systems to control the corrosiveness of their water.[2]
- The "Total coliforms" category covers all violations of the MCL for total coliform bacteria, which is an indicator of the presence of various fecal pathogens, including *E.Coli*.[87,88]
- The "Nitrate/nitrite" category takes account of all violations of the MCLs for nitrates and nitrites.

The "Disinfectants and disinfection byproducts" category covers violations of standards for several disinfectants—chlorine, chloramine, and chlorine dioxide—and disinfectant byproducts—total trihalomethanes, haloacetic acids, chlorite, and bromate.[89]

Monitoring and Reporting Violations

Indicator E8 presents statistics on violations of monitoring and reporting requirements. Monitoring and reporting violations occur when a water system does not monitor, does not report monitoring results, or was late in reporting results.[86] All monitoring and reporting violations are compiled from SDWIS/FED.

Data Presented in the Indicators

Indicator E7 estimates the percentage of children ages 0 to 17 years served by community water systems that did not meet all applicable health-based drinking water standards between 1993 and 2009. The indicator is calculated by identifying all community water systems with violations in SDWIS/FED each year by state, then summing the number of people served by those systems with violations. Census data for the number of children in each state are then used to adjust these estimates of the total population served to estimate the percentage of children served by systems with violations in relation to all children served by community water systems.

Indicator E8 estimates the percentage of children ages 0 to 17 years served by community water systems with violations of drinking water monitoring and reporting requirements. This indicator is based on data reported to SDWIS/FED for violations between 1993 and 2009. Violations of monitoring and reporting requirements for Indicator E8 were grouped into the same categories as in Indicator E7, except for the Nitrate/nitrite category.

For the most part, the indicator represents comparisons with a consistent set of standards over the years 1993–2009, with some exceptions. Revisions to the surface water treatment standard were finalized in 2002.[89] A revised standard for radionuclides went into effect in 2003, and for arsenic (included in the chemical and radionuclide category) in 2006.[90] A new standard for disinfection byproducts was implemented in 2002 for larger drinking water systems, and in

2004 for smaller systems.[91] The revisions to the surface water treatment standard were significant enough to warrant a break in the trend lines for this category in Indicators E7 and E8 between 2001 and 2002. The break in the "any violation" trend line between 2001 and 2002 is due to both the revision of the surface water standard and the implementation of the new disinfection byproducts standard for large systems beginning in 2002. Revisions to other standards had only minimal impacts on the indicator values. As new and revised drinking water standards take effect, water system compliance with all applicable health-based standards signifies higher levels of public health protection over time.

Violations of health-based standards (as represented in Indicator E7) may be under-reported as a result of monitoring and reporting violations. An EPA audit of drinking water data from 2002–2004 found that only 62% of health-based standards violations were reported to SDWIS.[86] Therefore, the data on systems reporting no violations of health based standards include a number of systems that have not gathered or reported all of the required data needed to make this determination.

Indicators E7 and E8 provide information about the extent to which contaminants in community water systems reach levels that may be of concern for children. However, the indicators do not provide a direct measure of children's exposure to drinking water contaminants and do not give an indication about how drinking water violations are related to health risks. A violation of a health-based standard represents a potential concern for children's health, but the importance of any violation depends on the particular contaminant, the magnitude and duration of the violation, and the extent of the violation within a system. Indicator E7 does not reflect the extent to which a standard has been exceeded or the extent to which a water system's distribution system may have been affected by a violation. The indicator does not take into account the duration of a violation within any calendar year. However, a violation that continues over an extended period of time is included in the indicator for each calendar year in which it occurs. A large water system with a single violation of short duration may significantly affect the indicator value for a single year.

The ability to examine children's potential exposure to contaminated drinking water is limited by the type of information collected and stored in the SDWIS/FED database. States are not required to report the actual contaminant levels measured to SDWIS/FED; instead, they report when standards are not met. As a result, SDWIS/FED data cannot be used to analyze national or local trends in contaminant concentrations, or to provide comparisons to the current health-based standards across all years shown.[i] EPA is working with states to develop a new drinking water data system that will compile and make available actual measurements of contaminant levels.

