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Blood Lead Levels for Persons 6 Months-74 Years of Age: United States, 1976-80

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Introduction

One of the more recent growing public health concerns is the impact of the changing environment on health.[1] As a part of this concern, the Division of Health Examination Statistics of the National Center for Health Statistics has measured the degree of exposure of the U.S. civilian noninstitutionalized population to certain toxic substances, including lead. This was accomplished by determining blood lead concentrations, a common index of lead exposure, on examinees from the second National Health and Nutrition Examination Survey (NHANES II). The rationale for measuring exposure to this environmental hazard was to (1) provide information for the first time about the distribution of blood lead levels in the general U.S. population, (2) establish baseline estimates for future studies to monitor changes in such exposure over time, (3) provide normative information for use in health policy and regulatory decisions, and (4) correlate levels of exposure to these toxic substances with other health and nutritional parameters measured on examinees in NHANES II.[2]

Surveillance data, from the Centers for Disease Control (CDC) on childhood lead poisoning in the United States gives some indication of the extent to which lead exposure is a public health problem among children. A recent Centers for Disease Control Morbidity and Mortality Weekly Report[3] states that for the first 6 months of fiscal year 1981, almost 20,000 children were known to be under pediatric management for lead toxicity. These CDC surveillance data come from approximately 60 federally funded screening projects located in about 25 States. Hazards of industrial exposure to lead are well documented, but the actual magnitude and significance of general community exposure to lead in the environment has been a controversial subject for years.[4]

This report presents statistics on the distribution of blood lead levels of persons ages 6 months-74 years in the United States with respect to age, race, sex, annual family income, and degree of urbanization (of place of residence). These are the first national estimates of lead levels in whole blood obtained on a representative sample of the U.S. population. A future NCHS Series 11 publication[5] is planned to provide detailed descriptive statistics for blood lead levels for selected demographic, socioeconomic, health, and nutritional factors.

NHANES II survey sample design

A brief description of the sample design of NHANES II is presented in the Technical Notes. A detailed description of the survey design has been published.[2]

From a total of 27,801 NHANES II sample persons, 16,563 persons were asked to provide blood specimens for use in the assessment of blood lead levels. These included all children ages 6 months-6 years and a half-sample (those assigned odd sample numbers for the examination) of persons ages 7-74 years. However, some parents refused to have their young children examined and/or give blood. Some adults, especially the elderly, were reluctant or unable to come to the mobile examination units (set up at centralized locations within the 64 sampling areas) for examination. Also, to a lesser degree, a number of blood specimens were lost during shipment and processing. As a result, reliable blood lead levels were determined for blood specimens from 10,049 examinees. Capillary blood was obtained from 113 children ages 6 months-7 years by fingerstick, and venous blood from the remaining 9,936 examinees by venipuncture.

To estimate the potential bias of missing data, the distribution of sample persons in the lead subsample

with missing blood lead data was investigated with respect to the relevant demographic variables. The results suggest that sample persons with missing blood lead data are distributed randomly by race, sex, income, and degree of urbanization. However, some caution should be exercised in using these findings because of the high percent of missing data. Approximately 40 percent of the 16,563 sample persons had no blood lead determinations. Details (tables I and II) on nonresponse are presented in the Technical Notes. Further investigation of potential bias due to nonresponse with respect to demographic variables and related medical history components is planned for the Series 11 report in preparation.[5]

In this report, statistics are presented for three age categories to ensure subsamples of sufficient size for reliable national estimates—preschool children ages 6 months-5 years, youths ages 6-17 years, and adults ages 18-74 years.

It should be noted that the mean blood lead levels and the proportion of children with elevated blood lead levels presented in this study would be expected to differ from those obtained from the community-based lead poisoning prevention programs directed by the CDC. The CDC program is designed to screen selectively or on request for individuals at potentially high risk of exposure to lead using initially an erythrocyte protoporphorin (EP) test followed by blood lead tests on those with EP levels of 50 micrograms per deciliter (μg/dl) of whole blood or more.[6] On the other hand, the NHANES II utilizes a probability sample representative of the general U.S. population selecting individuals for examination and blood lead determinations independent of their risk of exposure to lead or their EP test results.

Methods and procedures

The laboratory determinations of blood lead levels for this national survey were performed by the Clinical Chemistry Division, Center for Environmental Health, Centers for Disease Control (CDC), Atlanta, Georgia, and financed by the Division of Nutrition, Bureau of Foods, FDA, Cincinnati, Ohio. Descriptions of the materials, methods, and quality control procedures are presented elsewhere.[7,8] Lead concentrations of NHANES II whole blood specimens and control specimens were determined by atomic absorption spectrophotometry using a modified Delves cup micromethod.[9] Specimens were analyzed in duplicate with the two assessments done independently in the same analytic run. The average of the two measures was used in the analysis presented in this report.

The following national estimates are based on data obtained on 9,933 NHANES II examinees with blood lead levels ranging from 2.0-66.0 μg/dl of whole blood among those who received venipunctures. Although the fingertips were carefully prepared to minimize contamination, potential for contamination during the capillary blood collection by fingerstick (pricking the finger) is recognized.[10] Statistical analysis of the unweighted data suggested that inclusion of the fingerstick data in this analysis would have introduced bias to the estimates of mean venous blood lead levels in children. Overall, for children ages 6 months-5 years, unweighted mean blood lead level for those receiving fingersticks was observed to be approximately 6.0 μg/dl higher than for those receiving venipunctures. This observed mean difference was consistent for black and white people. The three examinees with venipunctures showing blood lead levels greater than 70.0 μg/dl are extreme cases of lead exposure. These have been considered a separate part of the distribution of blood lead levels in the general population. Therefore, the fingerstick data and values for the three extreme venipuncture cases were excluded from detailed tables 1-7 and further stages of the analysis. A description (table III) of blood lead levels for 113 children ages 6 months-7 years receiving fingersticks and of the three extreme cases of lead exposure is given in the Technical Notes.

Findings

Mean blood lead levels by age, race, and sex

Mean blood lead level estimates for the U.S. population differ substantially with respect to age, race, and sex (figures 1-3 and tables 1-3).

For young children ages 6 months-5 years, mean blood lead levels are similar among those of the same age and sex (figure 1). The differences between means among age and sex groups shown in figure 1 are not statistically significant at the 0.05 level. However, mean blood lead levels of black children significantly exceed those of white children. Overall for this age, blood lead levels among black children are, on the average, 6.0 μg/dl higher than among white children.

Overall for children and youths ages 6-17 years, there is a significant decreasing trend in mean blood lead levels with increasing age. Eliminating the effect of age, significant race and sex differences are evident. Generally, as age increases the difference in mean blood lead levels between boys and girls progressively increases. There is a significant inverse relationship of blood lead level with age for black persons; that is, mean blood lead levels decrease as age (successive age groups) increases through the age of 17 years. The relationship between blood lead level and age for white children and youths is similar to that for the respective black groups, except that mean blood lead levels decline with increasing age until about age 15 (or the 15-17-year age group) where the mean blood lead levels are observed to be higher (figure 2).

