VITAL & HEALTH STATISTICS

# Total White Blood Cell Counts for Persons Ages 1–74 Years With Differential Leukocyte Counts for Adults Ages 25–74 Years: United States, 1971–75

This report presents white blood cell count findings for persons ages 1-74 years and differential leukocyte count findings for adults ages 25-74 years, by age, sex, and race, from the first National Health and Nutrition Examination Survey: United States, 1971-75

**Data From the National Health Survey**
**Series 11, No. 220**

DHHS Publication No. (PHS) 82-1670

U.S. Department of Health and Human Services
Public Health Service
Office of Health Research, Statistics, and Technology
National Center for Health Statistics
Hyattsville, Md.
January 1982

**Library of Congress Cataloging in Publication Data**

McGrath, Cornelia R

Total white blood cell counts for persons ages 1-74 years with differential leukocyte counts for adults ages 25-74 years, United States, 1971-75.

(Vital and health statistics: Series 11, Data from the National Health Survey; no. 220) (DHHS publication; no. (PHS) 82-1670)

Includes bibliographical references.

Supt. of Docs. no.: HE 20.6209.11/220

1. Leucocytes—Tables. 2. Health surveys—United States. I. Hitchcock, Dale C., joint author. II. Assendelft, O. W. van, joint author. III. Title. IV. Series: United States. National Center for Health Statistics. Vital and health statistics: Series 11, Data from the National Health Survey, Data from the health examination survey; no. 220. V. Series: United States. Dept. of Health and Human Services. DHHS publication; no. (PHS) 82-1670. [DNLM: 1. Blood cell count—United States—Statistics. 2. Leukocyte count—United States—Statistics. W2 A N148vk no. 220]

RA407.3.A347 no. 220 [RB45] 312'.0973s [312'.6]

ISBN 0-8406-0202-2 80-607766

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

*Cooperation of the U.S. Bureau of the Census*

In accordance with specifications established by the National Center for Health Statistics, the U.S. Bureau of the Census, under a contractual agreement, participated in the design and selection of the sample and carried out the first stage of the field interviewing and certain parts of the statistical processing.

# Acknowledgments

The authors would like to acknowledge the work of Carol Williams and Laurel MacDowell, formerly of the Health Examination Field Operations Branch, Division of Data Services, National Center for Health Statistics, for their assistance in the preparation of this manuscript. The authors are also grateful for the advice of Marguerite Candler Ballard, M.S., M.D., Centers for Disease Control.

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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 |
| * | Figure does not meet standards of reliability or precision (more than 30-percent relative standard error) |
| # | Figure suppressed to comply with confidentiality requirements |

# Total White Blood Cell Counts for Persons Ages 1-74 Years With Differential Leukocyte Counts for Adults Ages 25-74 Years

by Cornelia R. McGrath, M.T. (ASCP),[a] Dale C. Hitchcock,[b] and Onno W. van Assendelft, M.D., Ph.D.[a]

## Introduction

### Highlights

During the first National Health and Nutrition Examination Survey, over 21,000 white blood cell counts were performed on examinees 1-74 years of age, and approximately 5,500 differential leukocyte counts were performed on a subsample of examinees 25-74 years of age. The data obtained have been expanded by appropriate weighting factors to represent the U.S. civilian noninstitutionalized population. The results have been reviewed for race, sex, and age differences.

Mean values, standard errors of the mean, and percent distributions have been estimated for the white blood cell counts. The white population was found to have a higher white blood cell count than the black population has. Children less than 6 years of age have higher white blood cell counts than older persons have.

Percent and absolute numbers of bands, segmented neutrophils, lymphocytes, monocytes, eosinophils, and basophils are also presented in this report. The white population was found to have a higher mean segmented neutrophil value both in percent and absolute number than the black population has. This higher neutrophil value accounts for most of the higher total white blood cell count in the white population. Black adults have a higher mean percent of lymphocytes than their white counterparts have.

### Data collection

The National Center for Health Statistics collects, analyzes, and disseminates data on the health of the U.S. population. One major program is the National Health Examination Survey, in which extensive examinations of a sample of the U.S. population are conducted, using mobile examination centers.

Between 1959 and 1970, three National Health Examination Survey programs, or cycles, were conducted; each one aimed at a specific segment of the U.S. civilian noninstitutionalized population. Cycle I (1959-62) was directed at the 18-79-year age group, with a focus on certain chronic diseases. Cycles II and III (1963-65 and 1966-70) were concerned with children ages 6-11 years and youths ages 12-17 years, respectively. These two programs studied growth and development by using selected tests and instruments and screened the target populations for such conditions as heart disease, ear-nose-throat conditions, and neuromuscular abnormalities. Descriptions[1-3] and findings from the three programs have been published by the National Center for Health Statistics.

In 1969, the Department of Health and Human Services (then known as the Department of Health, Education, and Welfare) established a continuing national surveillance system to measure the nutritional status of the U.S. population and to monitor changes in this status. The task of developing the program was assigned to the National Center for Health Statistics. Consequently, the National Health Examination Survey was expanded into the first National Health and Nutrition Examination Survey and was redesigned to measure aspects of the health and nutritional status of the U.S. population.

As in the three earlier programs, the first National Health and Nutrition Examination Survey used specially equipped mobile examination centers. The centers served as standardized environments in which teams of specially trained medical and technical personnel conducted the examinations. Three sets of three trailers were constructed as mobile examination centers. They were drawn by detachable truck tractors when moving from one sample location to another. At each examination site, the three trailers were set up side by side and were connected by enclosed passageways to form the mobile examination center.

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[a]Centers for Disease Control.

[b]Division of Health Examination Statistics.

The field staff consisted of three elements. The first was the team from the U.S. Bureau of the Census, usually consisting of 8-16 interviewers and a supervisor. The Census personnel administered household questionnaires to gather demographic information, and they also administered medical history questionnaires used during the final phase of the survey. The second element consisted of administrative personnel: field operation managers, their assistants, and specially trained health interviewers employed early in the survey to administer health history questionnaires and to make examination appointments. These interviewers later augmented the efforts of the Census interviewers who became responsible for those tasks. The third element was the examining staff that operated within the mobile examination center. This group included a physician, a nurse, a dermatologist, an ophthalmologist, a dentist, two dietary interviewers, two health technicians, one laboratory technician, and a receptionist-coordinator. Further details regarding the mobile examination center and the field staff have been published.[4-8]

The findings in this report are derived from a set of nationwide probability samples that totaled approximately 32,000 people ages 1-74 years from the civilian noninstitutionalized population of the coterminous United States. The survey began in April 1971, and the nutritional component was completed in June 1974. The sample was selected so that certain population groups thought to be at high risk of malnutrition (persons with low incomes, preschool children, women of childbearing age, and the elderly) were oversampled at predetermined rates. Although a major emphasis of the survey was placed on nutrition, a subsample of persons ages 25-74 years received a more detailed health examination. After the nutrition survey was completed, the detailed examination given to adults was continued through October 1975. This extension of the survey is referred to as the augmentation portion.

Examinations were conducted in 65 different locations (referred to as "stands") across the United States during the nutrition phase of the survey, and in the augmentation phase there were an additional 35 stands. The differential leukocyte count findings in this report are derived from the detailed examination of adults in the 25-74-year age group, and the white blood cell count findings are based on persons who received the nutrition examination. Out of 28,043 persons selected for the nutrition examination sample, 27,753 were interviewed, and 20,749 were examined, yielding a net response rate of nearly 75 percent. For the detailed examination sample, an initial sample of 9,881 persons, selected during both the nutrition and augmentation phases, resulted in 9,742 interviews and 6,913 examinations, yielding a response rate of 71 percent. A more detailed description of the sample design and estimation procedures is in appendix I.

Information was obtained by means of a household interview; a general medical history; a 24-hour dietary recall interview; a food frequency interview; a food program questionnaire; a general medical examination; dental, dermatological, and ophthalmological examinations; anthropometric measurement; hand-wrist X-rays (ages 1-17 years only); and 24 hematological, blood chemistry, and urological laboratory determinations.

Also, data were gathered on the detailed examination sample of adults by the following methods: a supplemental medical history questionnaire; supplemental questionnaires concerning arthritis and respiratory and cardiovascular conditions (when applicable); a health care needs questionnaire; a general well-being questionnaire; an extended medical examination; X-rays of the chest, hip, and knee joints; and audiometry, electrocardiography, goniometry, spirometry, pulmonary diffusion, and tuberculin tests, along with additional laboratory determinations, including the differential leukocyte count.

# Source of data

## Background

This report presents normative data for white blood cell (WBC) counts and differential leukocyte counts, based on findings from NHANES I. These findings will be compared in a future publication, which will present similar data from the second National Health and Nutrition Examination Survey (NHANES II).

The total WBC count includes several cell types; various physiological and pathological processes affect specific types. The WBC and differential counts perhaps provide more information in less time at less cost than any other laboratory test. The test results may guide the ordering of subsequent analyses, thus avoiding needless and often costly tests. While the WBC count has limited value in screening ambulatory patients in terms of sensitivity and specificity and has limited predictive value, the test is valuable in detecting acute disorders such as appendicitis or for following the course of an acute disease process. When combined with patient histories and examinations, WBC and differential leukocyte counts can add valuable supporting evidence for the diagnoses of numerous diseases.

Certain rare hereditary diseases, such as Alder's anomaly, May-Hegglin anomaly, and Chédiak-Higashi disease, have characteristic white blood cell abnormalities. A more common finding of increased neutrophils with a shift toward less mature forms is consistent with acute bacterial infections, toxemia of pregnancy, and certain myeloproliferative disorders. Increased nuclear lobulation of the segmented neutrophils with macrocytosis is indicative of megaloblastic anemia, whereas hypolobulation is indicative of the Pelger-Huët anomaly. Increased numbers of eosinophils are found in hypersensitivity states and in parasitemia with visceral involvement. Monitoring the eosinophil count guides adrenocortical steroid therapy in asthma. Lymphocytosis with atypical lymphocytes is found in children, especially those with viral diseases with accompanying exanthemata. Absolute atypical lymphocytosis is an essential criterion necessary to confirm the diagnosis of infectious mononucleosis. Marked elevated WBC counts with increased lymphocytes and smudge cells in middle-aged and older persons is highly suggestive of chronic lymphocytic leukemia.

## Procedures

Blood was drawn from examinees by venipuncture using evacuated tubes. An ethylene diaminetetra-acidic acid-containing (EDTA) sample (1.25 mg/ml) was used for the hematological laboratory determinations. Samples were collected by fingerstick from those persons, primarily children ages 1-3 years, on whom venipunctures were unsuccessful. Two peripheral blood smears, two white blood cell-hemaglobin dilutions, and two hematocrit tubes were collected from succeeding drops of blood.

White blood cell counts were determined in duplicate in the mobile examination center's laboratories on the Coulter Fn. The peripheral blood slides were stained and sent to the Hematology Division of the Centers for Disease Control for differential leukocyte counts. Further description of the methods are in appendix III.

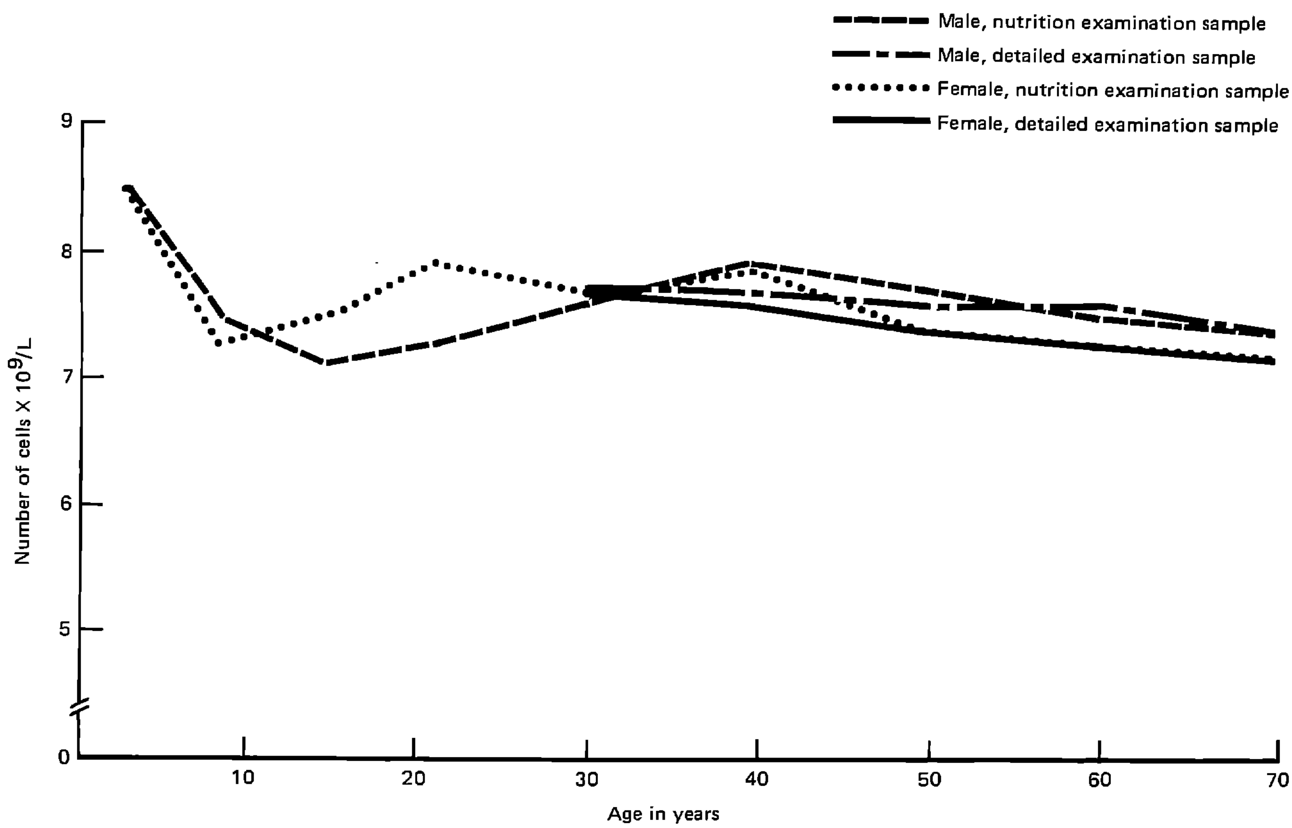
## Data base

Of the 6,913 adults in the detailed examination sample, a differential leukocyte count was performed on 5,854 slides, and the WBC count was considered satisfactory for 6,273 persons. If either the WBC or differential leukocyte count was missing for an examined person, then that person was excluded from the analysis, leaving 5,491 persons as the basis for all differential leukocyte counts in this report. Possible bias due to missing information is discussed in appendix I.

