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HEALTHY PEOPLE 2000 Statistical Notes

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Monitoring Air Quality in Healthy People 2000

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The quality of the environment has historically played a significant role in public health (1). One of the early successes of public health involved limiting access to a contaminated water supply (1). While focusing on the environment is an obvious and sometimes successful approach to improving public health, the scope of such efforts is complex (2).

This complexity is reflected in measurement of the levels of pollutants in the environment, the levels of individual exposure to these pollutants, individual susceptibility to the pollutants' toxic effects and the health effects attributable to the pollutants versus other influences. Measurement of pollution levels is complicated by the diverse sources of pollution and the varied media of pollution migration and exposure (e.g., air, water). Lengthy time periods may be required to accurately monitor pollution levels; similarly, some environment-related health problems (e.g., some forms of cancer) may also require considerable time to develop before they are detected (3). Measurement of pollution levels is also related to physical characteristics of the environment (e.g., temperature, wind).

While location may be a proxy measure for individual exposure to specific pollutants, its utility is somewhat compromised by individual behavior which may mitigate exposure to specific media. For example, an individual who spends a great deal of time indoors may be less affected by ambient air quality, but more susceptible to the effects of tobacco smoke or fungi. Similarly, individual susceptibility to the effects of pollutants may be affected by both genetic characteristics and/or health promotion/health care utilization. Data to monitor both individual exposure and susceptibility are not readily available for large area monitoring.

Finally, attributing health effects to specific pollutants is complicated by both the previously described factors affecting measurement and also the impact of non-environmental causes of the same health effects (e.g., smoking, dieting).

In chapter 11 (Environmental Health) of *Healthy People 2000* there are 16 objectives related to a wide range of environment-related public health problems. The objectives measure progress in health status, risk reduction, and services and protection related to these problems at the national level. Some of the measurement issues in the preceding paragraphs affect the monitoring of these objectives. This report focuses on one of these objectives (11.5 ambient air quality), which poses special problems in measurement and interpretation. The report presents background information on the environmental problems associated with the objective, including the health risks, the source (s) of the problem, and the media of transmission. It also discusses how *Healthy People 2000* monitors the objective, the data source used, issues related to the data source, and the interpretation of the data.

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The text of the objective follows:

11.5 Reduce human exposure to criteria air pollutants, as measured by an increase in the proportion of people who live in counties that have *not* exceeded any Environmental Protection Agency standard for air quality in the previous 12 months.

(Objective 11.5 is also the converse of 1 of the 18 Health Status Indicators (HSI) selected for monitoring public health at the state and local level (4). The *Healthy People 2000* objective targets an increase in the proportion of persons living in counties where air standards have *not* been exceeded; the health status indicator monitors the proportion of people living in counties where the standards *have* been exceeded.)

Background

Air pollution is related to a range of respiratory diseases including: chronic bronchitis, pulmonary emphysema, lung cancer, and bronchial asthma. Other health consequences include eye irritation, weakened immune system, and premature lung tissue aging (3). The annual health costs of exposure to the most serious air pollutants have been estimated to range from $40 to $50 billion (5).

Air pollution acts primarily as a direct threat to human health, given that most exposure occurs through respiration or eye and skin contact. Additionally, deposition in surface waters, including reservoirs, poses indirect threats to human health (2).

The Clean Air Act of 1970 and the Clean Air Act Amendments of 1990[2] address the six pollutants associated with the National Ambient Air Quality Standards (NAAQS). These pollutants–ozone, particulate matter (PM-10), carbon monoxide, sulphur dioxide, nitrogen dioxide, and lead—are called criteria pollutants and were identified as serious airborne threats to human health (6,7). Exceedance of standards associated with the criteria pollutants is used to monitor progress for *Healthy People 2000* objective 11.5. The health effects and sources of these pollutants are summarized in table 1.