For adults ages 18-74 years, the sex difference in blood lead levels is pronounced and significant. The mean blood lead levels of men are consistently higher than those of women in all age groups. The differences in these levels between the sexes are similar for

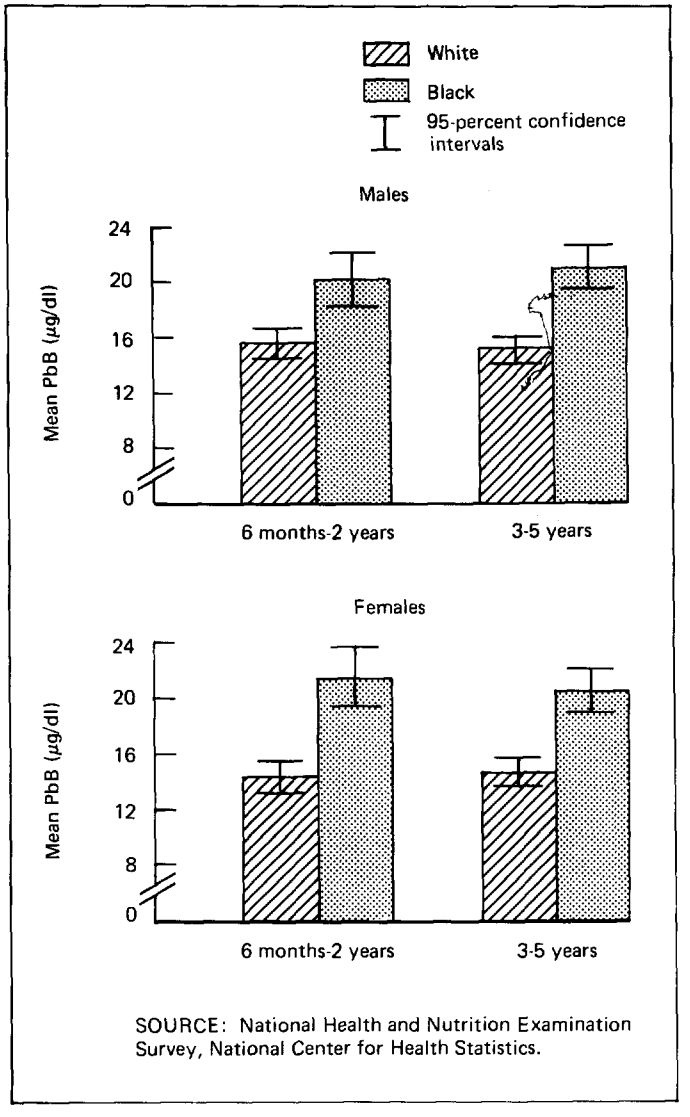


Figure 1. Mean blood lead levels (PbB) of children ages 6 months-5 years: United States, 1976-80

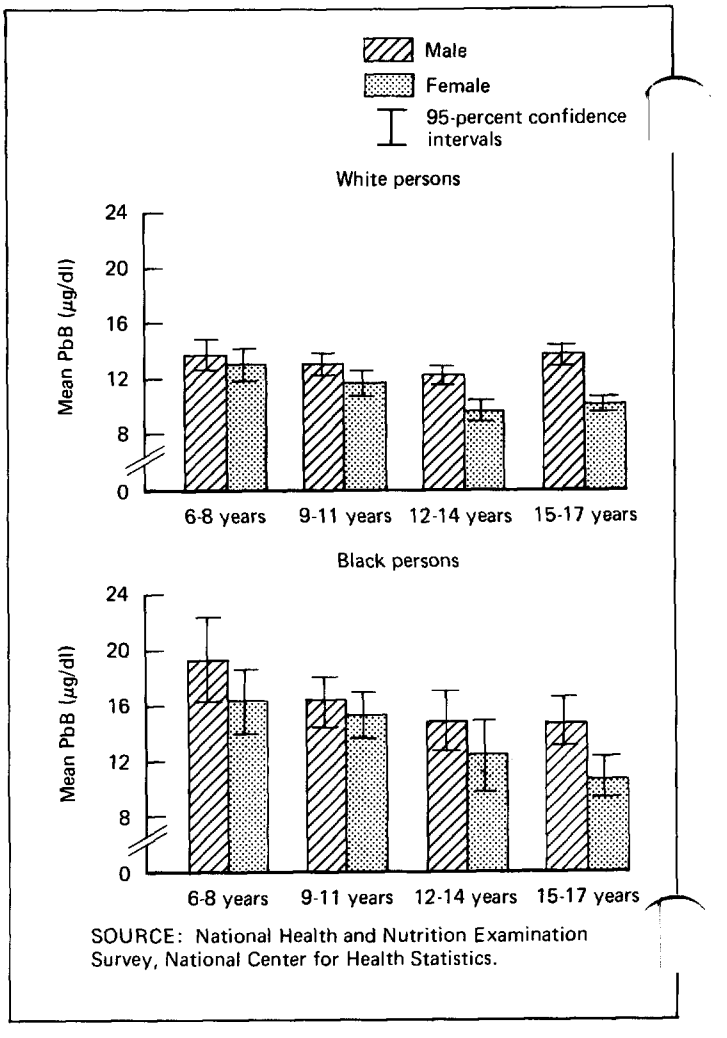


Figure 2. Mean blood lead levels (PbB) of youths ages 6-17 years: United States, 1976-80

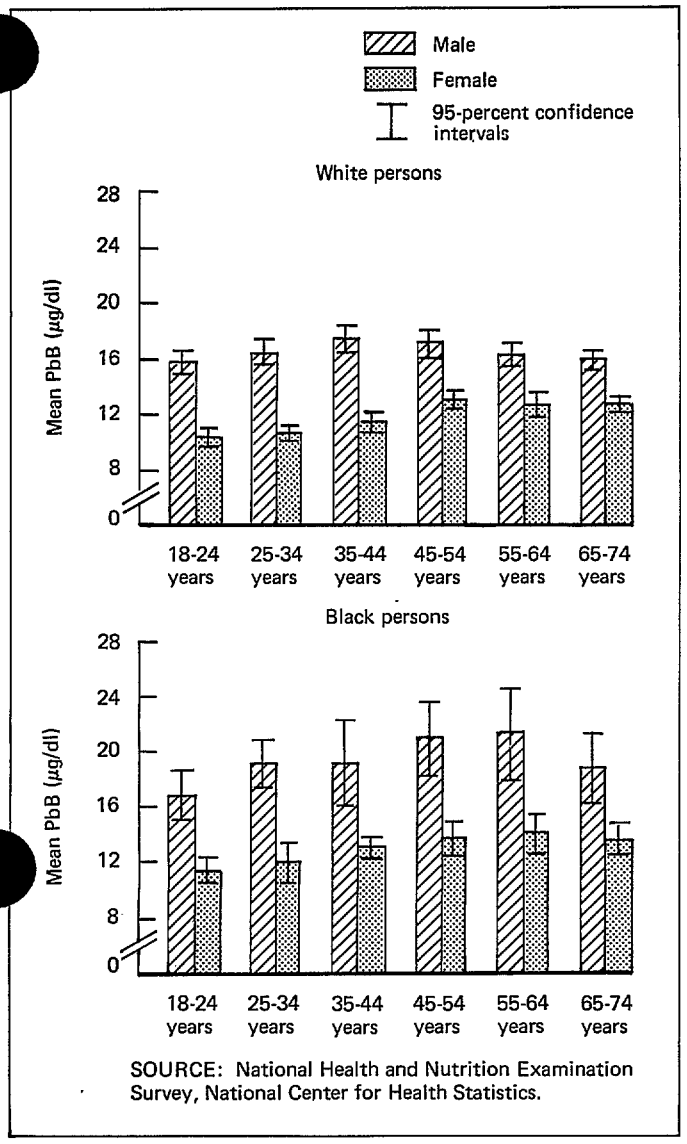


Figure 3. Mean blood lead levels (PbB) of adults ages 18-74 years: United States, 1976-80

white and for black persons (figure 3). In addition, there is a significant relationship between mean blood lead level and age. However, the trend in mean blood lead levels with age differs for white and for black men. For instance, when the mean blood lead levels for white and black men are compared, those for white men increase with age until age group 35-44 years and then decrease while those for black men remain high through age group 55-64 years. After accounting for differences in the age distributions for both races, there are significantly higher mean blood lead levels among black than among white adults.