Since WBC counts were also available for persons examined in the nutrition examination sample of NHANES I, these data were included in this report.

This means that the WBC findings presented in this study are based on more than 18,000 sample persons, including those under 25 years of age, instead of being based only on the 6,273 adults from the detailed examination sample. However, a differential leukocyte count was not done on nutrition examination sample persons unless they also were in the detailed examination sample. Figure 1 demonstrates the expected similarity of the results of the WBC counts for persons in the detailed examination sample and in the nutrition examination sample.

For the black population in particular, the use of the larger nutrition sample has the effect of raising the number of persons for the WBC estimates by a factor of 5 (from about 800 to approximately 4,000), thus increasing the reliability of the estimates for this segment of the population.




SOURCE: First National Health and Nutrition Examination Survey nutrition examination sample, 1971-74; detailed examination sample, 1971-75.

Figure 1. Estimated mean white blood cell count by sex, age, and examination sample: United States, 1971-75

# Findings

The white blood cell (WBC) and differential leukocyte count data from the nutrition examination sample (1971-74) and the detailed examination sample (1971-75) are presented in tables 1-11. Table A highlights findings for the overall target population. The data have been weighted to represent the U.S. civilian noninstitutionalized population in terms of age, sex, and race. The classification of race was done by observation; the interviewer classified examinees as "black," "white," or "other." A separate statistical analysis has not been presented for people of "other" races in this report because they were insufficiently represented in the sample. The data have been included under the designation "white" (see appendix II for definition).

## White blood cell count

There are differences in the mean WBC count between racial groups, between sexes, and among age groups within race-sex groups (table 1). The white population was found to have higher WBC counts than the black population. This was observed in both sexes at all ages (figure 2). The WBC counts for white males were significantly higher than were counts for black males in all age groups except for those ages 12-17 and 18-24 years (figure 3). Counts for white females were significantly higher than were counts for black females for those ages 12-17, 25-34, and 45-54 years (figure 4). When compared by sex, 12-24-year-old white females had counts that were significantly higher than were those for white males of the same age. Only at ages 65-74 years did white males have significantly higher counts than white females had (figure 5). Counts for black females were significantly higher than were those for black males only at ages 55-64 years (figure 6).

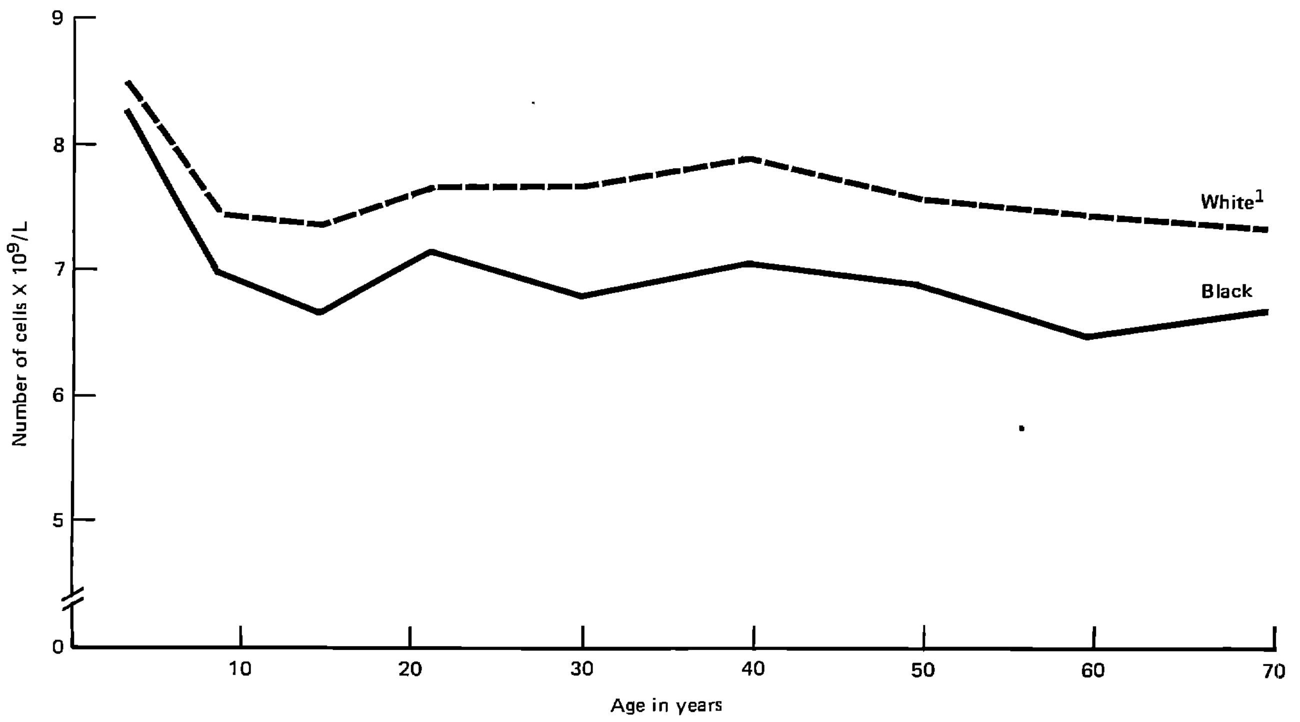
Table 1 shows that children of all races who were under 6 years old had a higher WBC count than older persons had. The mean WBC count for the

Table A. Estimated mean number and mean percent of leukocytes by type of leukocyte, according to age: United States, 1971-75

| Age | Total white blood cell count | Type of leukocyte | | | |
|---|---|---|---|---|---|
| | | Total neutrophils[1] | Lymphocytes | Monocytes | Eosinophils |
| | | Number of cells X $10^9$/L | | | |
| 1-5 years | 8.49 | --- | --- | --- | --- |
| 6-11 years | 7.42 | --- | --- | --- | --- |
| 12-17 years | 7.27 | --- | --- | --- | --- |
| 18-24 years | 7.60 | --- | --- | --- | --- |
| 25-44 years | 7.73 | 4.53 | 2.74 | 0.26 | 0.20 |
| 45-74 years | 7.50 | 4.40 | 2.64 | 0.26 | 0.19 |
| | | Percent of 100 cells | | | |
| 1-5 years | ... | --- | --- | --- | --- |
| 6-11 years | ... | --- | --- | --- | --- |
| 12-17 years | ... | --- | --- | --- | --- |
| 18-24 years | ... | --- | --- | --- | --- |
| 25-44 years | ... | 58.6 | 35.4 | 3.4 | 2.6 |
| 45-74 years | ... | 58.7 | 35.2 | 3.5 | 2.5 |

[1]Neutrophil statistics combine banded and segmented forms.

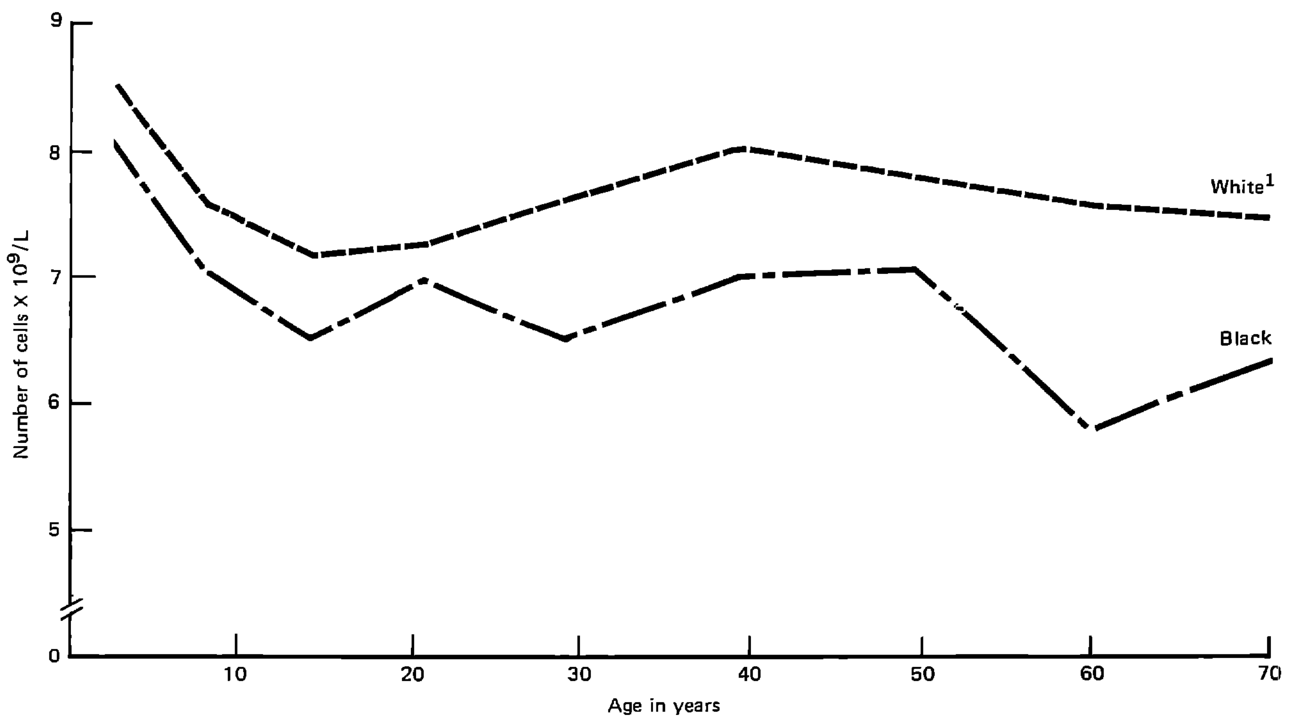
SOURCE: First National Health and Nutrition Examination Survey. Total white blood cell count data are from the nutrition examination sample, 1971-74, and differential leukocyte data are from the detailed examination sample, 1971-75.




[1]Includes persons of other races; see appendix II.

SOURCE: First National Health and Nutrition Examination Survey nutrition examination sample, 1971-74.

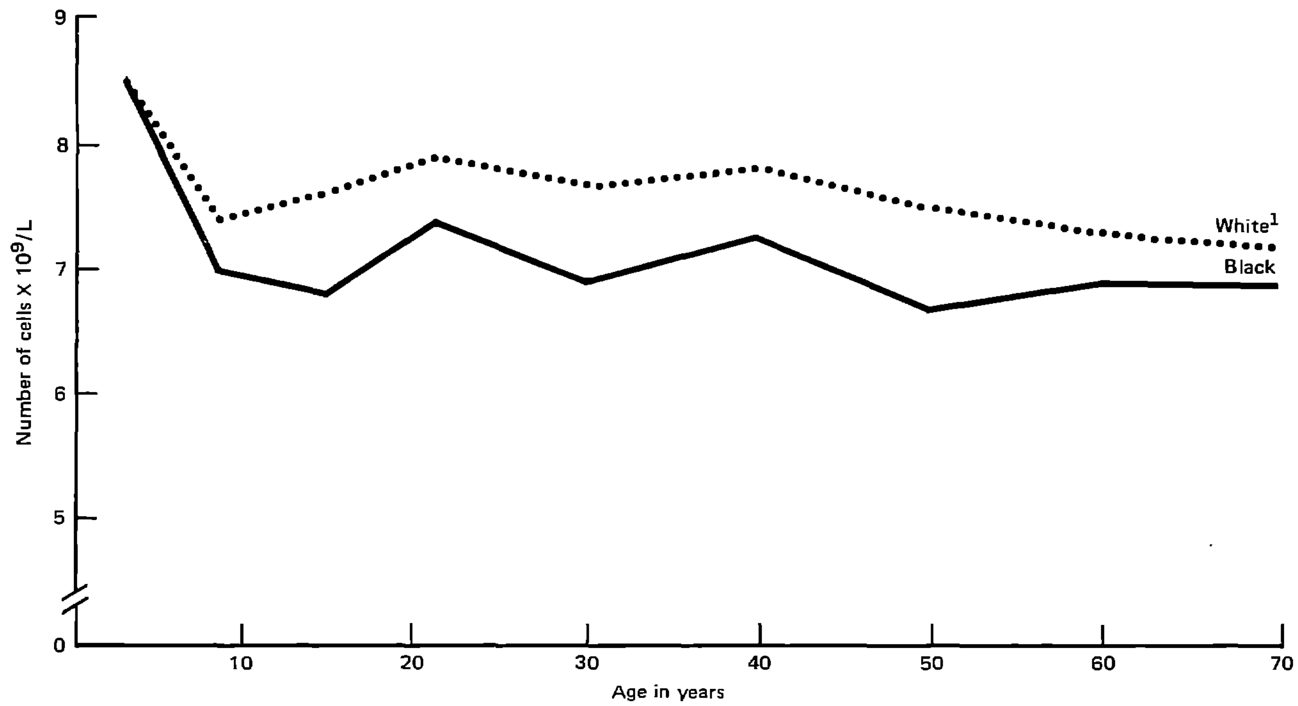
Figure 2. Estimated mean white blood cell count by race and age: United States, 1971-74




[1]Includes persons of other races; see appendix II.