Ozone, as discussed here, refers to low altitude (tropospheric) ozone, which is harmful to human life. At higher altitudes (stratospheric) ozone is beneficial, as it blocks the harmful effects of cosmic waves. Ozone is not directly emitted by any of the sources listed in table 1, but is formed by a photochemical process involving volatile organic compounds (such as hydrocarbons) and nitrogen oxides, which are produced by the sources listed. Because ozone formation is stimulated by sunlight and temperature, ozone is a seasonal problem, with peak concentrations occurring in the warmer times of the year. Mobile sources (such as cars) are major contributors of the compounds which produce ozone; these compounds may be transported considerable distances prior to the formation of ozone.

[2]The 1990 amendments also emphasize the atmospheric release of toxic substances by industry; this aspect of the law is the focus of objective 11.7, which is not discussed in this report.

Table 1. Criteria air pollutants, health risks and sources

Pollutants	*Health risks*	*Contributing sources*
Ozone[1] (O_3)	Asthma, reduced respiratory function, eye irritation	Cars, refineries, dry cleaners
Particulate matter (PM-10)	Bronchitis, cancer, lung damage	Dust, pesticides
Carbon monoxide (CO)	Blood oxygen carrying capacity reduction, cardiovascular and nervous system impairments	Cars, power plants, wood stoves
Sulphur dioxide (SO_2)	Respiratory tract impairment, destruction of lung tissue	Power plants, paper mills
Lead (Pb)	Retardation and brain damage, esp. children	Cars, non ferrous smelters, battery plants
Nitrogen dioxide (NO_2)	Lung damage and respiratory illness	Power plants, cars, trucks

(Source: Environmental progress and challenges: EPA's update)
[1]Ozone refers to tropospheric ozone which is hazardous to human health.

Ozone is a less localized environmental health problem than the other criteria pollutants. The mobility and seasonality of this pollutant pose some challenges in monitoring and addressing its risks (8).

Particulate matter, in this context, refers to dust, dirt, smoke and other particles suspended in air. From 1971–87, the national air quality standard for particulate matter included particles up to 45 microns in diameter. In 1987, the standard was revised to emphasize the smaller particles with diameter less than 10 microns (PM-10). These smaller particles pose a greater health threat because they are more easily transported into the lungs (8).

Sulphur dioxide pollution is closely tied to the burning of coal with a high sulphur content. This type of coal is more frequently used in power plants and factories in the midwestern United States. Sulphur dioxide levels are higher in this area of the country. Sulphur dioxide can also form acid rain and has indirect health effects through contamination of surface water (2).

With increased use of unleaded fuels, lead pollution has become more localized to areas near smelters and battery plants. Nitrogen dioxide is most common in urban areas; in addition to its independent detrimental health effects, it plays an important role in the formation of ozone. Carbon monoxide is also more common in urban areas, with automobiles being a major source (8).

Healthy People 2000 Objective Measure/Health Status Indicator

The *Healthy People 2000* measure for this objective is the *proportion of people* living in *counties* which have *not* exceeded any of the specific air quality standards for the six

criteria pollutants during the previous *one year* time period. The year 2000 target is 85 percent.

As mentioned in the introduction, 1 of the 18 Health Status Indicators (HSI) is the converse of this objective, and measures the proportion of people living in counties which *have* exceeded any of the U.S. EPA standards for air quality during the previous year. There is no target for the health status indicator; it is a method for monitoring health status for use at various geographic levels (e.g., national, state, county) (9). The data sources and data issues (discussed below) for the objective and the health status indicator are the same. The calculations are discussed later in this section. The data for the objective and health status indicator are displayed in tables 2a and 2b.

Since 1988 the proportion of people who live in counties where none of the standards were exceeded has increased. While there have been some fluctuations in the data, there is general progress towards the year 2000 target. In 1993, the proportion of people living in counties which did not exceed *any* of the standards was 76.5. The proportions for not exceeding the individual standards ranged from 79.5 for ozone to 100 for nitrogen dioxide. While ozone remains the most pervasive of the air pollution problems, it has also shown the largest increase in the proportion of people in counties where the criteria standard was not exceeded since the 1988 baseline. The proportions of people in counties which have not exceeded standards for carbon monoxide, nitrogen dioxide, sulphur dioxide, and particulates (PM-10) have also increased since 1988. The proportion of people which did not exceed standards for lead has declined slightly since 1988 (8).