Blood lead levels for children by income and degree of urbanization

The associations of family income and of the degree of urbanization with blood lead levels are generally consistent across all three broad age groups in the population with lower mean blood lead levels among the more affluent than among the poor and those in rural than in urban areas (tables 4 and 5). These associations were most pronounced, however, in children ages 6 months-5 years. Hence, further consideration of blood lead levels in this report with respect to these demographic variables will be limited to the findings among preschool-aged children.

The most common sources of environmental lead for young children are air, food, dust, dirt, soil, water, and lead-based paint. Lead usually enters the body by ingestion or inhalation. In very young children, clinical studies have shown that approximately 40 percent of the lead ingested is absorbed from the gastrointestinal tract, while adults absorb about 5 to 10 percent of ingested lead.

The rate of absorption of airborne lead in relation to age is not as clearly understood. Although percent retention of inhaled lead is influenced greatly by particle size, clinical studies[12] suggest that, in general, 20 to 40 percent of the inhaled lead will be deposited in the respiratory tract. However, because of higher metabolic rates and greater physical activity of children, it is estimated[13] that under comparable exposure, children inhale two to three times as much airborne lead per unit of body weight as adults do. Even at relatively low levels of lead, subclinical effects of lead exposure in children, including impaired hematopoiesis and neuropsychologic deficits, have been reported in the literature.[14,15]

In each of the three income groups, the mean blood lead levels of black children are significantly greater than those of white children (figure 4). The smallest race difference is in the highest income group. There is also a significant inverse relationship between mean blood lead level and income. For this analysis, three income categories were selected to ensure subsamples of adequate size for computing these national estimates. In 1978, the income level of $6,000 was near the poverty threshold for a family of four as determined by the U.S. Bureau of the Census.[16]

Mean blood lead levels are observed to be higher in the urban areas than in the rural areas for white and black children with statistically significant differences only for the white group (figure 5). Also, mean blood lead levels for black children are significantly higher than those for white children within all three urban-rural groups. This consistent mean difference between black and white children indicates that the observed racial effects are not simply explained by the degree of urbanization. No clearcut explanation can be given from the results of this study; however, these results are consistent with the findings of other studies regarding this racial difference.[17-19]

Further investigation of those living in the large urban areas (1 million or more people) (figure 6 and table 6) revealed that mean blood lead levels of black

Table 1. Blood lead levels of persons 6 months-74 years, with mean, standard error of the mean, median, and percent distribution, by race and age: United States, 1976-80

Race and age	Estimated population in thousands[1]	Number examined[2]	Blood lead level (µg/dl)									
			Mean	Standard error of the mean	Median	Less than 10	10-19	20-29	30-39	40-49	50-59	60-69
All races[3]						Percent distribution[4]						
All ages	203,554	9,933	13.9	0.24	13.0	22.1	62.9	13.0	1.6	0.2	0.1	0.0
6 months-5 years	16,862	2,372	16.0	0.42	15.0	12.2	63.3	20.5	3.5	0.3	0.1	0.0
6-17 years	44,964	1,720	12.5	0.30	12.0	27.6	64.8	7.1	0.5	-	-	-
18-74 years	141,728	5,841	14.2	0.25	13.0	21.2	62.3	14.3	1.8	0.3	0.1	0.0
White												
All ages	174,528	8,369	13.7	0.24	13.0	23.3	62.8	12.2	1.5	0.2	0.1	0.0
6 months-5 years	13,641	1,876	14.9	0.43	14.0	14.5	67.5	16.1	1.8	0.1	0.1	0.0
6-17 years	37,530	1,424	12.1	0.30	11.0	30.4	63.4	5.8	0.4	-	-	-
18-74 years	123,357	5,069	14.1	0.25	13.0	21.9	62.3	13.7	1.8	0.3	0.1	0.0
Black												
All ages	23,853	1,332	15.7	0.48	15.0	13.3	63.7	20.0	2.3	0.3	0.2	0.1
6 months-5 years	2,584	419	20.9	0.61	20.0	2.5	45.4	39.9	10.2	1.4	0.5	0.1
6-17 years	6,529	263	14.8	0.53	14.0	12.8	70.9	15.6	0.7	-	-	-
18-74 years	14,740	650	15.5	0.54	14.0	14.7	62.9	19.6	2.0	0.4	0.3	0.2

[1]At the midpoint of the survey, March 1, 1978.
[2]With lead determinations from blood specimens drawn by venipuncture.
[3]Includes data for races not shown separately.
[4]Numbers may not add to totals due to rounding.

Table 2. Blood lead levels of males 6 months-74 years, with mean, standard error of the mean, median, and percent distribution, by race and age: United States, 1976-80

Race and age	Estimated population in thousands[1]	Number examined[2]	Blood lead level (µg/dl)									
			Mean	Standard error of the mean	Median	Less than 10	10-19	20-29	30-39	40-49	50-59	60-69
All races[3]						Percent distribution[4]						
All ages	99,062	4,945	16.1	0.26	15.0	10.4	65.4	20.8	2.8	0.3	0.1	0.1
6 months-5 years	8,621	1,247	16.3	0.46	15.0	11.0	63.5	21.2	4.0	0.3	0.0	0.0
6-17 years	22,887	902	13.6	0.32	13.0	19.1	70.1	10.2	0.7	-	-	-
18-74 years	67,555	2,796	16.8	0.28	16.0	7.6	64.1	24.2	3.4	0.4	0.1	0.1
White												
All ages	85,112	4,153	15.8	0.27	15.0	11.3	66.0	19.6	2.6	0.3	0.1	0.0
6 months-5 years	6,910	969	15.2	0.46	14.0	13.0	67.6	17.3	2.0	0.1	-	-
6-17 years	19,060	753	13.1	0.33	13.0	21.4	69.5	8.4	0.7	-	-	-
18-74 years	59,142	2,431	16.6	0.29	16.0	8.1	64.8	23.3	3.3	0.4	0.1	0.1
Black												
All ages	11,171	664	18.3	0.52	17.0	4.0	59.6	31.0	4.1	0.7	0.4	0.2
6 months-5 years	1,307	231	20.7	0.74	19.0	2.7	48.8	35.1	11.1	1.9	0.2	0.3
6-17 years	3,272	129	16.0	0.62	15.0	8.0	69.9	21.1	1.0	-	-	-
18-74 years	6,592	304	19.1	0.70	18.0	2.3	56.4	34.9	4.5	0.8	0.6	0.4

[1]At the midpoint of the survey, March 1, 1978.
[2]With lead determinations from blood specimens drawn by venipuncture.
[3]Includes data for races not shown separately.
[4]Numbers may not add to totals due to rounding.