[i] EPA requires community water systems to provide annual drinking water quality reports to their customers. These reports summarize the contaminants measured in each system's drinking water over the course of a year, providing much more detail than the information reported to SDWIS. The drinking water quality reports for many systems can be found at: http://water.epa.gov/lawsregs/rulesregs/sdwa/ccr/index.cfm.

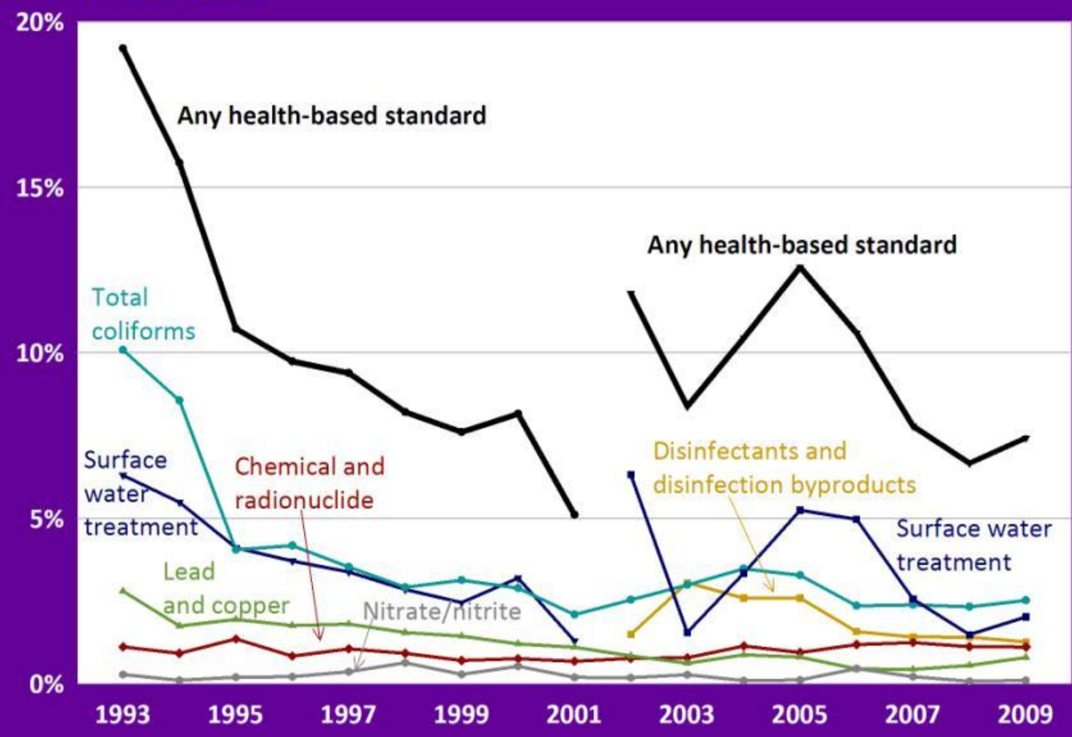
Indicators E7 and E8 are based on drinking water provided to residences served by community water systems. Community water systems are public water systems that serve water to the same residential population year-round.[92] The indicators do not account for all sources of children's drinking water. Some drinking water comes from other types of public water systems, including those that may not serve residences, or may not operate year-round (e.g., schools, factories, office buildings, and hospitals that have their own water systems; gas stations and campgrounds); and bottled water.[ii] [93-95]