Table 3 lists the 36 states in which at least one county exceeded *any* of the criteria standards in 1993. (It should be noted that 41 states had exceeded at least one standard in 1991 and 32 states exceeded at least one standard in 1992.) Among the states that exceeded standards in 1993 (column 1), the proportion of people living in counties which did *not* exceed any standard ranged from 99.7 percent in Oregon and Michigan to 3.1 percent in Connecticut. The second column in table 3 shows the proportion of people living in counties which exceeded criteria standards (the Health Status Indicator); these values are simply the converse of the values in column 1 and ranged from 0.3 percent in Oregon and Michigan to 96.9 percent in Connecticut. For the 14 states which are not included in the table, none of the NAAQS were exceeded. There are some measurement issues and alternative interpretations of the data which can produce different estimates; these are discussed in a later section of this report.

The ozone standard was most frequently exceeded in the 36 states which exceeded any of the criteria standards in 1993. Standards for PM-10 were the next most frequently exceeded, followed by lead and carbon monoxide. However, in California and several other populous states, the standards for multiple pollutants were exceeded in several counties.

Table 4 shows the proportions of people living in counties which exceeded criteria standards (in 1993) listed by state and race/ethnicity. Nationally, 23.5 percent of the population lived in counties which exceeded at least one criteria standard. Among the racial and ethnic groups, 42 percent of Hispanics and 37 percent of Asians and Pacific Islanders lived in counties which exceeded at least one standard. Much of this disparity is attributable to the high

Table 2a. Proportion of people who live in counties that have not exceeded NAAQS* standards in the previous 12 months (Objective 11.5)

	1988	*1989*	*1990*	*1991*	*1992*	*1993*	*Target*
Any standard	49.7%	65.3%	69.4%	65.3%	78.5%	76.5%	85.0%
Ozone	53.6%	72.6%	74.2%	72.0%	82.1%	79.5%	. . .
Carbon monoxide	87.8%	86.2%	91.1%	92.0%	94.3%	95.4%	. . .
Nitrogen dioxide	96.6%	96.5%	96.5%	96.5%	100%	100%	. . .
Sulphur dioxide	99.3%	99.9%	99.4%	98.0%	100%	99.4%	. . .
Particulates (PM-10)	89.4%	88.8%	92.3%	94.1%	89.6%	97.5%	. . .
Lead	99.3%	99.4%	97.8%	94.1%	98.1%	97.8%	. . .

Table 2b. Proportion of people who live in counties that have exceeded NAAQS* standards in the previous 12 months (Health Status Indicator)

	1988	*1989*	*1990*	*1991*	*1992*	*1993*
Any standard	50.3%	34.7%	30.6%	34.7%	21.5%	23.5%
Ozone	46.4%	27.4%	25.8%	28.0%	17.9%	20.5%
Carbon monoxide	12.2%	13.8%	8.9%	8.0%	5.7%	4.6%
Nitrogen dioxide	3.4%	3.5%	3.5%	3.5%	0%	0%
Sulphur dioxide	0.7%	<0.1%	0.6%	2.0%	0%	0.6%
Particulates (PM-10)	10.6%	11.2%	7.7%	5.9%	10.4%	2.5%
Lead	0.7%	0.6%	2.2%	5.9%	1.9%	2.2%

(Source: U.S. EPA Aerometric Information Reporting System).
*NAAQS are the National Ambient Air Quality Standards.