Table 3. Blood lead levels of females 6 months-74 years, with mean, standard error of the mean, median, and percent distribution, by race and age: United States, 1976-80

Race and age	Estimated population in thousands[1]	Number examined[2]	Blood lead level (μg/dl)									
			Mean	Standard error of the mean	Median	Less than 10	10-19	20-29	30-39	40-49	50-59	60-69
						Percent distribution[4]						
All races[3]												
All ages	104,492	4,988	11.9	0.23	11.0	33.3	60.5	5.7	0.4	0.1	0.1	-
6 months-5 years	8,241	1,125	15.8	0.42	15.0	13.5	63.2	19.8	3.0	0.3	0.2	-
6-17 years	22,077	818	11.4	0.32	11.0	36.6	59.3	3.9	0.2	-	-	-
18-74 years	74,173	3,045	11.8	0.22	11.0	33.7	60.6	5.2	0.3	0.1	0.1	-
White												
All ages	89,417	4,216	11.7	0.23	11.0	34.8	59.6	5.0	0.4	0.1	0.1	-
6 months-5 years	6,732	907	14.7	0.44	14.0	16.1	67.3	14.8	1.6	0.1	0.1	-
6-17 years	18,470	671	11.0	0.31	11.0	40.0	56.9	2.9	0.2	-	-	-
18-74 years	64,215	2,638	11.7	0.23	11.0	34.6	59.9	5.0	0.4	0.1	0.1	-
Black												
All ages	12,682	668	13.4	0.45	13.0	21.5	67.3	10.3	0.7	0.1	0.0	-
6 months-5 years	1,277	188	21.0	0.69	20.0	2.2	41.6	45.3	9.2	0.9	0.8	-
6-17 years	3,256	134	13.6	0.64	13.0	17.7	71.9	10.0	0.4	-	-	-
18-74 years	8,148	346	12.7	0.44	12.0	24.7	68.1	7.2	-	-	-	-

[1]At the midpoint of the survey, March 1, 1978.
[2]With lead determinations from blood specimens drawn by venipuncture.
[3]Includes data for races not shown separately.
[4]Numbers may not add to totals due to rounding.

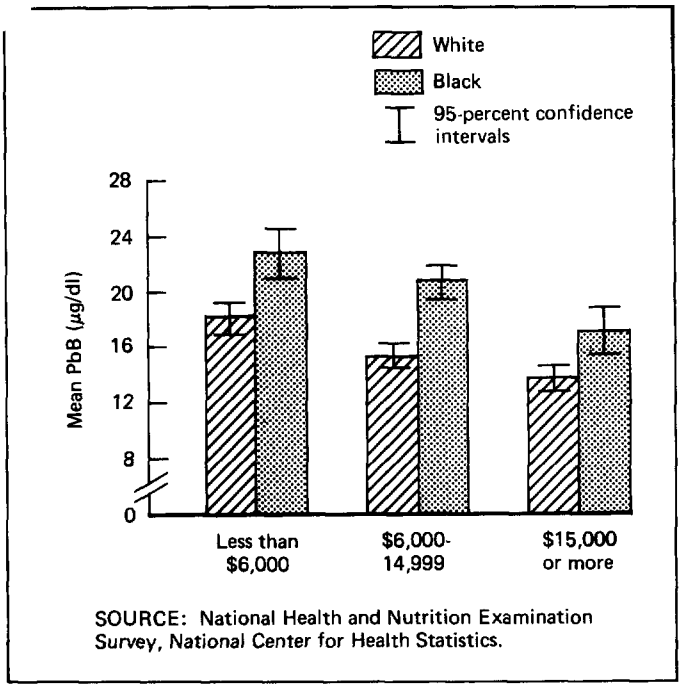


Figure 4. Mean blood lead levels (PbB) of children ages 6 months-5 years by annual family income: United States, 1976-80

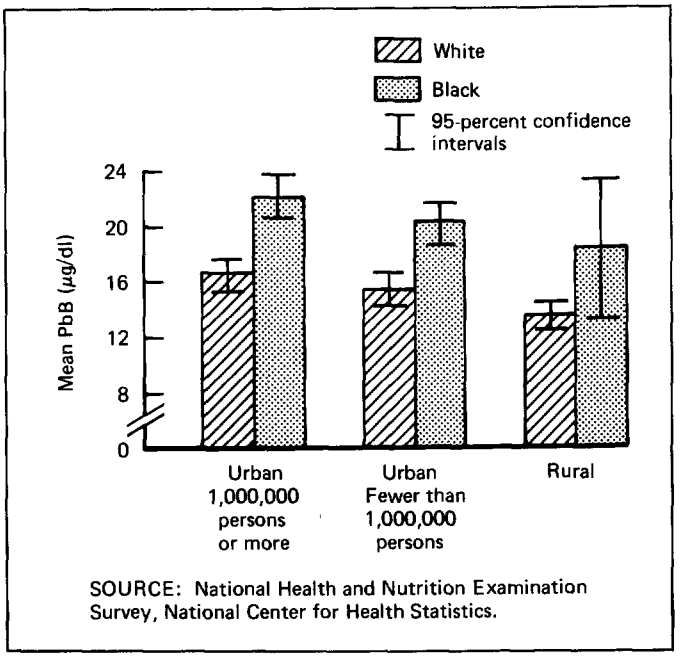


Figure 5. Mean blood lead levels (PbB) of children ages 6 months-5 years by degree of urbanization: United States, 1976-80

Table 4. Blood lead levels of persons 6 months-74 years, with mean, standard error of the mean, and selected percentiles, by annual family income, race, and age: United States, 1976-80

Race and age	Annual family income: Under $6,000						
	Estimated population in thousands[1]	Number examined[2]	Mean	Standard error of the mean	Percentile		
					10th	50th	90th
			Blood lead level (μg/dl)				
All races[3]							
All ages	29,410	1,862	14.5	0.40	8.0	13.0	23.0
6 months-5 years	2,465	448	20.0	0.56	11.0	19.0	31.0
6-17 years	5,046	230	14.6	0.61	8.0	13.0	22.0
18-74 years	21,898	1,184	14.1	0.38	7.0	13.0	23.0
White							
All ages	21,542	1,315	14.0	0.44	7.0	12.0	23.0
6 months-5 years	1,408	256	18.1	0.61	11.0	17.0	26.0
6-17 years	3,067	140	14.0	0.69	8.0	13.0	22.0
18-74 years	17,067	919	13.7	0.43	7.0	12.0	22.0
Black							
All ages	7,355	512	15.8	0.47	9.0	15.0	24.0
6 months-5 years	917	176	22.9	0.89	14.0	21.0	34.0
6-17 years	1,927	87	15.7	0.76	10.0	15.0	22.0
18-74 years	4,512	249	15.0	0.53	8.0	14.0	23.0

[1] At the midpoint of the survey, March 1, 1978.
[2] With lead determinations from blood specimens drawn by venipuncture.
[3] Includes data for races not shown separately.

Table 4. Blood lead levels of persons 6 months-74 years, with mean, standard error of the mean, and selected percentiles, by annual family income, race, and age: United States, 1976-80—Con.

Annual family income													
$6,000-14,999							$15,000 or more						
Estimated population in thousands[1]	Number examined[2]	Mean	Standard error of the mean	Percentile			Estimated population in thousands[1]	Number examined[2]	Mean	Standard error of the mean	Percentile		
				10th	50th	90th					10th	50th	90th
		Blood lead level (μg/dl)							Blood lead level (μg/dl)				
80,416	4,033	14.2	0.25	8.0	13.0	22.0	87,062	3,718	13.5	0.24	8.0	13.0	20.0
7,534	1,083	16.2	0.46	9.0	15.0	24.0	6,428	774	14.1	0.41	8.0	13.0	21.0
17,533	672	12.9	0.41	7.0	12.0	19.0	20,814	761	11.7	0.25	7.0	11.0	17.0
55,349	2,278	14.4	0.26	8.0	13.0	22.0	59,820	2,183	14.1	0.27	8.0	13.0	21.0
68,135	3,413	13.9	0.26	8.0	13.0	21.0	79,707	3,401	13.4	0.26	8.0	13.0	20.0
6,252	887	15.3	0.48	9.0	14.0	22.0	5,707	690	13.7	0.44	8.0	13.0	20.0
13,936	531	12.4	0.39	7.0	12.0	18.0	19,174	705	11.6	0.28	7.0	11.0	16.0
47,946	1,995	14.2	0.26	8.0	13.0	22.0	54,826	2,006	14.0	0.28	8.0	13.0	21.0
10,334	533	16.1	0.48	9.0	15.0	24.0	4,995	224	14.9	0.58	9.0	14.0	22.0
1,037	163	20.7	0.64	13.0	20.0	30.0	502	60	17.2	0.83	11.0	16.0	24.0
3,159	125	14.9	0.71	10.0	14.0	21.0	1,225	42	13.6	0.79	7.0	13.0	20.0
6,137	245	16.2	0.60	9.0	15.0	24.0	3,267	122	15.1	0.65	9.0	14.0	22.0