SOURCE: First National Health and Nutrition Examination Survey nutrition examination sample, 1971-74.

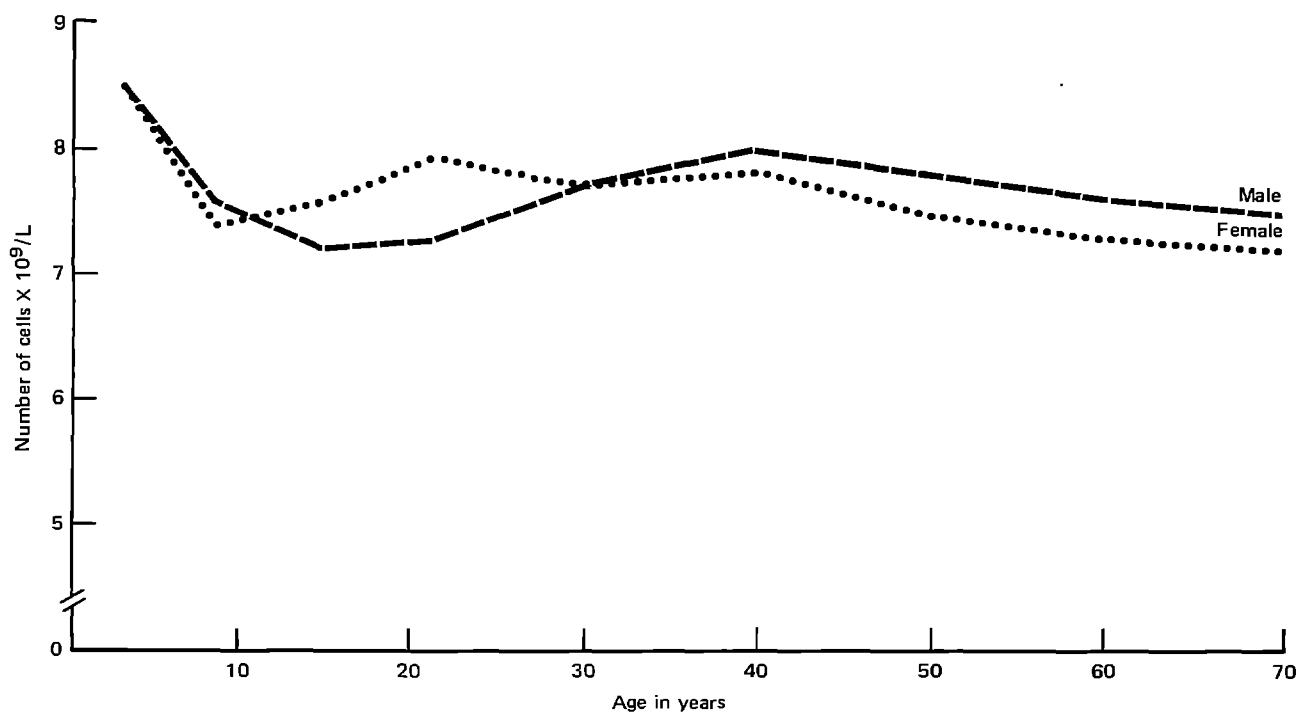
Figure 3. Estimated mean white blood cell count for males by race and age: United States, 1971-74




[1]Includes persons of other races; see appendix II.

SOURCE: First National Health and Nutrition Examination Survey nutrition examination sample, 1971-74.

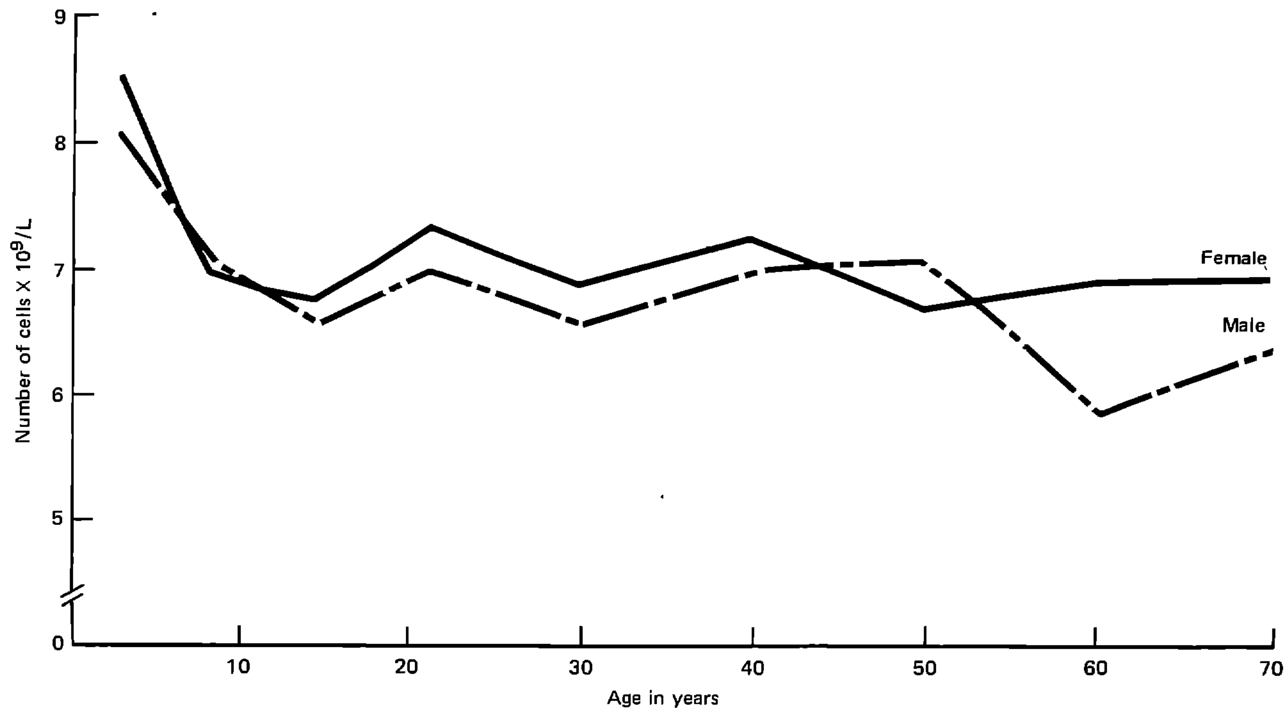
Figure 4. Estimated mean white blood cell count for females by race and age: United States, 1971-74




[1]Includes persons of other races; see appendix II.

SOURCE: First National Health and Nutrition Examination Survey nutrition examination sample, 1971-74.

Figure 5. Estimated mean white blood cell count for white[1] persons by sex and age: United States, 1971-74




SOURCE: First National Health and Nutrition Examination Survey nutrition examination sample, 1971-74.

Figure 6. Estimated mean white blood cell count for black persons by sex and age: United States, 1971-74

white population appears to decrease with age for both males and females, but the decrease is not statistically significant between each of the age groups employed in this study. This decrease in the mean WBC count is supported by previous studies.[9-11] The mean WBC count for males was significantly lower for those ages 65-74 years than was the mean WBC count for those ages 25-34 years. For white females, the mean WBC count for those ages 65-74 years was significantly lower than was the mean WBC count for both the 25-34- and the 35-44-year age groups.

Table 1 also shows that the black population has a significantly lower mean WBC count than their white counterparts have, which Broun also found.[12] Black males appear to have a lower observed mean WBC count than black females have, and the difference is greatest and statistically significant for the 55-64-year age group.

Table B shows the percent distribution of the U.S. population whose WBC counts are in the extremes of the WBC distribution and the percent of the population whose WBC counts fall into the broad range of 5.0-11.4 $\times 10^9/L$ cells. Tables 2-5 show percent distributions of WBC counts for males and females by race and age.

Table B. Percent distribution of the U.S. population by mean number of white blood cells, according to age: United States, 1971-74

| *Number of cells* $\times 10^9/L$ | *Age* | | | |
|---|---|---|---|---|
| | *1-5 years* | *6-17 years* | *18-44 years* | *45-74 years* |
| | Percent distribution | | | |
| 2.0-13.0 and over | 100.0 | 100.0 | 100.0 | 100.0 |
| 2.0-3.9 | 0.8 | 1.1 | 0.8 | 1.3 |
| 4.0-4.4 | 0.9 | 3.1 | 1.7 | 1.9 |
| 4.5-4.9 | 2.0 | 4.6 | 3.6 | 3.7 |
| 5.0-11.4 | 84.0 | 87.6 | 89.0 | 89.5 |
| 11.5-11.9 | 2.8 | 1.2 | 1.5 | 0.9 |
| 12.0-12.9 | 4.2 | 1.2 | 1.5 | 1.6 |
| 13.0 and over | 5.2 | 1.2 | 2.0 | 1.2 |

SOURCE: First National Health and Nutrition Examination Survey nutrition examination sample, 1971-74.

## Smoking and the white blood cell count

Smokers were found to have significantly elevated WBC counts for both races and both sexes (table C). Present smokers averaged 1.0 $\times 10^9/L$ more white cells than former smokers or persons who had never smoked averaged (see appendix II for definitions of these terms). Fisch and Freedman and Helman[13-14] have shown that the WBC count increases progressively with increasing intensity of exposure to tobacco smoke.

## Differential leukocyte count

The differential leukocyte count data obtained during NHANES I are presented in tables 6-9.

Table C. Number of examined persons, mean number, and mean percent of white blood cells, segmented neutrophils, and lymphocytes for adults ages 25-74 years by race, sex, and smoking status: United States, 1971-75

| Race and sex | Never smoked | | | | Former smoker | | | | Current smoker | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of examined persons | White blood cells | Segmented neutrophils | Lymphocytes | Number of examined persons | White blood cells | Segmented neutrophils | Lymphocytes | Number of examined persons | White blood cells | Segmented neutrophils | Lymphocytes |
| All races | | Number of cells X 10⁹/L | | | | Number of cells X 10⁹/L | | | | Number of cells X 10⁹/L | | |
| Both sexes | 2,247 | 7.1 | 4.18 | 2.57 | 1,184 | 7.2 | 4.24 | 2.60 | 2,055 | 8.1 | 4.82 | 2.89 |
| Male | 630 | 7.2 | 4.16 | 2.60 | 790 | 7.2 | 4.24 | 2.58 | 1,075 | 8.2 | 4.82 | 2.91 |
| Female | 1,617 | 7.1 | 4.19 | 2.56 | 394 | 7.2 | 4.25 | 2.63 | 980 | 8.1 | 4.81 | 2.87 |
| White[1] | | | | | | | | | | | | |
| Both sexes | 1,971 | 7.2 | 4.23 | 2.56 | 1,094 | 7.3 | 4.29 | 2.59 | 1,718 | 8.3 | 4.94 | 2.90 |
| Male | 548 | 7.2 | 4.21 | 2.61 | 729 | 7.3 | 4.28 | 2.58 | 903 | 8.3 | 4.93 | 2.93 |
| Female | 1,432 | 7.1 | 4.24 | 2.54 | 365 | 7.3 | 4.30 | 2.60 | 815 | 8.2 | 4.95 | 2.85 |
| Black | | | | | | | | | | | | |
| Both sexes | 276 | 6.7 | 3.66 | 2.70 | 90 | 6.5 | 3.51 | 2.74 | 337 | 7.2 | 4.02 | 2.86 |
| Male | 82 | 6.4 | 3.60 | 2.46 | 61 | 6.5 | 3.62 | 2.56 | 172 | 7.2 | 4.06 | 2.77 |
| Female | 194 | 6.8 | 3.69 | 2.81 | 29 | *6.7 | *3.25 | *3.17 | 165 | 7.2 | 3.98 | 2.94 |
| All races | | Percent of 100 cells | | | | Percent of 100 cells | | | | Percent of 100 cells | | |
| Both sexes | 2,247 | ... | 58.1 | 36.7 | 1,184 | ... | 58.5 | 26.1 | 2,055 | ... | 58.6 | 36.2 |
| Male | 630 | ... | 57.7 | 36.8 | 790 | ... | 58.5 | 35.8 | 1,075 | ... | 58.3 | 36.1 |
| Female | 1,617 | ... | 58.4 | 36.7 | 394 | ... | 58.5 | 36.8 | 980 | ... | 58.9 | 36.3 |
| White[1] | | | | | | | | | | | | |
| Both sexes | 1,971 | ... | 58.6 | 36.3 | 1,094 | ... | 58.9 | 35.7 | 1,718 | ... | 59.2 | 35.5 |
| Male | 548 | ... | 57.9 | 36.5 | 729 | ... | 58.8 | 35.4 | 903 | ... | 58.8 | 35.6 |
| Female | 1,432 | ... | 58.9 | 36.2 | 365 | ... | 59.0 | 36.2 | 815 | ... | 59.7 | 35.4 |
| Black | | | | | | | | | | | | |
| Both sexes | 276 | ... | 53.8 | 41.0 | 90 | ... | 52.9 | 42.8 | 337 | ... | 54.3 | 40.6 |
| Male | 82 | ... | 55.3 | 39.3 | 61 | ... | 54.7 | 41.0 | 172 | ... | 54.9 | 39.5 |
| Female | 194 | ... | 53.1 | 41.7 | 29 | ... | *48.6 | *47.1 | 165 | ... | 53.8 | 41.7 |

[1] Includes persons of other races; see appendix II.

SOURCE: First National Health and Nutrition Examination Survey detailed examination sample, 1971-75.