Table 3. Proportion of people living in counties which did not exceed NAAQS and proportion living in counties which exceeded NAAQS by state, 1993

State	% People in counties not exceeding NAAQS*	% People in counties exceeding any NAAQS**
Alabama	97.5	2.5
Alaska	39.9	60.1
Arizona	42.1	57.9
California	28.4	71.6
Colorado	86.0	14.0
Connecticut	3.1	96.9
Delaware	33.7	66.3
Georgia	79.6	20.4
Illinois	97.6	2.4
Indiana	84.0	16.0
Kentucky	82.0	18.0
Louisiana	89.6	10.4
Maine	83.9	16.1
Maryland	55.7	44.3
Massachusetts	54.9	45.1
Michigan	99.7	0.3
Missouri	77.0	23.0
Montana	94.1	5.9
Nebraska	73.6	26.4
Nevada	38.3	61.7
New Hampshire	69.7	30.3
New Jersey	72.0	28.0
New Mexico	91.1	8.9
New York	91.2	8.8
North Carolina	91.7	8.3
Ohio	87.0	13.0
Oregon	99.7	0.3
Pennsylvania	64.3	35.7
South Carolina	88.0	12.0
Tennessee	78.0	22.0
Texas	65.0	35.0
Utah	75.5	24.5
Virginia	83.1	16.9
Washington	92.6	7.4
West Virginia	98.0	2.0
Wisconsin	97.4	2.6
U.S	76.5	23.5

Source: U.S. EPA, Aerometric Information Reporting System.
*Healthy People 2000 objective 11.5 ; NAAQS are the National Ambient Air Quality Standards.
**Health Status Indicator; NAAQS are the National Ambient Air Quality Standards.

concentrations of both Hispanics and Asians and Pacific Islanders living in California and several other states which had higher proportions of all residents exposed to poor air quality. Specifically, 61.2 percent of all Hispanics *live* in California, Texas, Arizona, and New Jersey, all states where numerous counties exceeded criteria standards. These same four states contain 48 percent of the U.S. Asian and Pacific Islander population. Conversely, only about 18 percent of American Indians and Alaskan Natives live in counties where air standards were exceeded; this is partly attributable to the large proportion of this group who live in rural areas.

Some of these disparities may be attributable to the greater concentration of some minority group residences in urban areas where air pollution standards are most likely to be exceeded. Industries which contribute to air pollution may be attracted by lower property costs in some of these urban areas. Additionally, some minority populations may be less familiar with the operation of the political systems and less able to redress violations of pollution standards or laws (10).

Data Issues

As mentioned in the introduction, several data issues affect the measurement and interpretation of the air quality data. These include differences in standards and number of monitors for the different criteria pollutants, differences in the local versus regional effects of the pollutants, and issues related to the calculation and interpretation of the measures.

The air quality standards and number of monitoring sites across the U.S. are different for each of the criteria pollutants (see table 5). Each pollutant standard, however, includes a maximum average concentration level (micrograms per cubic meter) and one or more time intervals during which the level cannot be exceeded. Particulates, sulphur dioxide, and carbon monoxide each have two standards; this yields nine specific combinations of concentrations and time intervals for the six criteria pollutants. A county not in compliance with *any* one of the nine specific combinations of concentration and time interval listed in table 5 during a 12 month period has exceeded the EPA air quality standards. The time intervals included in the standards vary from one-hour averages for carbon monoxide and ozone to annual averages for nitrogen dioxide and sulphur dioxide. To assess compliance with these standards ozone, sulphur dioxide, nitrogen dioxide, and carbon monoxide levels are monitored hourly, whereas PM-10 and lead rely on a sampling schedule of one measurement every 24 hours once every 6 days (61 samples annually) (8).

State and local governments monitor the criteria pollutants and submit their data to U.S. EPA. Because of concern about population exposure to the pollutants, the monitoring devices are concentrated in urban areas. The *Healthy People 2000* measure is based on proportion of people living in counties with no exceedances. There are 3,186 counties in the U.S., but the maximum number of monitors for any of the individual criteria pollutants is 1,508 (PM-10). However, through a combination of data supplied from supplemental temporary monitors and air pollution models, it is also possible to assess potential health problems in less populated areas (8).

As indicated earlier, five of the six criteria pollutants are primarily localized phenomena; ozone is the exception. For these more localized pollutants, EPA reports that monitors have been sited where the specific pollutants are produced.