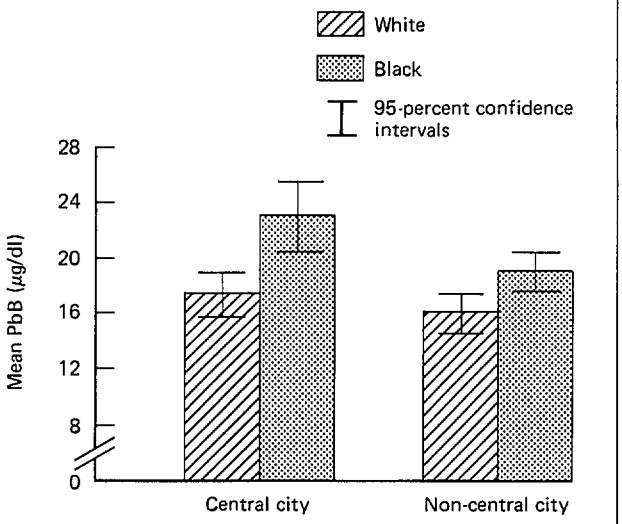
Table 5. Blood lead levels of persons 6 months-74 years, with mean, standard error of the mean, and selected percentiles, by degree of urbanization, race, and age: United States, 1976-80

Race and age	Degree of urbanization						
	Urban, 1 million persons or more						
	Estimated population in thousands[1]	Number examined[2]	Mean	Standard error of the mean	Percentile		
					10th	50th	90th
			Blood lead level (μg/dl)				
All races							
All ages	59,532	2,395	15.0	0.37	9.0	14.0	22.0
6 months-5 years	4,344	544	18.0	0.53	10.0	17.0	27.0
6-17 years	12,893	414	13.8	0.53	9.0	13.0	20.0
18-74 years	42,295	1,437	15.2	0.39	9.0	14.0	23.0
White							
All ages	46,407	1,767	15.0	0.31	9.0	14.0	22.0
6 months-5 years	3,112	358	16.6	0.59	10.0	16.0	24.0
6-17 years	9,681	294	13.3	0.55	9.0	12.0	20.0
18-74 years	33,615	1,115	15.3	0.31	9.0	14.0	23.0
Black							
All ages	11,687	570	15.5	0.84	9.0	14.0	23.0
6 months-5 years	1,093	172	22.2	0.83	14.0	20.0	35.0
6-17 years	3,010	111	15.3	0.83	10.0	15.0	22.0
18-74 years	7,585	287	15.0	0.89	8.0	14.0	22.0

[1] At the midpoint of the survey, March 1, 1978.
[2] With lead determinations from blood specimens drawn by venipuncture.
[3] Includes data for races not shown separately.

Table 5. Blood lead levels of persons 6 months-74 years, with mean, standard error of the mean, and selected percentiles, by degree of urbanization, race, and age: United States, 1976-80—Con.

Degree of urbanization													
Urban, fewer than 1 million persons							Rural						
Estimated population in thousands[1]	Number examined[2]	Mean	Standard error of the mean	Percentile			Estimated population in thousands[1]	Number examined[2]	Mean	Standard error of the mean	Percentile		
				10th	50th	90th					10th	50th	90th
		Blood lead level (μg/dl)							Blood lead level (μg/dl)				
79,906	3,869	13.9	0.32	8.0	13.0	21.0	64,116	3,669	13.0	0.40	7.0	12.0	20.0
6,891	944	16.5	0.67	9.0	16.0	24.0	5,627	884	13.9	0.64	8.0	13.0	20.0
16,988	638	12.6	0.35	7.0	12.0	19.0	15,083	668	11.4	0.52	7.0	11.0	16.0
56,027	2,287	14.1	0.33	8.0	13.0	22.0	43,405	2,117	13.4	0.38	7.0	12.0	21.0
67,707	3,144	13.6	0.32	8.0	13.0	21.0	60,414	3,458	12.8	0.39	7.0	12.0	20.0
5,297	699	15.4	0.67	9.0	15.0	23.0	5,233	819	13.5	0.57	8.0	13.0	19.0
13,871	510	12.2	0.36	7.0	11.0	18.0	13,978	620	11.2	0.48	7.0	11.0	16.0
48,540	1,935	13.8	0.32	8.0	13.0	21.0	41,203	2,019	13.3	0.38	7.0	12.0	21.0
9,783	612	15.9	0.54	9.0	15.0	24.0	2,383	150	16.2	0.68	9.0	14.0	25.0
1,246	205	20.3	0.78	12.0	20.0	30.0	245	42	18.3	2.60	11.0	16.0	32.0
2,717	113	14.5	0.64	8.0	14.0	20.0	802	39	13.9	1.33	8.0	13.0	20.0
5,820	294	15.9	0.70	9.0	15.0	24.0	1,336	69	17.0	0.89	9.0	15.0	26.0



SOURCE: National Health and Nutrition Examination Survey, National Center for Health Statistics.

Figure 6. Mean blood lead levels (PbB) of children ages 6 months-5 years in large urban areas: United States, 1976-80

children in the central cities were observed to be higher than those of black children living in the non-central cities and rural areas, respectively. These differences were neither statistically significant nor reliable because of the small number of black children in the sample. However, within the central cities, the mean blood lead level of black children was significantly higher than that of white children. Other studies indicate that[13] exposure to lead in central city children may be associated, to some degree, with socioeconomic factors. It was observed in this study that 43 percent of black compared with 22 percent of white children living in the central city areas were from households with annual family incomes of under $6,000 during the year preceding the time of interview.

The literature[13] suggests that preschool-aged children from low income households living in the inner cities (the "urban lead-belt") are at higher risk of exposure to environmental sources contaminated with lead than the general child population. Attempts to include such cross-classifications using the NHANES II data resulted in group sizes too small to be reliable estimators for the general population. For example, while it would have been of interest to determine if the association between race and blood lead level differed between various degrees of urbanization by income groups, the number of examinees within such groups was too small.

Elevated blood lead levels in children

The consistent difference in blood lead levels between black and white children ages 6 months-5 years and the presence of higher blood lead levels among those in the low income group and large urban areas can also be distinguished by looking at the percent of children with blood lead levels of 30 μg/dl or more. According to CDC guidelines published in 1978,[6] 30 μg/dl is the cutoff used in the CDC community-based lead poisoning prevention programs for referring children for followup.

Based on the CDC guidelines (30.0 μg/dl or more), NHANES II data indicate than an estimated 4.0 percent or approximately 675,000 U.S. children 6 months-5 years of age have elevated blood lead levels (table 7). Among children of this age, 12.2 percent of black children compared to 2.0 percent of white children had blood lead levels of 30 μg/dl or more. This difference is significant for boys and for girls. The percent with elevated blood lead levels are observed to be slightly higher in boys than girls, but this difference is not statistically significant at the 0.05 level of probability.

There was a significant decrease in the proportion of children with elevated blood lead levels with increased family income. This relationship was stronger for black than for white children. The highest percent of elevated blood lead levels (18.5 percent) was found among black children from low income families. For both white and black children, the percent of persons with elevated blood lead levels was lowest in the high income group.