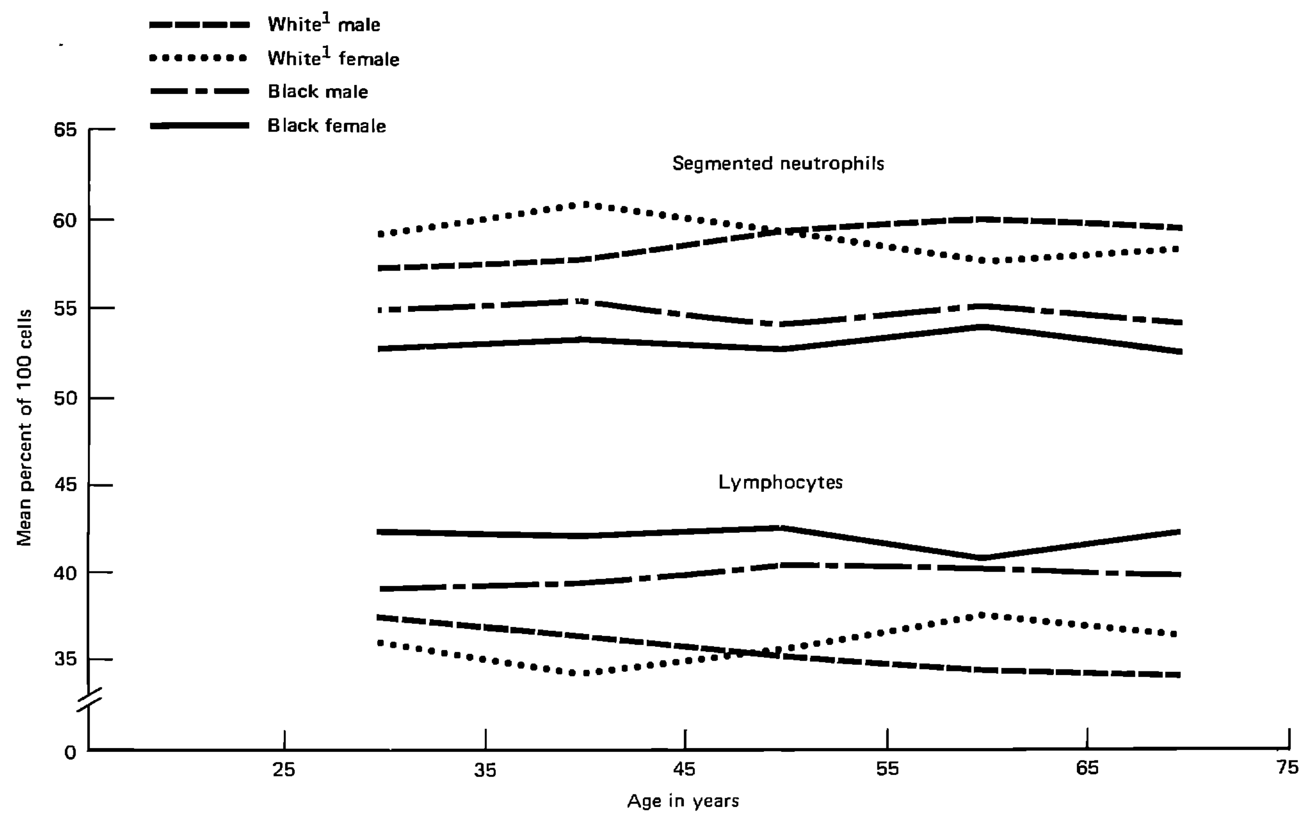
Differential leukocyte count statistics are based on readings of more than 5,400 peripheral blood smears prepared from blood drawn from adults who received the detailed examination.

Two differences should be noted. First, there was a difference in mean values with respect to both absolute numbers and percents for segmented neutrophils between races, with the white population having significantly higher values. The black population, however, had higher lymphocyte numeric values (table 8) and a significantly higher mean percent of lymphocytes (figure 7). Second, a difference (in terms of sex) was observed with changes in age. Before about age 50, white females have a higher segmented neutrophil mean and a lower lymphocyte mean than white males of comparable age. After age 50, the mean number of segmented neutrophils decreases for females, but the mean for males remains relatively constant with the increase in age. White females ages 25-34 years have a significantly higher mean number of segmented neutrophils than white females ages 65-74 years (figure 8).

For the black population, the reverse of the above relationship for the white population is seen. Males have a higher number of segmented neutrophils than have females up to about age 50, after which the mean for females becomes higher and the mean for males decreases with age (figure 9). The sex difference in the number of segmented neutrophils for each group is not significant for either race. In the 45-54-, 55-64-, and 65-74-year age groups, white males have a mean number of segmented neutrophils that is significantly higher than the numbers for their black counterparts. White females have a significantly higher mean number of segmented neutrophils for the age groups 25-34 years, 35-44 years, and 45-54 years than have black females. This relationship continues for the older age groups, but the differences are not statistically significant. Tables 10 and 11 show summary information about the distribution of segmented neutrophils and lymphocytes in the adult population, and figures 10 and 11 graphically summarize this information.

## Discussion

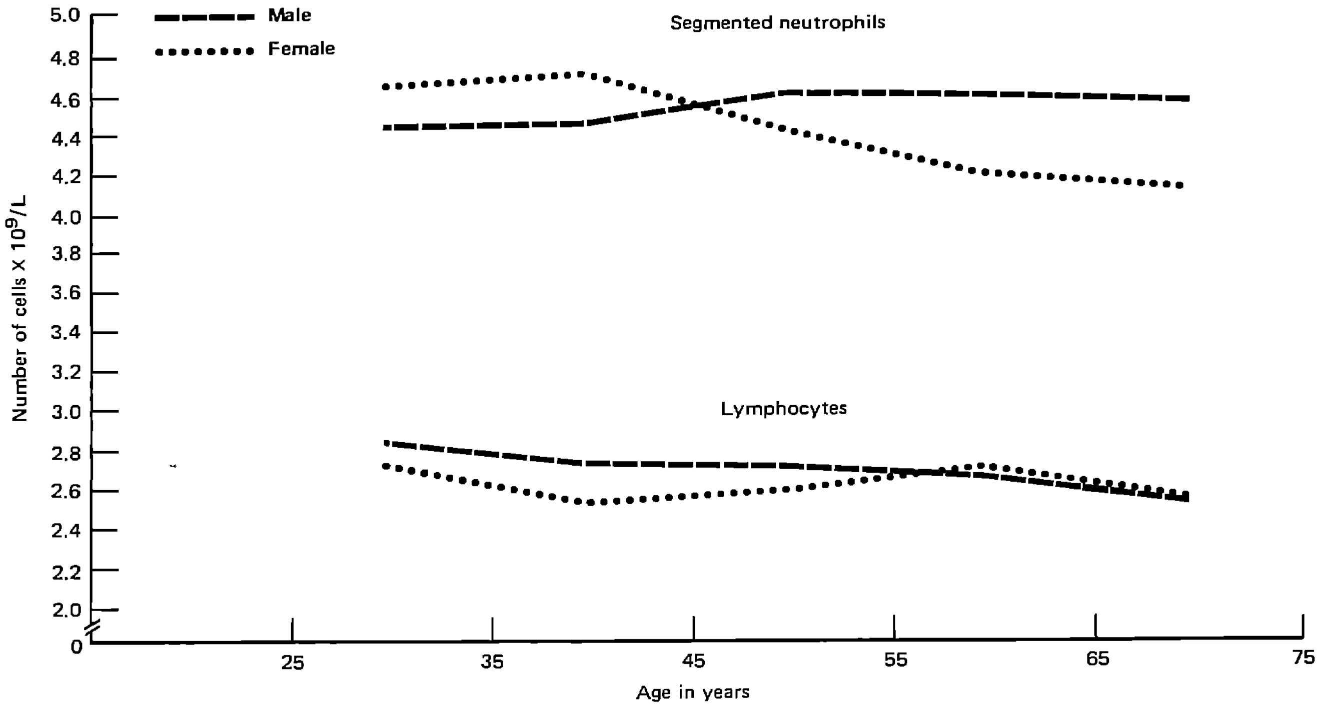
Much has been published over the decades about the variability of a single 100-white-cell differential




[1]Includes persons of other races; see appendix II.

SOURCE: First National Health and Nutrition Examination Survey detailed examination sample, 1971-75.

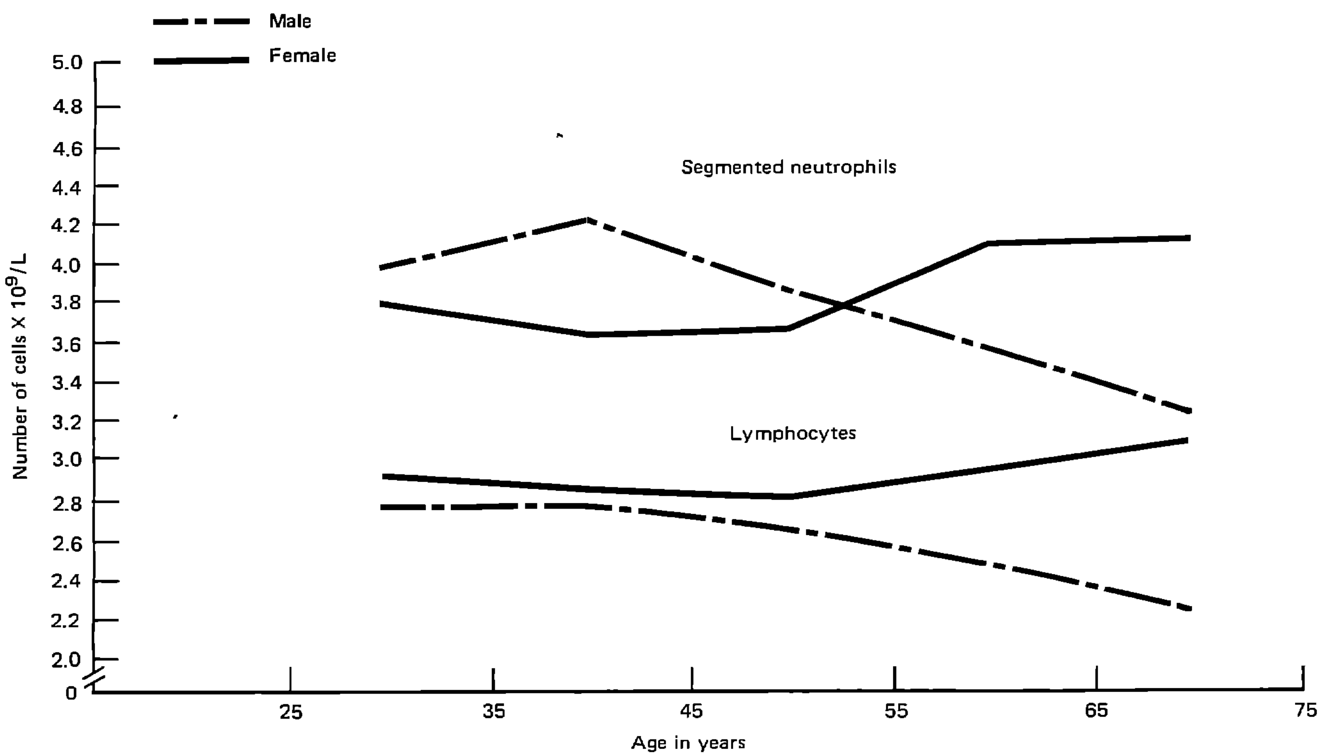
Figure 7. Estimated mean percent of segmented neutrophils and lymphocytes by race and age: United States, 1971-75




[1]Includes persons of other races; see appendix II.

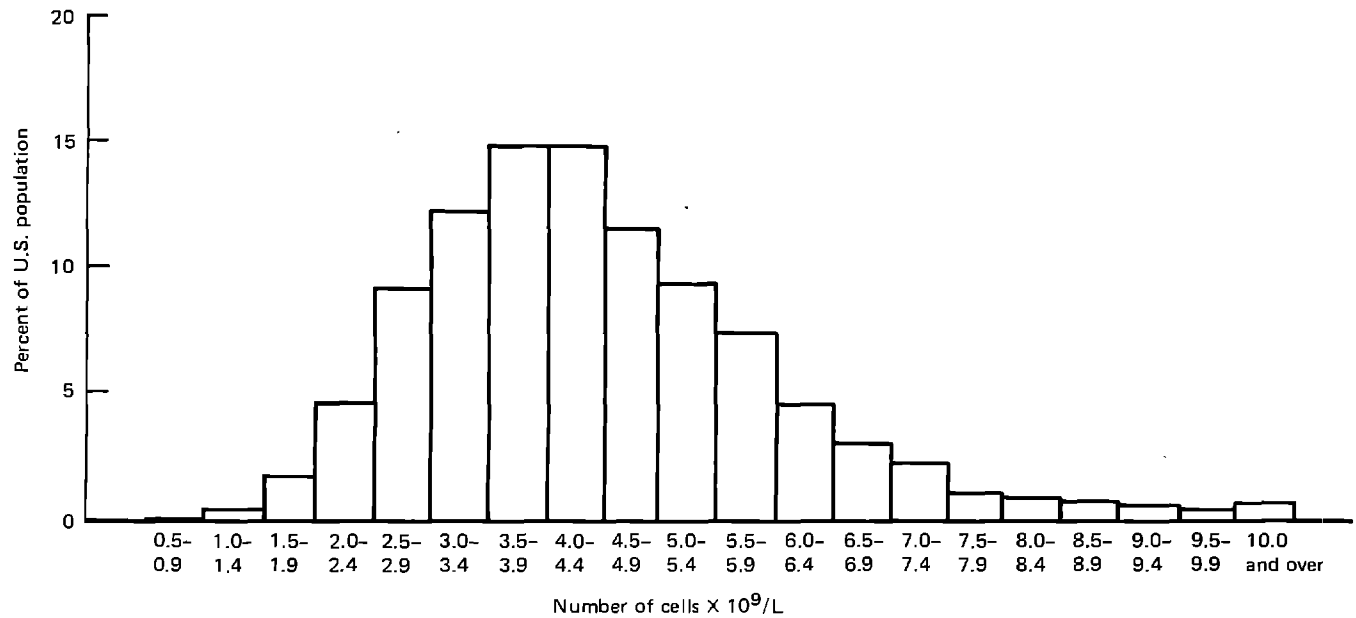
SOURCE: First National Health and Nutrition Examination Survey detailed examination sample, 1971-75.