In addition, many homes are not served by community water systems and instead obtain their drinking water from individual residential wells.[93,96] EPA does not have the authority under the Safe Drinking Water Act to regulate wells that serve fewer than 25 persons or 15 service connections. Thus, the SDWIS/FED database does not contain data on non-public water systems, such as privately owned household wells, that are not required to monitor or report the quality of drinking water to EPA.[94,97] In 2000, approximately 15% of the total U.S. population was served by non-public water systems[97] and more than 90,000 new domestic wells are installed every year.[98] Separate data collection activities have found that the contaminants in untreated groundwater are generally at lower levels than the MCL; however, more than 20% of wells sampled by the U.S. Geological Survey between 1991 and 2004 contained at least one contaminant at a level of potential health concern.[99] Approximately 4% of the 2,167 sampled wells exceeded the nitrate MCL, and 7% exceeded the arsenic MCL.[99] Nitrate concentrations above the MCL were more frequently detected in agricultural regions than any other land-use setting.[99] Groundwater-sourced wells in rural and agricultural regions may be at an increased risk for nitrate and nitrite contamination due to local fertilizer use and animal waste runoff.[100]

[ii] Bottled water is regulated by the Food and Drug Administration.

Indicator E7

Estimated percentage of children ages 0 to 17 years served by community water systems that did not meet all applicable health-based drinking water standards, 1993-2009



Data: U.S. Environmental Protection Agency, Office of Water, Safe Drinking Water Information System, Federal Version

Note: Breaks in lines for "Any health-based standard" and "Surface water treatment" reflect substantial regulatory changes implemented in 2002.

America's Children and the Environment, Third Edition

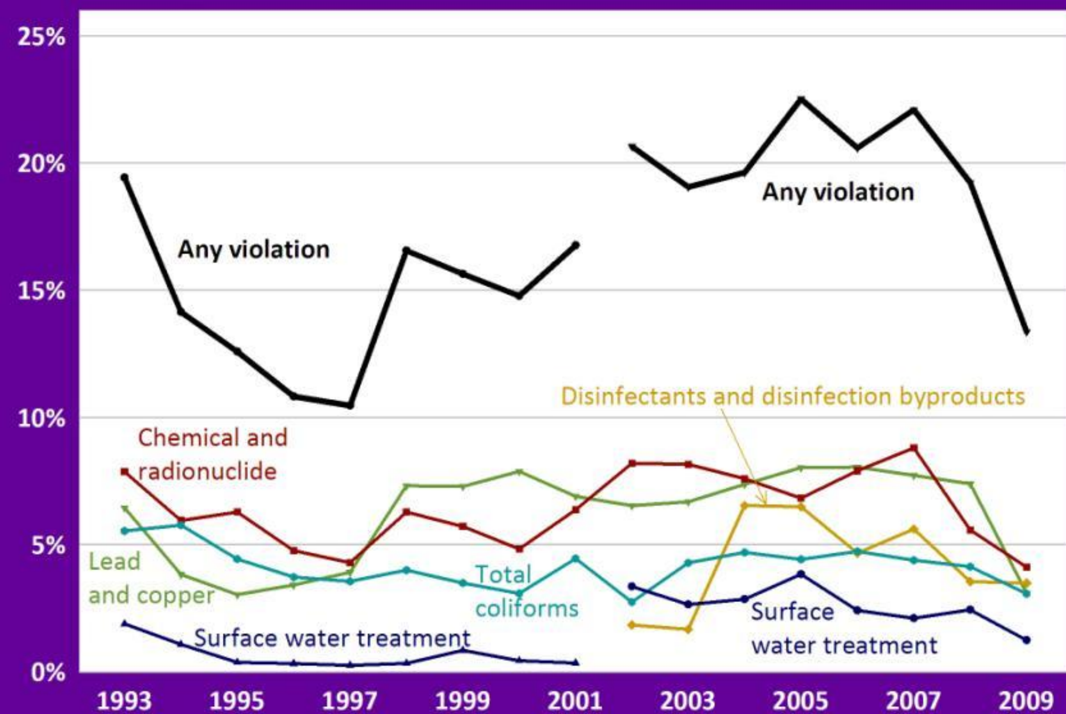
Data characterization

- Data for this indicator are obtained from EPA's database to which states are required to report public water system violations of national drinking water standards.
- All violations of health-based standards are supposed to be reported to the database; however, it is known that not all violations are reported and the magnitude of underreporting is not known.
- Some drinking water standards have been changed over time to increase the level of public health protection; therefore, as noted on the figure, some types of violations in more recent years are not strictly comparable to violations in earlier years.
- Non-public drinking water systems, such as private wells, are not represented in the database. In 2000, about 15% of the U.S. population was served by non-public water systems.