With respect to degree of urbanization, the percent with elevated blood lead levels living in the central cities was significantly higher for black than white children. Even in the smaller urban and rural areas, 10.0 percent of black children were observed to have elevated blood lead levels compared with less than 2.0 percent for white children. Caution should be exercised in interpreting racial differences in rural areas because of a relatively small number of examined persons (42 cases) in the estimation cell for rural black children.

Trends in lead levels

Preliminary analyses suggest that in the 4-year period of this survey there was a 37-percent decrease in the mean blood lead levels from 15.8 μg/dl during the first 6 months of the survey to 10.0 μg/dl during the last 6 months (figure 7).

Decreases were found for both black and white races, all age groups, and both sexes (figure 8). Further analysis indicated that the decline was not due to seasonal, income, geographic region, or urban-rural differences. Nor was it due to laboratory measurement error or chance.[20]

Table [redacted]. Blood lead levels of persons 6 months-74 years, with mean, standard error of the [redacted], and selected percentiles, by large urban areas, race, and age: United States, 1976-[redacted]

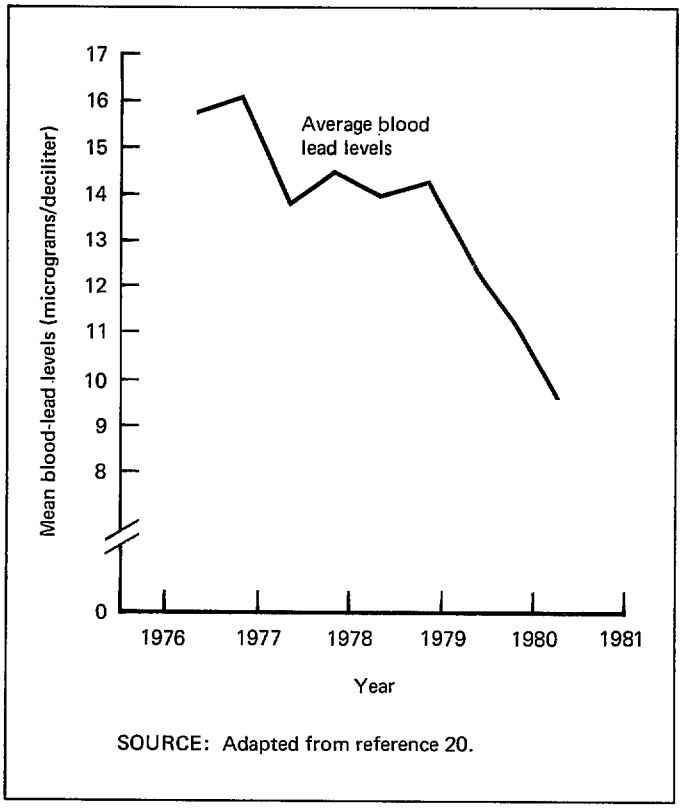
Race and age	Large urban areas											
	Central city						Non-central city					
	Estimated population in thousands[1]	Number examined[2]	Mean	Standard error of the mean	Percentile			Estimated population in thousands[1]	Number examined[2]	Mean	Standard error of the mean	Percentile		
					10th	50th	90th					10th	50th	90th
All races[3]			Blood lead level (μg/dl)							Blood lead level (μg/dl)				
All ages	24,560	1,123	14.9	0.67	9.0	14.0	22.0	34,908	1,268	15.1	0.30	9.0	14.0	23.0
6 months-5 years	1,822	286	20.0	0.71	11.0	19.0	31.0	2,519	257	16.5	0.60	10.0	16.0	24.0
6-17 years	5,124	177	14.6	0.87	9.0	14.0	21.0	7,746	236	13.3	0.59	9.0	12.0	19.0
18-74 years	17,614	660	14.7	0.70	8.0	14.0	22.0	24,643	775	15.6	0.29	9.0	14.0	23.0
White														
All ages	14,602	625	14.8	0.56	9.0	14.0	22.0	31,741	1,138	15.1	0.32	9.0	14.0	23.0
6 months-5 years	885	133	17.4	0.84	10.0	17.0	25.0	2,223	224	16.2	0.65	10.0	15.0	24.0
6-17 years	2,710	86	14.3	0.93	9.0	14.0	21.0	6,949	207	13.0	0.63	8.0	12.0	18.0
18-74 years	11,007	406	14.8	0.59	9.0	14.0	22.0	22,569	707	15.6	0.30	9.0	14.0	23.0
Black														
All ages	8,856	452	15.4	0.94	8.0	14.0	23.0	2,831	118	16.0	0.60	9.0	15.0	22.0
6 months-5 years	855	143	23.1	1.30	14.0	21.0	36.0	238	29	19.2	0.74	14.0	19.0	26.0
6-17 years	2,259	84	15.0	1.00	9.0	14.0	21.0	751	27	16.0	0.67	10.0	16.0	22.0
18-74 years	5,742	225	14.8	0.95	8.0	14.0	22.0	1,842	62	15.7	0.80	9.0	15.0	22.0

[1]At the midpoint of the survey, March 1, 1978.
[2]With lead determinations from blood specimens drawn by venipuncture.
[3]Includes data for races not shown separately.

Table 7. Percent of children ages 6 months-5 years with blood lead levels of 30.0 μg/dl or more,[1] with standard error of the percent, by selected demographic variables: United States, 1976-80

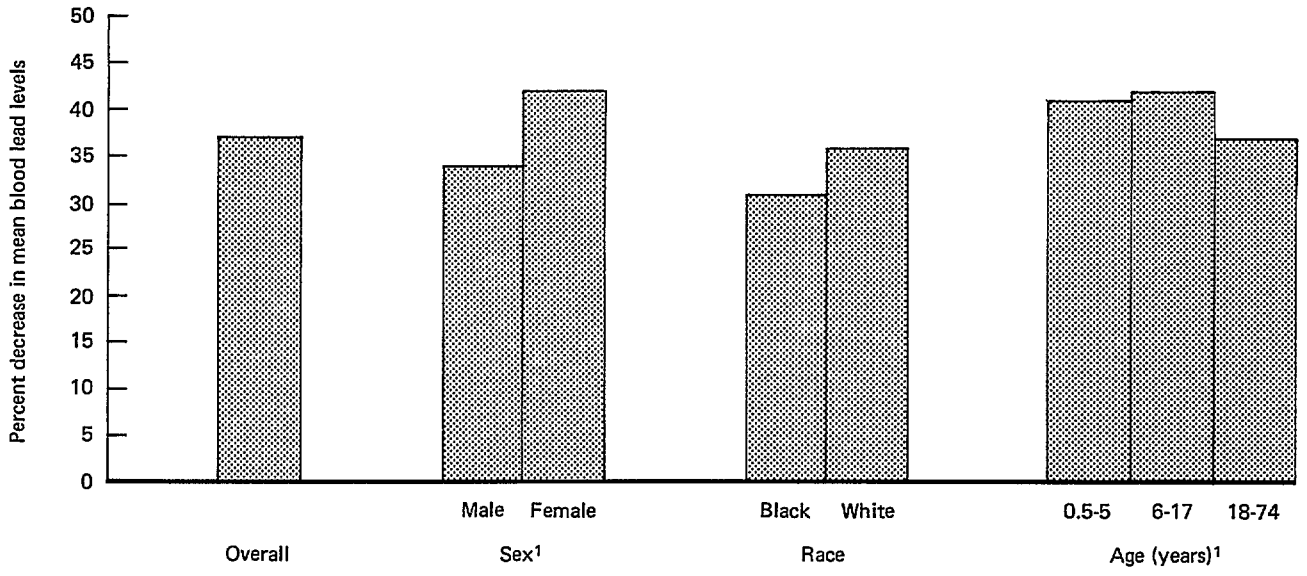
Demographic variable	All races[2]	White	Black	All races[2]	White	Black
	Percent of children[1,3]			Standard error		
Both sexes	4.0	2.0	12.2	0.5	0.3	1.5
Boys	4.4	2.1	13.4	0.7	0.5	2.0
Girls	3.5	1.8	10.9	0.5	0.4	2.4
Annual family income						
Under $6,000	10.9	5.9	18.5	1.4	1.3	3.6
$6,000-14,999	4.2	2.2	12.1	0.7	0.5	1.9
$15,000 or more	1.2	0.7	2.8	0.4	0.3	1.2
Degree of urbanization of place of residence						
Urban, 1 million persons or more	7.2	4.0	15.2	0.7	0.7	1.5
Central city	11.6	4.5	18.6	1.9	1.9	2.8
Non-central city	3.7	3.8	3.3	0.8	0.8	1.4
Urban, fewer than 1 million persons	3.5	1.6	10.2	0.6	0.4	2.4
Rural	2.1	1.2	10.3	0.9	0.5	5.3