Ozone is a regional problem, though it is somewhat concentrated in urban areas. High ozone concentrations may also occur downwind from urban areas. Because of the area wide influence of ozone, fewer monitors are needed. There were 925 ozone monitors in 1993 (11).

Another measurement issue with this objective is that the calculation uses the *total population* of any county with

Table 4. Proportion of population living in counties which exceeded NAAQS* standards by state, race, and Hispanic origin

State	Total	Race				
		White	Black	American Indian/ Alaska native	Asian and Pacific Islander	Hispanic[1]
Alabama	2.5	3.0	0.8	1.6	2.6	2.1
Alaska	60.0	64.7	90.7	27.4	71.1	72.5
Arizona	57.9	59.9	66.8	19.8	65.6	50.2
California	71.6	72.2	75.1	66.1	64.8	81.4
Colorado	14.0	13.0	45.0	21.0	19.0	25.0
Connecticut	96.9	96.6	99.6	94.9	98.5	98.0
Delaware	66.3	66.6	64.8	38.2	77.6	74.6
Georgia	20.4	15.7	32.3	17.1	33.6	27.8
Illinois	2.4	2.7	1.0	3.1	0.5	0.3
Indiana	16.0	13.8	40.3	14.8	21.1	9.1
Kentucky	18.0	16.1	43.1	18.1	26.7	19.9
Louisiana	10.4	10.0	11.2	3.8	13.4	7.2
Maine	16.1	16.2	17.5	6.9	20.1	19.5
Maryland	44.3	44.5	44.4	44.4	39.0	39.0
Massachusetts	45.1	45.9	29.9	35.6	49.6	45.2
Michigan	0.3	0.3	0.0	0.3	0.1	0.2
Missouri	23.0	22.6	25.6	9.6	35.4	17.8
Montana	5.9	6.2	2.8	2.2	5.7	4.7
Nebraska	26.4	24.3	79.2	20.3	32.8	30.8
Nevada	61.7	59.9	89.8	33.1	68.5	66.6
New Hampshire	30.3	30.1	42.2	28.7	40.9	50.3
New Jersey	28.0	28.0	28.1	28.4	28.2	35.9
New Mexico	8.9	9.9	7.0	0.8	7.8	13.2
New York	8.8	10.2	3.5	5.2	4.1	4.4
North Carolina	8.3	7.7	10.2	2.5	16.2	9.2
Ohio	13.0	10.9	30.3	12.7	19.9	22.5
Oregon	0.3	0.3	0.0	0.5	0.1	0.2
Pennsylvania	35.7	31.1	76.8	43.5	59.4	49.7
South Carolina	12.0	11.0	14.0	17.8	20.0	17.6
Tennesee	22.0	17.1	47.3	20.3	26.9	25.0
Texas	35.0	32.5	49.5	35.6	56.8	33.5
Utah	24.5	24.8	24.2	12.9	18.8	23.1
Virginia	16.9	17.6	9.4	21.2	50.9	47.0
Washington	7.4	7.8	3.4	6.5	3.1	3.3
West Virginia	2.0	2.0	1.6	1.7	1.5	2.3
Wisconsin	2.6	2.7	2.2	1.2	1.2	6.0
U.S	23.5	23.1	24.8	17.6	37.2	42.3

Source: U.S. EPA, Aerometric Information Reporting System.

[1]Hispanics may be of any race.

*Health Status Indicator; NAAQS are National Ambient Air Quality Standards.

any exceedance of any criteria standard. Given the localized nature of most criteria pollutants, some people in a county which exceeds the standards will *not* be exposed to unhealthy air. Hence, estimates of persons exposed to pollutants, other than ozone, may be somewhat overstated (8). Conversely, it is possible that some people living in counties which were not reported as exceeding the standards (due to the absence of a monitor, etc.) may be exposed to air which exceeds NAAQS standards. Hence, the complementary mathematical relationship assumed in calculation of the data for the objective and the health status indicator may be somewhat compromised by data limitations.