Figure 8. Estimated mean number of segmented neutrophils and lymphocytes for white[1] persons by sex and age: United States, 1971-75



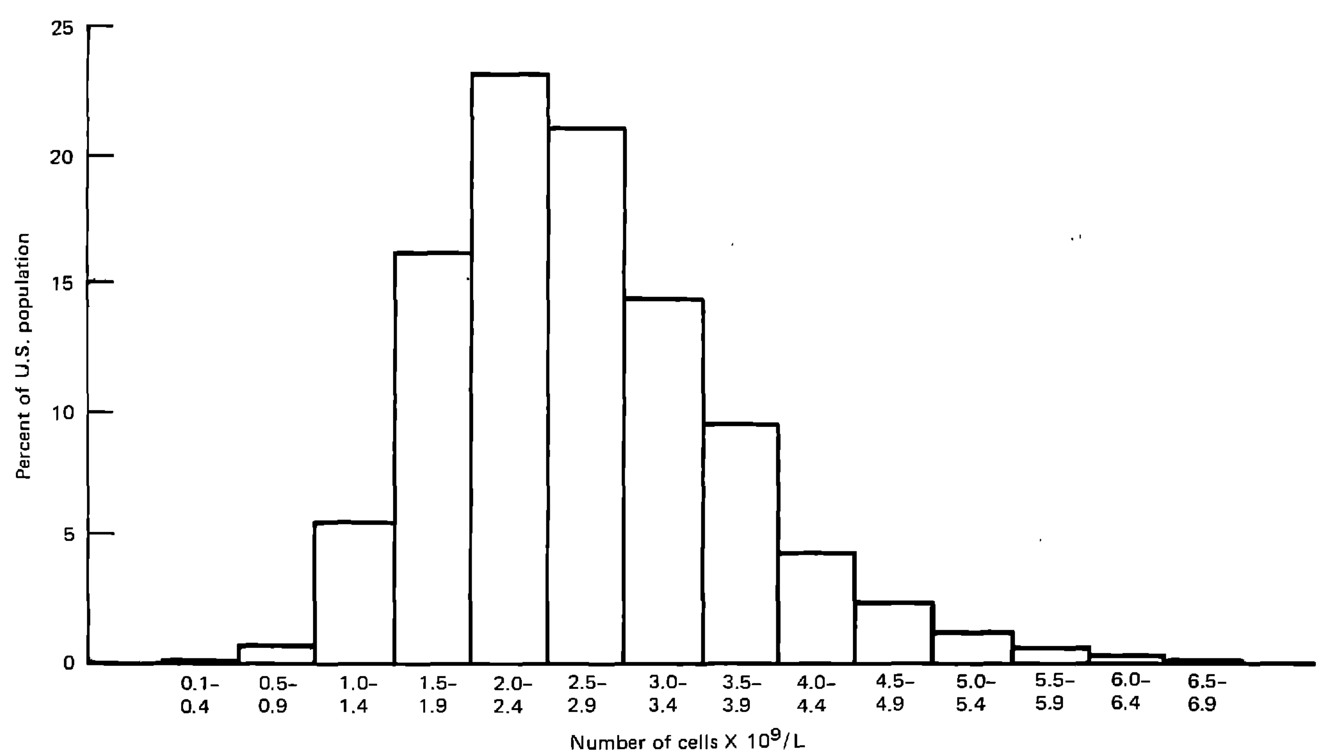

SOURCE: First National Health and Nutrition Examination Survey detailed examination sample, 1971-75.

Figure 9. Estimated mean number of segmented neutrophils and lymphocytes for black persons by sex and age: United States, 1971-75




SOURCE: First National Health and Nutrition Examination Survey detailed examination sample, 1971-75.

Figure 10. Estimated percent distribution of the U.S. population ages 25-74 years by mean number of segmented neutrophils: United States, 1971-75




SOURCE: First National Health and Nutrition Examination Survey detailed examination sample, 1971-75.

Figure 11. Estimated percent distribution of the U.S. population ages 25-74 years by mean number of lymphocytes: United States, 1971-75

count. Many factors influence the observed WBC count.[15] Statland and Winkel published a study on the physiological variability of leukocytes in healthy subjects.[16] Goldner and Mann[17] published 95-percent confidence curves, and Rümke and coworkers[18] published an article that explained the required difference in percents that must be found in counts of 100 or 200 cells for a change in counts to be regarded as significant at a 5.0-percent or a 2.5-percent confidence level. The present study, however, presents the results of approximately 5,500 single 100-white-cell differential counts.

In comparing the mean values with those found in the literature (Bain and England,[19] Cecil and Loeb,[20] Dacie and Lewis,[21] Documenta Geigi,[23] Gradwohl,[23] Miale,[24] Wintrobe,[25] and Zacharski et al.[26]), the following should be noted: In the NHANES I study, fewer juvenile neutrophils (band forms) have been found, and the mean value for monocytes is lower than the mean value generally indicated in the literature. The lower monocyte values may be attributable to technical difficulties, as noted by Dacie,[27] such as excessively thick preparations or smears that were not margin free.

Because five different technologists were involved in performing differential leukocyte counts during the course of the survey, the mean values each obtained have been calculated for the different cell types. Table D shows that one technologist (number 4) counted more band forms, and another (number 3) obtained appreciably higher monocyte counts than any of the others. On the whole, however, mean values of all cell types obtained by all five technologists compared favorably. Promyelocytes, myelocytes, and metamyelocytes were reported in 2, 1, and 1 smears respectively and were excluded from analysis.

A single-channel electronic cell counter that is properly calibrated and maintained is recognized as the best available method for routine cell counting.[28] Differences were minimal because only three instruments, operated by teams of two technicians, were employed in the mobile examination centers. All instruments were monitored concurrently with the same lots of commercial control material.

White blood cell counts and differential leukocyte counts have also been performed on examined persons in the second National Health and Nutrition Examination Survey (NHANES II), 1976-80. When data from NHANES II are analyzed, differential leukocyte count findings from the two surveys will be compared.

Table D. Number of smears and percent distribution by type of leukocyte, according to technologist number

| Technologist number | Number of smears | Type of leukocyte: Total leukocytes | Segmented neutrophils | Band neutrophils | Lymphocytes | Monocytes | Eosinophils | Basophils |
|---|---|---|---|---|---|---|---|---|
| | | Percent distribution | | | | | | |
| 1 | 826 | 100.0 | 58.97 | 0.14 | 36.09 | 2.53 | 2.18 | 0.29 |
| 2 | 2,466 | 100.0 | 57.95 | 0.32 | 37.41 | 2.19 | 2.05 | 0.32 |
| 3 | 973 | 100.0 | 58.80 | 0.16 | 32.57 | 6.08 | 2.04 | 0.55 |
| 4 | 794 | 100.0 | 56.80 | 0.48 | 36.95 | 3.49 | 2.19 | 0.32 |
| 5 | 795 | 100.0 | 59.04 | 0.06 | 36.28 | 2.91 | 1.55 | 0.42 |

SOURCE: First National Health and Nutrition Examination Survey detailed examination sample, 1971-75.

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# List of detailed tables

Table 1. Number of examined persons, estimated mean white blood cell count, and standard error of the mean by examination sample, race, sex, and age: United States, 1971-75

| Sex and age | *Nutrition examination sample* | | | | | | *Detailed examination sample* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *White*[1] | | | *Black* | | | *White*[1] | | | *Black* | | |
| | *Number of examined persons* | *Number of cells X $10^9$/L* | *Standard error of the mean* | *Number of examined persons* | *Number of cells X $10^9$/L* | *Standard error of the mean* | *Number of examined persons* | *Number of cells X $10^9$/L* | *Standard error of the mean* | *Number of examined persons* | *Number of cells X $10^9$/L* | *Standard error of the mean* |
| Both sexes | | | | | | | | | | | | |
| 1-74 years ..... | 14,820 | 7.7 | 0.05 | 3,577 | 7.0 | 0.08 | 5,509 | 7.6 | 0.06 | 768 | 6.9 | 0.14 |
| 1-5 years ...... | 1,835 | 8.5 | 0.09 | 612 | 8.3 | 0.16 | - | - | - | - | - | - |
| 6-11 years ..... | 1,385 | 7.5 | 0.08 | 450 | 7.0 | 0.12 | - | - | - | - | - | - |
| 12-17 years .... | 1,437 | 7.4 | 0.08 | 445 | 6.7 | 0.18 | - | - | - | - | - | - |
| 18-24 years .... | 1,688 | 7.7 | 0.07 | 402 | 7.2 | 0.24 | - | - | - | - | - | - |
| 25-34 years .... | 2,050 | 7.7 | 0.08 | 403 | 6.8 | 0.13 | 1,265 | 7.8 | 0.11 | 160 | 7.1 | 0.23 |
| 35-44 years .... | 1,704 | 7.9 | 0.11 | 367 | 7.1 | 0.21 | 971 | 7.7 | 0.12 | 135 | 7.0 | 0.36 |
| 45-54 years .... | 1,207 | 7.6 | 0.11 | 227 | 6.9 | 0.13 | 1,284 | 7.6 | 0.10 | 187 | 6.8 | 0.25 |
| 55-64 years .... | 950 | 7.5 | 0.09 | 169 | 6.5 | 0.22 | 1,038 | 7.5 | 0.12 | 133 | 6.9 | 0.28 |
| 65-74 years .... | 2,564 | 7.4 | 0.08 | 502 | 6.7 | 0.23 | 951 | 7.3 | 0.10 | 153 | 6.8 | 0.50 |
| Male | | | | | | | | | | | | |
| 1-74 years ..... | 6,331 | 7.7 | 0.07 | 1,468 | 6.9 | 0.10 | 2,530 | 7.7 | 0.08 | 339 | 6.8 | 0.24 |
| 1-5 years ...... | 953 | 8.5 | 0.11 | 302 | 8.1 | 0.21 | - | - | - | - | - | - |
| 6-11 years ..... | 692 | 7.6 | 0.09 | 225 | 7.1 | 0.18 | - | - | - | - | - | - |
| 12-17 years .... | 723 | 7.2 | 0.12 | 219 | 6.6 | 0.28 | - | - | - | - | - | - |
| 18-24 years .... | 591 | 7.3 | 0.11 | 116 | 7.0 | 0.32 | - | - | - | - | - | - |
| 25-34 years .... | 627 | 7.7 | 0.11 | 108 | 6.6 | 0.19 | 550 | 7.8 | 0.12 | 66 | 7.1 | 0.39 |
| 35-44 years .... | 510 | 8.0 | 0.20 | 76 | 7.0 | 0.32 | 429 | 7.8 | 0.18 | 49 | 7.3 | 0.63 |
| 45-54 years .... | 568 | 7.8 | 0.14 | 118 | 7.1 | 0.19 | 590 | 7.7 | 0.13 | 90 | 6.8 | 0.47 |
| 55-64 years .... | 457 | 7.6 | 0.13 | 66 | 5.8 | 0.28 | 500 | 7.7 | 0.19 | 58 | 6.3 | 0.39 |
| 65-74 years .... | 1,210 | 7.5 | 0.09 | 238 | 6.4 | 0.12 | 461 | 7.6 | 0.19 | 76 | 5.8 | 0.43 |
| Female | | | | | | | | | | | | |
| 1-74 years ..... | 8,489 | 7.7 | 0.05 | 2,109 | 7.1 | 0.10 | 2,979 | 7.5 | 0.07 | 429 | 7.0 | 0.19 |
| 1-5 years ...... | 882 | 8.5 | 0.10 | 310 | 8.5 | 0.23 | - | - | - | - | - | - |
| 6-11 years ..... | 693 | 7.4 | 0.13 | 225 | 7.0 | 0.16 | - | - | - | - | - | - |
| 12-17 years .... | 714 | 7.6 | 0.07 | 226 | 6.8 | 0.17 | - | - | - | - | - | - |
| 18-24 years .... | 1,097 | 7.9 | 0.09 | 286 | 7.4 | 0.28 | - | - | - | - | - | - |
| 25-34 years .... | 1,423 | 7.7 | 0.09 | 295 | 6.9 | 0.19 | 715 | 7.8 | 0.17 | 94 | 7.0 | 0.32 |
| 35-44 years .... | 1,194 | 7.8 | 0.09 | 291 | 7.3 | 0.32 | 542 | 7.7 | 0.17 | 86 | 6.8 | 0.45 |
| 45-54 years .... | 639 | 7.5 | 0.11 | 109 | 6.7 | 0.22 | 694 | 7.5 | 0.13 | 97 | 6.7 | 0.30 |
| 55-64 years .... | 493 | 7.3 | 0.11 | 103 | 6.9 | 0.28 | 538 | 7.3 | 0.13 | 75 | 7.3 | 0.42 |
| 65-74 years .... | 1,354 | 7.2 | 0.09 | 264 | 6.9 | 0.38 | 490 | 7.1 | 0.12 | 77 | 7.5 | 0.81 |

[1] Includes persons of other races; see appendix II.

SOURCE: First National Health and Nutrition Examination Survey nutrition examination sample, 1971-74; detailed examination sample, 1971-75.