[1]The one child (a black male, family income under $6,000, in a rural area) with an excessively high Pb-B level (76.0 μg/dl) was excluded. This exclusion has a negligible effect on the national estimates shown here.
[2]Includes data for races not shown separately.
[3]Estimated using data on blood lead levels determined from specimens drawn by venipuncture.



SOURCE: Adapted from reference 20.

Figure 7. Mean blood levels of U.S. population 6 months-74 years: United States, February 1976-February 1980



SOURCE: Adapted from reference 20.

[1]For white persons only.

Figure 8. Percent decrease in mean blood lead levels of U.S. population 6 months-74 years, by sex, race, and age: United States, February 1976-February 1980

Summary

For years excessive exposure to lead has been a serious public health concern for selected groups of the population--particularly young children and lead smelter and other industrial workers. This report provides the first national estimates of the blood lead levels in the U.S. population, based on the findings from the National Health and Nutrition Examination Survey of 1976-80 (NHANES II). Blood lead levels were determined on a cross-sectional sample representative of the U.S. civilian noninstitutionalized population 6 months-74 years of age examined in NHANES II. These data were obtained for baseline use in studies of the effect of lead contamination on health and for identifying areas or groups at high risk throughout the country.

Based on the CDC guideline for elevated blood lead levels (30 micrograms or more per deciliter of whole blood), an estimated 4.0 percent or approximately 675,000 U.S. children ages 6 months-5 years show evidence of excessive amounts of lead in their blood. The percent of children with this degree of elevated blood lead level is significantly higher in black (12.2 percent) than in white (2.0 percent) children. Almost one-fifth (18.5 percent) of black children from low income families have elevated blood lead levels.

Among children 6 months-5 years of age, mean blood lead levels are significantly higher in black than in white children across all family income levels and degrees of urbanization of their place of residence. Mean blood lead levels are significantly higher among children from families with low income levels and those in the large urbanized communities (1 million or more population) than among children from families with moderate or high income levels and those living in smaller cities or rural areas, respectively.

Among children ages 6-17 years, mean blood lead levels decrease across successive age groups until about adolescence. For persons 18-74 years of age, mean blood lead levels are positively associated with age until the middle ages (45-54 year group), with a moderate decline in the older age groups. Across all adult age groups, the mean blood lead levels of men substantially exceed those of women.

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Symbols

- - -	Data not available
. . .	Category not applicable
-	Quantity zero
0.0	Quantity more than zero but less than 0.05
Z	Quantity more than zero but less than 500 where numbers are rounded to thousands
*	Figure does not meet standards of reliability or precision

Technical notes

Sample design

The information presented in this report is based on data from the direct standardized physical examination, tests and measurements, and medical histories collected in the second National Health and Nutrition Examination Survey (NHANES II) during 1976-80. The target population of NHANES II encompassed the civilian noninstitutionalized population (ages 6 months through 74 years) of the United States, including Alaska and Hawaii.

NHANES II utilized a multistage probability design that involved selection of primary sampling units (PSU's), segments (clusters of households) within PSU's, households, eligible persons, and finally sample persons. PSU's are typically composed of a county or group of contiguous counties. The sample design provided for oversampling among those persons ages 6 months-5 years, those ages 60-74 years, and those living in poverty areas (as defined by the United States Bureau of the Census for the 1970 census[16]).

The U.S. Bureau of the Census selected the NHANES II sample of 27,801 persons according to specifications from the National Center for Health Statistics. Of this sample, 20,322 (73.1 percent) were examined. A total of 16,563 persons in the NHANES II sample, including all persons ages 6 months-6 years and a half-sample of persons ages 7-74 years, were assigned to receive the test for lead levels in the blood. Of these sample persons, blood specimens were drawn and analyzed for blood lead on 10,049 persons giving an overall response rate of 60.7 percent.

Blood lead levels and related data in this report are presented as population estimates; examination findings for each sample person have been inflated by the reciprocal of selection probabilities, adjusted to account for persons who were not examined, and poststratified by race, sex, and age. The final estimates will then closely approximate the independent U.S. Bureau of Census estimates for the civilian noninstitutionalized population of the United States as of March 1, 1978. No further adjustment was made for examined persons in the lead subsample with missing blood lead data due to refusal to give a blood specimen or otherwise.

Standard errors and tests of significance

The statistical methods used to analyze the data take into account the complex survey design of NHANES II.[2] Complex survey techniques were used to decrease the cost of sampling a large population. Although complex survey designs complicate data analysis, they must be taken into consideration to avoid the erroneous assumptions that would be made using a simple random sampling method. The latter usually results in an inferential analysis with too many significant test results due solely to underestimation of variances.

The standard errors of the weighted means and proportions of persons with elevated blood lead levels presented in this report were calculated using the Taylor Series linearization method.[21] This process approximates the variance of nonlinear statistics, e.g., means and proportions, by using a first order Taylor Series expansion. If the higher order terms of the expansion are negligible, and if the sample is of a reasonable size for the domains of interest, then this approximation provides variance estimates as reliable as those from the pseudoreplication method adapted for analyzing NHANES II data.[22]

For blood lead analysis in this study, the population was divided into three age groups—children 6 months-5 years, youths 6-17 years, and adults 18-74 years. Regression analysis was performed within each age group using blood lead level as the dependent variable and age as a covariate. The effect on blood lead level of each of the demographic variables—race, sex, income, and degree of urbanization—were tested in this analysis after accounting for age. Tests of significance for comparing the means shown in figure 1 through 6 were performed using a regression program, called SURREGR,[23] which takes into consideration the complex survey sample design.