- The estimated percentage of children served by community drinking water systems that did not meet all applicable health-based standards declined from 19% in 1993 to about 5% in 2001. Since 2002, this percentage has fluctuated between 7% and 13%, and was 7% in 2009.
- The estimated percentage of children served by community drinking water systems that did not meet surface water treatment standards varied substantially from 2002–2007, following the adoption of new regulatory requirements. The percentage was more consistent from 2007–2009, and was 2% in 2009.
- Total coliforms indicate the potential presence of harmful bacteria associated with infectious illnesses. The estimated percentage of children served by community drinking water systems that did not meet the health-based standard for total coliforms was about 10% in 1993 and about 3% in 2009.
- A new standard for disinfection byproducts was adopted in 2001. The estimated percentage of children served by community water systems that had violations of the disinfection byproducts standard has declined steadily from 3% in 2003 to about 1% in 2009.

Indicator E8

Estimated percentage of children ages 0 to 17 years served by community water systems with violations of drinking water monitoring and reporting requirements, 1993-2009



Data: U.S. Environmental Protection Agency, Office of Water, Safe Drinking Water Information System, Federal Version

Note: Breaks in lines for "Any violation" and "Surface water treatment" reflect substantial regulatory changes implemented in 2002.

America's Children and the Environment, Third Edition

Data characterization

- Data for this indicator are obtained from EPA's database to which states are required to report public water system violations of national drinking water standards.
- Not all violations of monitoring and reporting requirements are reported to the database, and the magnitude of underreporting is not known.
- Some drinking water standards have been changed over time to increase the level of public health protection; therefore, as noted on the figure, some types of violations in more recent years are not strictly comparable to violations in earlier years.
- Non-public drinking water systems, such as private wells, are not represented in the database. In 2000, about 15% of the U.S. population was served by non-public water systems.

- Between 1993 and 2009, the estimated percentage of children served by community water systems that had at least one monitoring and reporting violation fluctuated between about 11% and 23%, and was 13% in 2009.
- In 1993, approximately 6% of children served by community water systems lived in an area with significant monitoring and reporting violations for lead and copper. This figure dropped to about 3% in 2009.
- The estimated percentage of children served by community water systems with a chemical and radionuclide monitoring violation has varied between 4 and 9%, and was 4% in 2009.

Environments and Contaminants

Drinking Water Contaminants

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Environments and Contaminants

Drinking Water Contaminants

Table E7: Estimated percentage of children ages 0 to 17 years served by community water systems that did not meet all applicable health-based drinking water standards, 1993-2009

1993-1997					
Type of standard violated	**1993**	**1994**	**1995**	**1996**	**1997**
Any health-based standard	19.2	15.7	10.7	9.7	9.4
Total coliforms	10.1	8.6	4.0	4.2	3.5
Surface water treatment#	6.3	5.5	4.1	3.7	3.4
Lead and copper†	2.8	1.7	1.9	1.8	1.8
Chemical and radionuclide	1.1	0.9	1.3	0.8	1.0
Nitrate/nitrite	0.3	0.1	0.2	0.2	0.4

1998-2003						
Type of standard violated	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Any health-based standard	8.2	7.6	8.1	5.1	11.8	8.4
Total coliforms	2.9	3.1	2.9	2.1	2.5	3.0
Surface water treatment#	2.8	2.4	3.2	1.3	6.3	1.5
Disinfectants and disinfection byproducts	NA‡	NA‡	NA‡	NA‡	1.5	3.0
Lead and copper†	1.5	1.4	1.2	1.1	0.8	0.6
Chemical and radionuclide	0.9	0.7	0.8	0.7	0.8	0.8
Nitrate/nitrite	0.6	0.3	0.5	0.2	0.2	0.3