Table 2. Percent distribution of white[1] males by estimated number of white blood cells, according to age: United States, 1971-74

| *Number of cells* X *10⁹/L* | Age | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *1-5 years* | *6-11 years* | *12-17 years* | *18-24 years* | *25-34 years* | *35-44 years* | *45-54 years* | *55-64 years* | *65-74 years* |
| | Percent distribution | | | | | | | | |
| Under 2.0-14.0 and over | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 2.0-2.9 | - | - | - | - | - | - | - | 0.3 | 0.1 |
| 3.0-3.9 | 1.2 | 0.5 | 1.1 | 0.7 | 0.3 | 0.4 | 1.3 | 1.3 | 0.9 |
| 4.0-4.9 | 3.2 | 5.9 | 8.5 | 4.8 | 4.5 | 2.9 | 2.4 | 4.5 | 3.7 |
| 5.0-5.9 | 9.2 | 18.2 | 23.0 | 19.8 | 15.5 | 13.8 | 13.5 | 13.2 | 15.6 |
| 6.0-6.9 | 17.7 | 21.1 | 18.5 | 19.0 | 18.3 | 22.0 | 22.8 | 17.9 | 20.9 |
| 7.0-7.9 | 17.3 | 16.3 | 19.7 | 20.7 | 20.7 | 18.1 | 19.3 | 22.1 | 21.3 |
| 8.0-8.9 | 15.5 | 14.5 | 14.0 | 18.1 | 17.7 | 14.5 | 17.6 | 18.8 | 18.8 |
| 9.0-9.9 | 11.8 | 13.3 | 8.5 | 10.8 | 13.4 | 12.9 | 11.7 | 11.1 | 9.7 |
| 10.0-10.9 | 7.6 | 5.1 | 2.2 | 2.5 | 4.1 | 7.7 | 5.3 | 5.6 | 4.6 |
| 11.0-11.9 | 5.7 | 2.2 | 1.8 | 1.4 | 3.2 | 3.5 | 1.0 | 3.1 | 2.7 |
| 12.0-12.9 | 4.5 | 0.9 | 1.5 | 1.3 | 1.4 | 2.0 | 3.3 | 1.0 | 0.7 |
| 13.0-13.9 | 3.7 | 0.6 | 0.6 | 0.4 | 0.4 | 1.1 | 0.5 | 0.8 | 0.5 |
| 14.0 and over | 2.7 | 1.3 | 0.5 | 0.5 | 0.7 | 1.1 | 1.2 | 0.1 | 0.4 |

[1] Includes persons of other races; see appendix II.

SOURCE: First National Health and Nutrition Examination Survey nutrition examination sample, 1971-74.

Table 3. Percent distribution of white[1] females by estimated number of white blood cells, according to age: United States, 1971-74

| *Number of cells* X *10⁹/L* | Age | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *1-5 years* | *6-11 years* | *12-17 years* | *18-24 years* | *25-34 years* | *35-44 years* | *45-54 years* | *55-64 years* | *65-74 years* |
| | Percent distribution | | | | | | | | |
| Under 2.0-14.0 and over | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 2.0-2.9 | - | - | - | 0.0 | 0.4 | - | - | 0.0 | - |
| 3.0-3.9 | 0.5 | 0.7 | 0.7 | 0.3 | 0.5 | 0.7 | 0.8 | 1.1 | 0.5 |
| 4.0-4.9 | 2.2 | 6.1 | 5.1 | 3.1 | 5.2 | 5.6 | 5.1 | 5.2 | 7.4 |
| 5.0-5.9 | 9.5 | 17.9 | 10.8 | 11.5 | 13.2 | 12.8 | 16.7 | 17.1 | 19.8 |
| 6.0-6.9 | 13.7 | 22.1 | 26.2 | 19.2 | 21.0 | 18.3 | 23.6 | 24.8 | 22.2 |
| 7.0-7.9 | 17.3 | 20.2 | 17.9 | 22.7 | 19.1 | 19.1 | 19.6 | 19.8 | 20.6 |
| 8.0-8.9 | 20.9 | 12.6 | 16.5 | 16.4 | 17.0 | 17.9 | 13.0 | 15.0 | 15.0 |
| 9.0-9.9 | 13.4 | 10.9 | 14.2 | 12.1 | 12.0 | 13.1 | 9.4 | 9.8 | 8.9 |
| 10.0-10.9 | 7.9 | 3.9 | 5.1 | 6.2 | 4.7 | 4.9 | 5.9 | 2.5 | 2.5 |
| 11.0-11.9 | 6.5 | 3.5 | 1.8 | 4.6 | 3.5 | 3.8 | 2.4 | 2.4 | 1.4 |
| 12.0-12.9 | 4.1 | 0.8 | 1.6 | 1.3 | 1.7 | 1.5 | 2.4 | 1.1 | 0.9 |
| 13.0-13.9 | 2.0 | 0.8 | 0.0 | 1.7 | 0.7 | 1.1 | 1.0 | 1.3 | 0.2 |
| 14.0 and over | 2.0 | 0.6 | 0.2 | 0.9 | 1.1 | 1.3 | 0.1 | - | 0.6 |

[1] Includes persons of other races; see appendix II.

SOURCE: First National Health and Nutrition Examination Survey nutrition examination sample, 1971-74.

Table 4. Percent distribution of black males by estimated number of white blood cells, according to age: United States, 1971-74

| *Number of cells* × $10^9$/L | *Age* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *1-5 years* | *6-11 years* | *12-17 years* | *18-24 years* | *25-34 years* | *35-44 years* | *45-54 years* | *55-64 years* | *65-74 years* |
| | Percent distribution | | | | | | | | |
| Under 2.0-14.0 and over | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 2.0-2.9 | - | - | 1.6 | - | - | - | - | 1.9 | 0.4 |
| 3.0-3.9 | 0.3 | 1.4 | 4.1 | 3.1 | 4.1 | 1.1 | 1.0 | 3.2 | 6.1 |
| 4.0-4.9 | 4.1 | 14.4 | 17.5 | 8.9 | 10.2 | 15.3 | 9.0 | 25.9 | 19.9 |
| 5.0-5.9 | 15.5 | 19.9 | 22.3 | 20.0 | 33.1 | 22.6 | 19.2 | 30.2 | 24.4 |
| 6.0-6.9 | 20.7 | 19.0 | 20.1 | 33.9 | 17.0 | 23.0 | 23.4 | 20.2 | 15.1 |
| 7.0-7.9 | 19.9 | 12.1 | 10.4 | 8.5 | 11.4 | 5.2 | 11.8 | 7.4 | 13.6 |
| 8.0-8.9 | 11.8 | 14.3 | 14.1 | 10.7 | 13.8 | 17.9 | 21.5 | 4.7 | 8.6 |
| 9.0-9.9 | 11.5 | 10.4 | 5.8 | 3.8 | 7.5 | 9.4 | 9.5 | 5.2 | 4.7 |
| 10.0-10.9 | 5.7 | 3.6 | 2.1 | 5.2 | 1.5 | 0.9 | 3.1 | - | 4.9 |
| 11.0-11.9 | 2.4 | 2.8 | 1.2 | 3.3 | 1.1 | - | 1.4 | - | 1.9 |
| 12.0-12.9 | 4.0 | 2.0 | 0.3 | - | - | 0.4 | - | 1.2 | 0.2 |
| 13.0-13.9 | 2.4 | - | - | - | - | 1.6 | - | - | - |
| 14.0 and over | 1.7 | - | 0.5 | 2.5 | 0.2 | 2.8 | - | - | 0.2 |

SOURCE: First National Health and Nutrition Examination Survey nutrition examination sample, 1971-74.

Table 5. Percent distribution of black females by estimated number of white blood cells, according to age: United States, 1971-74

| *Number of cells* × $10^9$/L | *Age* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *1-5 years* | *6-11 years* | *12-17 years* | *18-24 years* | *25-34 years* | *35-44 years* | *45-54 years* | *55-64 years* | *65-74 years* |
| | Percent distribution | | | | | | | | |
| Under 2.0-14.0 and over | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 2.0-2.9 | - | - | - | 0.2 | 1.2 | - | - | - | 0.2 |
| 3.0-3.9 | 1.2 | 3.8 | 2.9 | 0.8 | 1.5 | 2.9 | 2.1 | 2.6 | 4.3 |
| 4.0-4.9 | 4.2 | 14.2 | 15.0 | 16.1 | 15.9 | 9.0 | 9.5 | 20.6 | 18.1 |
| 5.0-5.9 | 9.3 | 23.5 | 17.7 | 11.3 | 21.9 | 18.5 | 26.8 | 16.5 | 22.1 |
| 6.0-6.9 | 18.7 | 15.1 | 21.3 | 22.4 | 16.7 | 23.8 | 24.4 | 11.0 | 19.5 |
| 7.0-7.9 | 17.4 | 15.2 | 17.5 | 16.8 | 12.4 | 18.6 | 18.2 | 15.3 | 13.1 |
| 8.0-8.9 | 16.8 | 8.0 | 13.3 | 14.5 | 13.7 | 10.3 | 11.7 | 14.2 | 9.1 |
| 9.0-9.9 | 8.9 | 10.0 | 3.8 | 9.6 | 8.7 | 6.6 | 1.5 | 12.3 | 6.4 |
| 10.0-10.9 | 10.8 | 4.4 | 6.2 | 3.3 | 4.3 | 4.5 | 3.0 | 6.8 | 3.4 |
| 11.0-11.9 | 6.0 | 3.1 | 1.3 | 2.2 | 0.8 | 1.2 | 2.7 | 0.3 | 0.8 |
| 12.0-12.9 | 3.4 | 1.8 | 0.5 | 0.9 | 1.3 | 2.9 | - | 0.4 | 0.5 |
| 13.0-13.9 | 0.1 | - | - | 0.9 | 0.7 | 0.3 | - | - | 0.3 |
| 14.0 and over | 3.1 | 0.9 | 0.3 | 1.2 | 1.1 | 1.5 | - | - | 2.0 |

SOURCE: First National Health and Nutrition Examination Survey nutrition examination sample, 1971-74.

Table 6. Estimated mean number and mean percent of leukocytes for white[1] persons by type of leukocyte, according to sex and age: United States, 1971-75

| *Sex and age* | *Total leukocytes* | *Type of leukocyte* | | | | | |
|---|---|---|---|---|---|---|---|
| | | *Segmented neutrophils* | *Band neutrophils* | *Lymphocytes* | *Monocytes* | *Eosinophils* | *Basophils* |
| | | Number of cells X $10^9$/L | | | | | |
| Both sexes, 25-74 years | 7.6 | 4.51 | 0.02 | 2.69 | 0.22 | 0.15 | 0.01 |
| Male | | | | | | | |
| 25-74 years | 7.7 | 4.54 | 0.02 | 2.74 | 0.24 | 0.17 | 0.01 |
| 25-34 years | 7.8 | 4.48 | 0.02 | 2.86 | 0.24 | 0.17 | 0.01 |
| 35-44 years | 7.8 | 4.47 | 0.02 | 2.75 | 0.24 | 0.17 | 0.01 |
| 45-54 years | 7.7 | 4.61 | 0.02 | 2.72 | 0.24 | 0.17 | 0.01 |
| 55-64 years | 7.7 | 4.61 | 0.02 | 2.68 | 0.22 | 0.15 | 0.01 |
| 65-74 years | 7.6 | 4.59 | 0.03 | 2.56 | 0.24 | 0.18 | 0.01 |
| Female | | | | | | | |
| 25-74 years | 7.5 | 4.48 | 0.02 | 2.65 | 0.20 | 0.14 | 0.01 |
| 25-34 years | 7.8 | 4.68 | 0.03 | 2.74 | 0.20 | 0.15 | 0.01 |
| 35-44 years | 7.7 | 4.71 | 0.02 | 2.56 | 0.18 | 0.14 | 0.01 |
| 45-54 years | 7.5 | 4.47 | 0.01 | 2.62 | 0.21 | 0.13 | 0.01 |
| 55-64 years | 7.3 | 4.23 | 0.01 | 2.73 | 0.22 | 0.13 | 0.01 |
| 65-74 years | 7.1 | 4.16 | 0.02 | 2.58 | 0.20 | 0.13 | 0.01 |
| | | Percent of 100 cells | | | | | |
| Both sexes, 25-74 years | ... | 58.9 | 0.2 | 35.9 | 2.9 | 2.0 | 0.1 |
| Male | | | | | | | |
| 25-74 years | ... | 58.5 | 0.3 | 35.8 | 3.1 | 2.2 | 0.1 |
| 25-34 years | ... | 57.1 | 0.3 | 37.3 | 3.1 | 2.2 | 0.1 |
| 35-44 years | ... | 57.9 | 0.2 | 36.3 | 3.2 | 2.2 | 0.1 |
| 45-54 years | ... | 59.2 | 0.3 | 35.2 | 3.0 | 2.2 | 0.1 |
| 55-64 years | ... | 60.1 | 0.2 | 34.6 | 2.9 | 2.0 | 0.1 |
| 65-74 years | ... | 59.6 | 0.3 | 34.2 | 3.3 | 2.4 | 0.1 |
| Female | | | | | | | |
| 25-74 years | ... | 59.2 | 0.2 | 35.9 | 2.7 | 1.9 | 0.1 |
| 25-34 years | ... | 59.1 | 0.4 | 35.9 | 2.6 | 2.0 | 0.1 |
| 35-44 years | ... | 60.9 | 0.3 | 34.5 | 2.4 | 1.8 | 0.1 |
| 45-54 years | ... | 59.4 | 0.2 | 35.7 | 2.8 | 1.8 | 0.1 |
| 55-64 years | ... | 57.5 | 0.2 | 37.6 | 2.9 | 1.8 | 0.1 |
| 65-74 years | ... | 58.5 | 0.2 | 36.4 | 2.9 | 1.9 | 0.1 |

[1]Includes persons of other races; see appendix II.

SOURCE: First National Health and Nutrition Examination Survey detailed examination sample, 1971-75.