To calculate the *Healthy People 2000* objective measure at the national level, the sum of all county populations exceeding *any* of the standards is subtracted from the national population. (The population of a county exceeding more than one standard is summed only once.) The remainder is divided by the national population. EPA data on the counties which exceeded pollution standards in 1990 used 1987 population estimates from the census (8); the 1991 through 1993 standards data used the 1990 census data (11).

To calculate the *Health Status Indicator* at the national level, the populations of counties which exceeded *any* of the standards for the six criteria pollutants are summed. This sum divided by the U.S. population is the proportion of people living in counties with any exceedance.

To calculate national proportions for the individual pollutants, populations of counties which exceeded the individual pollutant standards are summed. Again, the U.S. population is the denominator.

At the state level, the process is the same, except that only population data for the counties within the state are

Table 5. National Ambient Air Quality Standards (NAAQS)

Pollutant	*Averaging time*	*Concentration level*	*Number of monitors 1993*
Particulate matter (PM-10)	a) Annual mean b) 24 hour	50 ug/m^3 150 ug/m^3	1508
Sulphur dioxide (SO2)	c) Annual mean d) 24 hour	80 ug/m^3 365 ug/m^3	692
Carbon monoxide (CO)	e) 8 hour f) 1 hour	10 ug/m^3 35 ug/m^3	537
Nitrogen dioxide (NO2)	g) Annual mean	100 ug/m^3	377
Ozone (O3)	h) Maximum daily 1 hour avg.	235 ug/m^3	925
Lead (Pb)	i) Maximum quarterly avg.	1.5 ug/m^3	430

Source: EPA, National Air Quality and Emissions Trend Report, 1993
(Note: In this table, ug/m_3 represents micrograms per cubic meter.)

included. The state population is the denominator. Data on counties with exceedances are available in the Aerometric Information Retrieval System (AIRS) maintained by EPA. Information on accessing county level AIRS data can be obtained from EPA Office of Air and Radiation, (919-541-5454) or by contacting the Division of Health Promotion Statistics at the National Center for Health Statistics, (301-436-3548).

Other Air Pollution Measures

Non-Attainment Areas

EPA recently (1990) introduced ''non-attainment areas'' as a method for monitoring criteria pollutants, especially ozone. Non-attainment areas are defined very differently than the HSI and the *Healthy People 2000* objective. States designate these areas through political processes and use *multiple* years of data on the criteria pollutant exceedances. The areas include counties with exceedances, but also counties or jurisdictions which are *sources* of the pollutants, but which did *not* exceed the air quality standards. The boundaries of non-attainment areas are variable because they may include parts of counties or metropolitan areas and their designation is partially based on meteorological and other data (8). The HSI, the *Healthy People 2000* objective, and non-attainment areas all use population data in calculating a measure of exposure. However, the use of multiple years of data and variable boundaries in defining non-attainment areas produces very different population estimates. Using the HSI definition, in 1993 23.5 percent of the people in the U.S. lived in counties where any criteria standard was exceeded; using the non-attainment measure, the proportion of people in 1993 was 59.5 percent (11).

California Air Standards

Different estimates of population exposure to unhealthy air have also been calculated by applying more restrictive exceedance standards to the data reported in AIRS. The American Lung Association used the California standards for particulates (the most stringent in the nation) and estimated that the nationwide population exposed to air with unhealthy levels of PM-10 in 1992 to be 114.6 million. This estimate is roughly five times higher than the 22.9 million people exposed when the Federal standards are applied[3] (12,13).

Pollutant Standards Index (PSI)

AIRS data are also frequently summarized through use of the Pollutant Standards Index (PSI). This measure is not comparable to the *Healthy People 2000* measure or the health status indicator, but is widely used by both public health agencies and the media (14). It is used in metropolitan areas and summarizes the data on the six criteria pollutants into a single number ranging from 0 to 500. Five ranges are specified and are paired with descriptions of air quality (good, moderate, unhealthy, very unhealthy, and hazardous) to facilitate interpretation of the data.

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[3]It should be noted that the American Lung Association also used 1991 population estimates with the 1992 data, whereas the EPA used 1990 census data.

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