2004-2009						
Type of standard violated	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Any health-based standard	10.4	12.6	10.6	7.8	6.7	7.4
Total coliforms	3.5	3.3	2.3	2.4	2.3	2.5
Surface water treatment#	3.3	5.2	5.0	2.6	1.5	2.0
Disinfectants and disinfection byproducts	2.6	2.6	1.6	1.4	1.4	1.3
Lead and copper†	0.9	0.8	0.4	0.4	0.5	0.8
Chemical and radionuclide	1.1	0.9	1.2	1.2	1.1	1.1
Nitrate/nitrite	0.1	0.1	0.5	0.2	0.1	0.1

DATA: U.S. Environmental Protection Agency, Office of Water, Safe Drinking Water Information System Federal Version

"Surface water treatment" includes violations of the Surface Water Treatment Rule and of the Interim Enhanced Surface Water Treatment Rule.

† Lead and copper represents the lead and copper rule, which is a set of standards and implementation measures.

‡ The standard for disinfectants and disinfection byproducts was first implemented in 2002.

NOTE: A new standard for disinfection byproducts was implemented beginning in 2002 for larger drinking water systems and 2004 for smaller systems.[1] Revisions to the standard for surface water treatment took effect in 2002.[2] A revised standard for radionuclides went into effect in 2003.[3] A revised standard for arsenic went into effect in 2006.[4] No other revisions to the standards have taken effect during the period of trend data.

Table E8: Estimated percentage of children ages 0 to 17 years served by community water systems with violations of drinking water monitoring and reporting requirements, 1993-2009

1993-1997					
Type of standard violated	**1993**	**1994**	**1995**	**1996**	**1997**
Any violation	19.4	14.1	12.6	10.8	10.5
Chemical and radionuclide	7.9	5.9	6.3	4.8	4.3
Lead and copper	6.4	3.8	3.0	3.4	3.9
Total coliforms	5.5	5.8	4.4	3.7	3.6
Surface water treatment#	1.9	1.1	0.4	0.3	0.3

1998-2003						
Type of standard violated	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Any violation	16.6	15.6	14.8	16.8	20.6	19.1
Chemical and radionuclide	6.3	5.7	4.8	6.4	8.2	8.2
Lead and copper	7.3	7.3	7.9	6.9	6.5	6.7
Total coliforms	4.0	3.5	3.1	4.4	2.7	4.3
Disinfectants and disinfection byproducts	NA‡	NA‡	NA‡	NA‡	1.8	1.7
Surface water treatment#	0.3	0.8	0.4	0.3	3.3	2.6

2004-2009						
Type of standard violated	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Any violation	19.6	22.5	20.6	22.1	19.2	13.4
Chemical and radionuclide	7.6	6.8	7.9	8.8	5.6	4.1
Lead and copper	7.4	8.0	8.0	7.7	7.4	3.1
Total coliforms	4.7	4.4	4.7	4.4	4.1	3.1
Disinfectants and disinfection byproducts	6.5	6.5	4.7	5.6	3.5	3.5
Surface water treatment#	2.9	3.8	2.4	2.1	2.4	1.2

DATA: U.S. Environmental Protection Agency, Office of Water, Safe Drinking Water Information System Federal Version

"Surface water treatment" includes violations of the Surface Water Treatment Rule and of the Interim Enhanced Surface Water Treatment Rule.

‡ The standard for disinfectants and disinfection byproducts was first implemented in 2002.

NOTE: A new standard for disinfection byproducts was implemented beginning in 2002 for larger drinking water systems and 2004 for smaller systems.[1] Revisions to the standard for surface water treatment took effect in 2002.[2] A revised standard for radionuclides went into effect in 2003.[3] A revised standard for arsenic went into effect in 2006.[4] No other revisions to the standards have taken effect during the period of trend data.

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