Table 7. Estimated standard error of mean number and mean percent of leukocytes for white[1] persons by type of leukocyte, sex, and age: United States, 1971-75

| Sex and age | *Number of cells X 10⁹/L* | | | | | *Percent of 100 cells* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Total leukocytes* | *Segmented neutrophils* | *Lymphocytes* | *Monocytes* | *Eosinophils* | *Total leukocytes* | *Segmented neutrophils* | *Lymphocytes* | *Monocytes* | *Eosinophils* |
| | Estimated standard error | | | | | | | | | |
| Both sexes, 25-74 years | 0.06 | 0.05 | 0.04 | 0.02 | 0.01 | ... | 0.36 | 0.41 | 0.19 | 0.06 |
| Male | | | | | | | | | | |
| 25-74 years | 0.08 | 0.06 | 0.05 | 0.02 | 0.01 | ... | 0.48 | 0.52 | 0.19 | 0.09 |
| 25-34 years | 0.12 | 0.09 | 0.07 | 0.02 | 0.01 | ... | 0.81 | 0.89 | 0.23 | 0.14 |
| 35-44 years | 0.18 | 0.15 | 0.08 | 0.02 | 0.02 | ... | 0.97 | 0.99 | 0.28 | 0.18 |
| 45-54 years | 0.13 | 0.10 | 0.07 | 0.02 | 0.01 | ... | 0.71 | 0.74 | 0.22 | 0.16 |
| 55-64 years | 0.19 | 0.12 | 0.12 | 0.02 | 0.02 | ... | 0.86 | 0.84 | 0.25 | 0.19 |
| 65-74 years | 0.19 | 0.18 | 0.09 | 0.02 | 0.01 | ... | 0.90 | 0.91 | 0.35 | 0.18 |
| Female | | | | | | | | | | |
| 25-74 years | 0.07 | 0.05 | 0.04 | 0.02 | 0.01 | ... | 0.38 | 0.43 | 0.20 | 0.08 |
| 25-34 years | 0.17 | 0.15 | 0.07 | 0.02 | 0.01 | ... | 0.84 | 0.87 | 0.21 | 0.14 |
| 35-44 years | 0.17 | 0.16 | 0.06 | 0.02 | 0.01 | ... | 0.81 | 0.83 | 0.26 | 0.17 |
| 45-54 years | 0.13 | 0.10 | 0.05 | 0.02 | 0.01 | ... | 0.57 | 0.52 | 0.25 | 0.14 |
| 55-64 years | 0.13 | 0.10 | 0.08 | 0.02 | 0.01 | ... | 0.84 | 0.83 | 0.25 | 0.14 |
| 65-74 years | 0.12 | 0.10 | 0.07 | 0.02 | 0.01 | ... | 0.68 | 0.73 | 0.30 | 0.14 |

[1] Includes persons of other races; see appendix II.

SOURCE: First National Health and Nutrition Examination Survey detailed examination sample, 1971-75.

Table 8. Estimated mean number and mean percent of leukocytes for black persons by type of leukocyte, according to sex and age: United States, 1971-75

| *Sex and age* | *Total leukocytes* | *Type of leukocyte* | | | | | |
|---|---|---|---|---|---|---|---|
| | | *Segmented neutrophils* | *Band neutrophils* | *Lymphocytes* | *Monocytes* | *Eosinophils* | *Basophils* |
| | | | | Number of cells X $10^9$/L | | | |
| Both sexes, 25-74 years | 6.9 | 3.83 | 0.01 | 2.79 | 0.20 | 0.14 | 00.1 |
| Male | | | | | | | |
| 25-74 years | 6.8 | 3.86 | 0.01 | 2.65 | 0.20 | 0.15 | 0.01 |
| 25-34 years | 7.1 | 3.98 | 0.00 | 2.76 | 0.23 | 0.19 | 0.01 |
| 35-44 years | 7.3 | 4.20 | 0.01 | 2.77 | 0.21 | 0.15 | 0.00 |
| 45-54 years | 6.8 | 3.84 | 0.01 | 2.67 | 0.18 | 0.15 | 0.02 |
| 55-64 years | 6.3 | 3.56 | 0.00 | 2.49 | 0.18 | 0.10 | 0.00 |
| 65-74 years | 5.8 | 3.20 | 0.01 | 2.25 | 0.17 | 0.12 | 0.00 |
| Female | | | | | | | |
| 25-74 years | 7.0 | 3.80 | 0.01 | 2.89 | 0.19 | 0.12 | 0.01 |
| 25-34 years | 7.0 | 3.76 | 0.01 | 2.91 | 0.19 | 0.15 | 0.01 |
| 35-44 years | 6.8 | 3.63 | 0.01 | 2.85 | 0.19 | 0.10 | 0.01 |
| 45-54 years | 6.7 | 3.67 | 0.01 | 2.80 | 0.17 | 0.12 | 0.01 |
| 55-64 years | 7.3 | 4.08 | 0.01 | 2.93 | 0.23 | 0.10 | 0.00 |
| 65-74 years | 7.5 | 4.12 | 0.00 | 3.09 | 0.20 | 0.13 | 0.01 |
| | | | | Percent of 100 cells | | | |
| Both sexes, 25-74 years | ... | 53.9 | 0.1 | 41.0 | 2.8 | 2.0 | 0.1 |
| Male | | | | | | | |
| 25-74 years | ... | 54.9 | 0.1 | 39.8 | 2.9 | 2.3 | 0.1 |
| 25-34 years | ... | 54.9 | 0.0 | 39.1 | 3.2 | 2.6 | 0.1 |
| 35-44 years | ... | 55.6 | 0.1 | 39.5 | 2.7 | 2.1 | 0.0 |
| 45-54 years | ... | 54.3 | 0.2 | 40.5 | 2.6 | 2.2 | 0.2 |
| 55-64 years | ... | 55.1 | 0.0 | 40.3 | 2.7 | 1.8 | 0.0 |
| 65-74 years | ... | 54.4 | 0.2 | 40.0 | 3.0 | 2.3 | 0.0 |
| Female | | | | | | | |
| 25-74 years | ... | 53.1 | 0.1 | 42.1 | 2.8 | 1.8 | 0.1 |
| 25-34 years | ... | 52.8 | 0.1 | 42.3 | 2.5 | 2.2 | 0.1 |
| 35-44 years | ... | 53.5 | 0.1 | 41.8 | 3.0 | 1.5 | 0.1 |
| 45-54 years | ... | 52.9 | 0.1 | 42.6 | 2.6 | 1.7 | 0.1 |
| 55-64 years | ... | 54.1 | 0.1 | 41.0 | 3.2 | 1.5 | 0.1 |
| 65-74 years | ... | 52.7 | 0.1 | 42.4 | 2.8 | 1.9 | 0.1 |

SOURCE: First National Health and Nutrition Examination Survey detailed examination sample, 1971-75.

Table 9. Estimated standard error of mean number and mean percent of leukocytes for black persons by type of leukocyte, sex, and age: United States, 1971-75

| Sex and age | Number of cells X $10^9$/L | | | | | Percent of 100 cells | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Total leukocytes* | *Segmented neutrophils* | *Lymphocytes* | *Monocytes* | *Eosinophils* | *Total leukocytes* | *Segmented neutrophils* | *Lymphocytes* | *Monocytes* | *Eosinophils* |
| | Estimated standard error | | | | | | | | | |
| Both sexes, 25-74 years | 0.14 | 0.10 | 0.08 | 0.02 | 0.01 | ... | 0.76 | 0.75 | 0.34 | 0.18 |
| Male | | | | | | | | | | |
| 25-74 years | 0 24 | 0.20 | 0.10 | 0.03 | 0.02 | ... | 1.19 | 1.15 | 0.43 | 0.26 |
| 25-34 years | 0.39 | 0.33 | 0.18 | 0.05 | 0.05 | ... | 2.15 | 2.12 | 0.77 | 0.49 |
| 35-44 years | 0.63 | 0.52 | 0.21 | 0.05 | 0.03 | ... | 2.76 | 2.77 | 0.59 | 0.45 |
| 45-54 years | 0 47 | 0.40 | 0.19 | 0.05 | 0.03 | ... | 2.72 | 2.73 | 0.65 | 0.40 |
| 55-64 years | 0.39 | 0.39 | 0.16 | 0.04 | 0.03 | ... | 3.25 | 2.84 | 0.79 | 0.60 |
| 65-74 years | 0 43 | 0.36 | 0.17 | 0.04 | 0.03 | ... | 2.39 | 2.25 | 0.65 | 0.52 |
| Female | | | | | | | | | | |
| 25-74 years | 0.19 | 0.14 | 0.11 | 0.03 | 0.01 | ... | 0.90 | 0.91 | 0.37 | 0.20 |
| 25-34 years | 0.32 | 0.27 | 0.17 | 0.04 | 0.03 | ... | 2.12 | 1.95 | 0.42 | 0.44 |
| 35-44 years | 0.45 | 0.28 | 0.21 | 0.05 | 0.02 | ... | 1.28 | 1.25 | 0.75 | 0.34 |
| 45-54 years | 0.30 | 0.24 | 0.16 | 0.03 | 0.03 | ... | 2.01 | 2.17 | 0.49 | 0.31 |
| 55-64 years | 0.42 | 0.35 | 0.17 | 0.08 | 0.03 | ... | 1.70 | 1.39 | 1.02 | 0.43 |
| 65-74 years | 0.81 | 0.75 | 0.34 | 0.05 | 0.03 | ... | 3.40 | 3.55 | 0.78 | 0.49 |

SOURCE: First National Health and Nutrition Examination Survey detailed examination sample, 1971-75.

Table 10. Number of examined persons, estimated mean number of segmented neutrophils, standard deviation, and selected percentiles by race, sex, and age: United States, 1971-75

| Race, sex, and age | Number of examined persons | Number of cells X $10^9/L$ | Standard deviation | Percentile 5th | 10th | 25th | 50th | 75th | 90th | 95th |
|---|---|---|---|---|---|---|---|---|---|---|
| White[1] | | | | | | | | | | |
| Both sexes | | | | | | | | | | |
| 25-34 years | 1,095 | 4.58 | 1.65 | 2.40 | 2.79 | 3.52 | 4.37 | 5.46 | 6.54 | 7.30 |
| 35-44 years | 833 | 4.59 | 1.73 | 2.42 | 2.79 | 3.41 | 4.31 | 5.45 | 6.71 | 7.54 |
| 45-54 years | 1,132 | 4.54 | 1.44 | 2.56 | 2.86 | 3.48 | 4.36 | 5.34 | 6.41 | 7.14 |
| 55-64 years | 895 | 4.40 | 1.41 | 2.41 | 2.77 | 3.42 | 4.18 | 5.22 | 6.26 | 6.78 |
| 65-74 years | 832 | 4.34 | 1.58 | 2.54 | 2.86 | 3.36 | 4.09 | 4.99 | 5.97 | 6.65 |
| Male | | | | | | | | | | |
| 25-34 years | 484 | 4.48 | 1.44 | 2.39 | 2.72 | 3.48 | 4.31 | 5.46 | 6.45 | 7.06 |
| 35-44 years | 363 | 4.47 | 1.57 | 2.54 | 2.80 | 3.30 | 4.14 | 5.24 | 6.46 | 7.56 |
| 45-54 years | 510 | 4.61 | 1.38 | 2.75 | 3.00 | 3.63 | 4.47 | 5.33 | 6.32 | 7.03 |
| 55-64 years | 427 | 4.61 | 1.43 | 2.62 | 3.01 | 3.59 | 4.47 | 5.51 | 6.36 | 7.06 |
| 65-74 years | 399 | 4.59 | 1.95 | 2.70 | 2.97 | 3.49 | 4.21 | 5.24 | 6.04 | 6.94 |
| Female | | | | | | | | | | |
| 25-34 years | 611 | 4.67 | 1.82 | 2.52 | 2.80 | 3.54 | 4.40 | 5.44 | 6.72 | 7.67 |
| 35-44 years | 470 | 4.71 | 1.85 | 2.22 | 2.65 | 3.54 | 4.46 | 5.62 | 6.92 | 7.50 |
| 45-54 years | 622 | 4.47 | 1.49 | 2.40 | 2.78 | 3.34 | 4.28 | 5.36 | 6.53 | 7.34 |
| 55-64 years | 468 | 4.23 | 1.36 | 2.34 | 2.65 | 3.34 | 4.05 | 4.94 | 6.07 | 6.72 |
| 65-74 years | 433 | 4.16 | 1.20 | 2.51 | 2.78 | 3.29 | 3.98 | 4.76 | 5.82 | 6.56 |
| Black | | | | | | | | | | |
| Both sexes | | | | | | | | | | |
| 25-34 years | 146 | 3.86 | 1.50 | 2.01 | 2.20 | 2.60 | 3.67 | 4.62 | 5.54 | 6.32 |
| 35-44 years | 128 | 3.89 | 1.59 | 1.82 | 2.15 | 2.73 | 3.72 | 4.77 | 5.56 | 6.13 |
| 45-54 years | 172 | 3.75 | 1.64 | 1.53 | 1.89 | 2.55 | 3.40 | 4.56 | 5.98 | 6.83 |
| 55-64 years | 117 | 3.86 | 1.59 | 1.85 | 1.94 | 2.50 | 3.64 | 5.25 | 5.82 | 6.49 |
| 65-74 years | 141 | 3.73 | 2.61 | 1.65 | 1.79 | 2.35 | 3.11 | 4.42 | 5.88 | 6.50 |
| Male | | | | | | | | | | |
| 25-34 years | 61 | 3.98 | 1.35 | 2.32 | 2.38 | 2.84 | 3.75 | 4.81 | 5.62 | 6.34 |
| 35-44 years | 47 | 4.20 | 1.83 | 1.54 | 2.17 | 2.89 | 3.94 | 5.32 | 5.57 | 6.59 |
| 45-54 years | 82 | 3.84 | 1.73 | 1.80 | 1.89 | 2.57 | 3.40 | 4.66 | 6.49 | 6.87 |
| 55-64 years | 53 | 3.56 | 1.36 | 1.69 | 1.88 | 2.37 | 3.25 | 4.35 | 5.38 | 5.78 |
| 65-74 years | 72 | 3.20 | 1.37 | 1.70 | 1.72 | 2.11 | 2.70 | 3.93 | 5.12 | 5.60 |
| Female | | | | | | | | | | |
| 25-34 years | 85 | 3.76 | 1.61 | 1.97 | 2.01 | 2.48 | 3.53 | 4.54 | 5.20 | 5.63 |
| 35-44 years | 81 | 3.63 | 1.32 | 1.83 | 1.97 | 2.67 | 3.52 | 4.24 | 5.21 | 5.79 |
| 45-54 years | 90 | 3.67 | 1.57 | 1.38 | 1.89 | 2.53 | 3.59 | 4.51 | 5.31 | 6.04 |
| 55-64 years | 64 | 4.08 | 1.70 | 1.86 | 1.91 | 2.52 | 3.77 | 5.36 | 6.00 | 6.71 |
| 65-74 years | 69 | 4.12 | 3.18 | 1.53 | 1.92 | 2.44 | 3.38 | 4.78 | 6.16 | 6.55 |

[1] Includes persons of other races; see appendix II.