Using the Grizzle-Starner-Koch (GSK) approach to categorical data analysis,[24] tests of the hypothesis that there is no difference among population subgroups in proportions of persons with elevated blood lead levels (table 7) were performed. This analysis involved two stages, (1) estimation of the proportion of those with elevated blood lead levels for the subgroups of interest and (2) estimation of an appropriate variance-covariance matrix and hypothesis testing using categorical data analysis. The computation for this analysis involved interfacing two programs—SURREGR for the first stage calculations and GENCAT, a program for generalized chi-square analysis of categorical data, for the second stage.[26,27]

Description of nonrespondents and exclusions

All NHANES II sample persons ages 6 months-6 years and a half-sample of those ages 7-74 years were to have had blood lead determinations. However, 39.3 percent of these sample persons had missing lead values due to nonresponse at various stages of partici-

NOTE: A list of references follows the text.

pation in the survey. The rate of nonresponse was greater among preschool-aged children than among youths or adults (table I). About half (51.0 percent) of the children ages 6 months-5 years compared with 28.6 percent of persons ages 6-17 years and 35.7 percent of adults ages 18-74 years had no blood lead determinations. Among medically examined persons in the lead subsample (table II), those with missing blood lead values were randomly distributed by demographic (other than age) and socioeconomic categories. The analysis of the distribution of nonresponse for noninterviewed and nonexamined persons in these categories is planned for a forthcoming report.[5]

Blood lead data from blood specimens drawn by fingerstick (pricking the finger) and from extreme cases of lead exposure (blood lead values of 70.0 μg/dl or more) were excluded from computation of national estimates. A description of blood lead levels for persons receiving fingersticks is given in table III. Seventy-five percent of the 113 children with blood lead values who received fingersticks were under 3 years of age. Table IV shows the characteristics of three persons receiving venipunctures who had blood lead values greater than 70.0 μg/dl. Each of these three individuals was referred to his personal physician for medical attention.

Quality control methods

Lead concentrations were measured in whole blood by atomic absorption spectroscopy using a modification of the Delves method.[9,27] All materials used for collecting and processing specimens were screened for possible lead contamination. All preparatory work on the specimens, including field and laboratory procedures, were conducted under laminar flow hoods that provided class 100 air (i.e., air containing less than 100 particles/m^3 of greater than 0.5 micron diameter).

Two quality control systems using bovine wh[illegible] blood were set up by CDC. These two systems we[illegible] (1) "bench" quality control pools inserted by the analyst and measured 2-4 times in each analytical run to make judgments on the day of analysis and (2) "blind" quality control specimens placed in vials, labeled, and processed in duplicate to be indistinguishable from regular NHANES II specimens. If the average of replicate values of either "bench" or "blind" quality control specimens fell outside of their respective previously established 95-percent confidence limits, the run was repeated. Also, NHANES II specimens were run in duplicate. When replicate absorbance values differed by more than 0.025 absorbance or the difference between calculated concentrations for duplicates was greater than 7 μg Pb/dl, analysis was repeated for the specimen.

The "normal blind" pool with a mean of 13.7 μg/dl had a standard deviation (SD) of 2.2 μg/dl (0.022 ppm) while the "high blind" pool with a mean of 25.5 μg/dl had a SD of 3.2 μg/dl (0.032 ppm). The coefficients of variation, that is, the standard deviation expressed as a fraction of the mean blood lead level for a given pool, for the "bench" quality controls having blood lead levels of 30.0 μg/dl or more ranged from 7.0 to 15.0 percent.[7]

Limitations of the data

Rigorous quality control methods were implemented throughout specimen collection and processing and in data processing to ensure validity and accuracy of the results reported. However, there are some factors that might affect the data. Foremost is the relative imprecision of a measurement or measurement error. Based on an analysis of the quality control pools,[8] the coefficient of variation for the laboratory methods used are approximately 15.0 percent

NOTE: A list of references follows the text.

Table I. Nonresponse among sample persons ages 6 months-74 years in the lead subsample by age: National Health and Nutrition Examination Survey, 1976-80

Age	Number of sample persons								Percent of sample persons[2] without lead values	Percent of examinees[2] without lead values
	In lead subsample	Interviewed	Not interviewed	Examined	Not examined	Examined but missing blood lead values: Overall	Refused to give blood specimen	Blood specimen drawn[1]		
All ages	16,563	15,179	1,384	12,288	2,891	2,239	1,197	1,042	39.3	18.2
6 months-5 years	5,069	4,876	193	4,118	758	1,634	988	646	51.0	39.7
6-17 years	2,413	2,261	152	1,967	294	245	122	123	28.6	12.5
18-74 years	9,081	8,042	1,039	6,203	1,839	360	87	273	35.7	5.8

[1]By venipuncture or fingerstick.
[2]In the lead subsample.

Table II. Nonresponse among examined persons ages 6 months-74 years in the lead subsample by age, race, sex, income, and degree of urbanization: National Health and Nutrition Examination Survey, 1976-80

Demographic variables	Age											
	6 months-74 years			6 months-5 years			6-17 years			18-74 years		
	Number of persons examined	Examined persons with missing lead values		Number of persons examined	Examined persons with missing lead values		Number of persons examined	Examined persons with missing lead values		Number of persons examined	Examined persons with missing lead values	
		Number	Percent		Number	Percent		Number	Percent		Number	Percent
Total	12,288	2,239	18.2	4,118	1,634	39.7	1,967	245	12.5	6,203	360	5.8
Race												
White	10,253	1,806	17.6	3,264	1,311	40.2	1,616	192	11.9	5,373	303	5.6
Black	1,737	367	21.1	723	269	37.2	313	48	15.3	701	50	7.1
Other	298	66	22.1	131	54	41.2	38	5	13.2	129	7	5.4
Sex												
Male	6,123	1,119	18.3	2,143	840	39.2	1,022	119	11.6	2,958	160	5.4
Female	6,165	1,120	18.2	1,975	794	40.2	945	126	13.3	3,245	200	6.2
Annual family income												
Under $6,000	2,291	404	17.6	752	281	37.4	268	37	13.8	1,271	86	6.8
$6,000-$14,999	5,082	994	19.6	1,876	739	39.4	780	107	13.7	2,426	148	6.1
$15,000 or more	4,509	758	16.8	1,368	562	41.1	852	91	10.7	2,289	105	4.6
Unknown	406	83	20.4	122	52	42.6	67	10	14.9	217	21	9.7
Degree of urbanization												
Large urban[1]	2,993	583	19.5	949	391	41.2	483	69	14.3	1,561	123	7.9
Smaller urban[2]	4,805	869	18.1	1,647	639	38.8	721	81	11.2	2,437	149	6.1
Rural	4,490	787	17.5	1,522	604	39.7	763	95	12.5	2,205	88	4.0

[1]With 1 million or more persons.
[2]With fewer than 1 million persons.

and 12.0 percent for control pools with low (less than 30.0 μg/dl) and high (30.0 μg/dl or more) mean lead levels, respectively. In addition, there are significant within-day and among-day components of variance.

A possible logistical factor indirectly influencing the blood lead data is the itinerary of the Mobile Examination Centers (MEC's). To minimize the effects of adverse weather conditions on response rates, MEC's were set up in the northern States during the summer and more southern States during the winter. The potential environmental effects on blood lead levels associated with seasonality[28] and geographic location may be confounded, to some undetermined degree, with those associated with degree of urbanization of place of residence.

NOTE: A list of references follows the text.

Table III. Description of raw data on blood lead determinations from specimens collected by fingersticks in children ages 6 months-7 years: National Health and Nutrition Examination Survey, 1976-80

Race	Number examined	Mean	Standard deviation	Mode	Median	Minimum	Maximum	Skewness
		(μg/dl)						
All races[1]	113	24.8	15.4	18.0	22.2	7.0	116.0	3.5
White	77	23.2	17.6	18.0	19.0	7.0	116.0	3.7
Black	36	28.3	8.0	27.0	28.0	12.0	47.0	0.1

[1]Includes data for races not shown separately.

Table IV. Characteristics of three persons with blood lead values greater than 70.0 μg/dl who received venipuncture: National Health and Nutrition Examination Survey, 1976-80

Blood lead value (μg/dl)	Demographic factors				
	Age in years	Sex	Race	Family income	Degree of urbanization
76.0	1	Male	Black	Under $6,000	Rural
80.0	42	Male	White	$15,000 or more	Large urban[1]
90.0	18	Male	Black	Under $6,000	Smaller urban[2]

[1]With 1 million or more persons.
[2]With fewer than 1 million persons.

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