SOURCE: First National Health and Nutrition Examination Survey detailed examination sample, 1971-75.

Table 11. Number of examined persons, estimated mean number of lymphocytes, standard deviation, and selected percentiles by race, sex, and age: United States, 1971-75

| *Race, sex, and age* | *Number of examined persons* | *Number of cells X $10^9$/L* | *Standard deviation* | *Percentile* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *5th* | *10th* | *25th* | *50th* | *75th* | *90th* | *95th* |
| **White[1]** | | | | | | | | | | |
| Both sexes | | | | | | | | | | |
| 25-34 years | 1,095 | 2.80 | 0.89 | 1.54 | 1.80 | 2.17 | 2.66 | 3.33 | 3.93 | 4.32 |
| 35-44 years | 833 | 2.65 | 0.91 | 1.38 | 1.59 | 1.98 | 2.54 | 3.20 | 3.77 | 4.22 |
| 45-54 years | 1,132 | 2.67 | 0.87 | 1.46 | 1.65 | 2.01 | 2.55 | 3.21 | 3.84 | 4.25 |
| 55-64 years | 895 | 2.71 | 1.36 | 1.39 | 1.63 | 2.03 | 2.56 | 3.23 | 3.85 | 4.37 |
| 65-74 years | 832 | 2.57 | 0.96 | 1.29 | 1.53 | 1.94 | 2.44 | 3.07 | 3.74 | 4.16 |
| Male | | | | | | | | | | |
| 25-34 years | 484 | 2.86 | 0.87 | 1.59 | 1.85 | 2.24 | 2.76 | 3.41 | 3.94 | 4.30 |
| 35-44 years | 363 | 2.75 | 0.96 | 1.30 | 1.54 | 2.05 | 2.65 | 3.32 | 3.95 | 4.54 |
| 45-54 years | 510 | 2.72 | 0.90 | 1.45 | 1.64 | 2.03 | 2.64 | 3.27 | 4.05 | 4.38 |
| 55-64 years | 427 | 2.68 | 1.73 | 1.35 | 1.58 | 1.96 | 2.50 | 3.20 | 3.78 | 4.25 |
| 65-74 years | 399 | 2.56 | 0.90 | 1.20 | 1.45 | 1.95 | 2.46 | 3.06 | 3.77 | 4.16 |
| Female | | | | | | | | | | |
| 25-34 years | 611 | 2.74 | 0.90 | 1.48 | 1.77 | 2.10 | 2.60 | 3.26 | 3.88 | 4.34 |
| 35-44 years | 470 | 2.56 | 0.84 | 1.40 | 1.62 | 1.92 | 2.47 | 3.00 | 3.68 | 3.96 |
| 45-54 years | 622 | 2.62 | 0.84 | 1.48 | 1.65 | 1.98 | 2.50 | 3.10 | 3.74 | 4.17 |
| 55-64 years | 468 | 2.73 | 0.91 | 1.45 | 1.67 | 2.08 | 2.61 | 3.24 | 3.97 | 4.45 |
| 65-74 years | 433 | 2.58 | 1.01 | 1.35 | 1.58 | 1.94 | 2.38 | 3.12 | 3.71 | 4.17 |
| **Black** | | | | | | | | | | |
| Both sexes | | | | | | | | | | |
| 25-34 years | 146 | 2.84 | 0.93 | 1.49 | 1.83 | 2.26 | 2.55 | 3.43 | 4.35 | 4.53 |
| 35-44 years | 128 | 2.81 | 0.93 | 1.18 | 1.71 | 2.21 | 2.75 | 3.30 | 3.91 | 4.45 |
| 45-54 years | 172 | 2.74 | 0.82 | 1.55 | 1.73 | 2.12 | 2.61 | 3.33 | 3.88 | 4.24 |
| 55-64 years | 117 | 2.74 | 0.82 | 1.65 | 1.79 | 2.12 | 2.60 | 3.32 | 3.78 | 4.13 |
| 65-74 years | 141 | 2.73 | 1.30 | 1.25 | 1.43 | 1.83 | 2.42 | 3.31 | 4.24 | 5.23 |
| Male | | | | | | | | | | |
| 25-34 years | 61 | 2.76 | 0.83 | 1.65 | 1.80 | 2.26 | 2.55 | 3.22 | 3.70 | 4.48 |
| 35-44 years | 47 | 2.77 | 0.79 | 1.77 | 1.94 | 2.23 | 2.66 | 2.97 | 3.63 | 3.93 |
| 45-54 years | 82 | 2.67 | 0.82 | 1.45 | 1.59 | 2.11 | 2.55 | 3.33 | 3.82 | 4.08 |
| 55-64 years | 53 | 2.49 | 0.77 | 1.35 | 1.75 | 2.01 | 2.37 | 2.70 | 3.49 | 3.67 |
| 65-74 years | 72 | 2.25 | 0.74 | 1.20 | 1.26 | 1.53 | 2.28 | 2.74 | 3.25 | 3.39 |
| Female | | | | | | | | | | |
| 25-34 years | 85 | 2.91 | 1.00 | 1.44 | 1.94 | 2.17 | 2.58 | 3.67 | 4.41 | 4.58 |
| 35-44 years | 81 | 2.84 | 1.04 | 1.11 | 1.25 | 2.06 | 2.91 | 3.55 | 4.21 | 4.69 |
| 45-54 years | 90 | 2.80 | 0.81 | 1.64 | 1.90 | 2.12 | 2.65 | 3.30 | 3.96 | 4.40 |
| 55-64 years | 64 | 2.93 | 0.81 | 1.73 | 1.87 | 2.35 | 3.00 | 3.44 | 3.97 | 4.18 |
| 65-74 years | 69 | 3.09 | 1.49 | 1.28 | 1.50 | 2.02 | 2.71 | 3.79 | 4.91 | 5.49 |

[1] Includes persons of other races; see appendix II.

SOURCE: First National Health and Nutrition Examination Survey detailed examination sample, 1971-75.

# Appendixes

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**List of Appendix Tables**

# Appendix I

# Statistical Notes

## The survey design

The sampling plan for the first 65 stands, or locations, of the first National Health and Nutrition Examination Survey (NHANES I) followed a stratified multistage probability design in which a sample of the civilian noninstitutionalized population ages 1-74 years of the coterminous United States was selected. Excluded from the selection were persons residing in Alaska and Hawaii and those within the coterminous United States who were confined to institutions or residing on American Indian reservation lands. Successive elements dealt with in the process of sampling were the primary sampling unit (PSU), census enumeration district, segment (a cluster of households), household, eligible persons, and finally, sample persons.

The starting points in the first stage of this design were the 1960 decennial census lists of addresses and the nearly 100 PSU's into which the entire United States was divided by the U.S. Bureau of the Census. Each PSU is either a standard metropolitan statistical area (SMSA), a single county, or two or three contiguous counties. The PSU's were grouped into 357 strata for use in the Health Interview Survey and were then collapsed into 40 superstrata for use in Cycles II and III of the Health Examination Survey and NHANES I.

Fifteen of the 40 superstrata contained a single large metropolitan area with a population of more than 2 million. The 15 large metropolitan areas were selected for the sample with certainty. The 25 noncertainty strata were classified into 4 broad population density groups in each region. Then a controlled selection technique was used to select 2 PSU's from each of the 25 noncertainty superstrata with the probability of selection of a PSU proportionate to its 1960 population. Thus, proportionate representation of specified State groups and rate-of-population-change classes was maintained in the sample. In this manner a total first-stage sample of 65 PSU's was selected. These 65 sample PSU's, or stands, are the areas within which a sample of persons would be selected for examination over the 3-year survey period.

Although the 1970 census data were used as the frame for selecting the sample of PSU's when they became available, the calendar of operations required that 1960 census data be used for 44 of the 65 stands in the NHANES I sample. Census enumeration districts (ED's) in each PSU were divided into segments of an expected six housing units each. In urban ED's the segments were clusters of six addresses from the 1960 census listing books. For ED's not having usable addresses, area sampling was employed and, consequently, the segment size varied. To make the sample representative of the current population of the United States, the address or list segments were supplemented by a sample of housing units that had been constructed since 1960.

Within each PSU a systematic sample of segments was selected. The ED's that fell into the sample were coded into one of two economic classes. The first class, identified as the "poverty stratum," was composed of current poverty areas that had been identified by the U.S. Bureau of the Census in 1970 (pre-1970 census), plus other ED's in the PSU with a mean income of less than $3,000 in 1959 (based on 1960 census data). The second economic class, the "nonpoverty stratum," included all ED's not designated as belonging to the poverty stratum.

All sample segments classified as being in the poverty stratum were retained in the sample. For those sample segments in nonpoverty stratum ED's, the selected segments were divided into eight random subgroups and one of the subgroups was chosen to remain in the NHANES I sample. This procedure permits separate analyses with adequate reliability of those classified as being below the poverty level and those classified as being above the poverty level.

After the sample segments had been identified, a list of all current addresses within the segment boundaries was made, and a person in each of the households was interviewed to determine the age and sex of each household member and to gather other demographic and socioeconomic information required for the survey.

In selecting the persons in sample segments to be examined in NHANES I, all household members ages 1-74 years in each segment were listed on a sample selection worksheet with each household in the segment listed serially. The number of household members in each of the six age-sex groups shown below were listed on the worksheet under the appropriate age-sex-group column. The sample selection worksheets were then ordered by segment number, and a systematic random sample of persons in each age-sex group was selected to be examined by using the following sampling rates:

| *Age* | *Sampling rate* |
|---|---|
| 1-5 years | 1/2 |
| 6-19 years | 1/4 |
| 20-44 years (male) | 1/4 |
| 20-44 years (female) | 1/2 |
| 45-64 years | 1/4 |
| 65-74 years | 1/1 |

The persons selected for the 65-stand nutrition component of NHANES I constitute a representative sample of the target population and include 28,043 persons ages 1-74 years, of whom 20,749, or nearly 74 percent, were examined. When adjustments are made for differential sampling for high risk groups, the response rate becomes 75.2 percent.

The subsample of adults ages 25-74 years who received the detailed examination in addition to the more general nutrition examination was chosen systematically after a random start. This group comprised one-fifth of the total sample of adults ages 25-74 years and was selected in accordance with the following rates:

| *Age* | *Rate applied to nutrition sample* | *Resultant effective sampling rate* |
|---|---|---|
| 25-44 years (male) | 2/5 | 1/10 |
| 25-44 years (female) | 1/5 | 1/10 |
| 45-64 years | 3/5 | 3/20 |
| 65-74 years | 1/4 | 1/4 |

The continuation of the detailed medical examination from 1974 to 1975 is referred to as the NHANES I augmentation survey of adults. The sample design had two basic requirements: The sample of persons selected for examination in survey locations 66-100 would constitute a national probability sample of the target population, and, when considered jointly with those persons receiving the detailed examination in NHANES I survey locations 1-65, the sample would be a 100-PSU national probability sample. Table I is a list of the sample locations at which examinations were conducted during the survey.

The PSU's for the augmentation survey were selected by the same process used earlier at the beginning of NHANES I (described earlier[4]). The final sampling stage involved the random selection of one of every two adults ages 25-74 years who were eligible for the sample.

All the data presented in this report are based on "weighted" observations. That is, data recorded for each sample person are inflated to characterize the subuniverse from which that sample person was drawn.

### Derivation of estimates

Because the design of NHANES I is a multistage probability sample, complex procedures must be used in the derivation of estimates. Three basic operations are involved, the results of which are presented separately in tables II and III for the nutrition examination sample and the detailed examination sample, respectively.

*Inflation by the reciprocal of the probability of selection.*—The probability of selection is the product of the probabilities of selection from each step of selection in the design (PSU, segment, and sample person).

*Nonresponse adjustment.*—The estimates are inflated by a multiplication factor calculated within each PSU for each of five selected income groups (less than $3,000; $3,000-$6,999; $7,000-$9,999; $10,000-$14,999; and $15,000 and over). The numerator of these factors consists of the sum of the weights for sample persons resulting from the reciprocal of the probability of selection, and the denominator consists of the sum of the weights for examined persons also resulting from the reciprocal of the probability of selection.

*Poststratification by age-sex-race.*—The estimates are ratio adjusted within age-sex-race cells to an independent estimate, provided by the U.S. Bureau of the Census, of the population of each cell as of the midpoint of the survey. The effect of the ratio-estimating process is to make the sample more closely representative of the U.S. civilian noninstitutionalized population by age, sex, and race, which thereby reduces sampling variance.

More detailed descriptions of the survey design and selection technique have been published.[4,5]

### Nonresponse

In any health examination survey, after the sample is identified and the sample persons are requested to participate in the examination, the survey meets one of its more severe problems: Usually, a sizable number of sample persons will not participate

NOTE: A list of references follows the text.

Table I. Sample locations of the first National Health and Nutrition Examination Survey by region, county, and State

| *Region, county,[1] and State* |
|---|
| Northeast |
| Essex, Morris, Union, Somerset, Hudson, Middlesex, N.J. |
| Nassau, Queens, Suffolk, N.Y. |
| Bronx, N.Y. |
| Kings, Richmond, N.Y. |
| Westchester, Rockland, N.Y.: Bergen, Passaic, N.J. |
| Bucks, Chester, Delaware, Montgomery, Philadelphia, Pa. |
| Philadelphia, Pa.: Camden, Gloucester, Burlington, N.J. |
| Essex, Middlesex, Norfolk, Plymouth, Suffolk, Mass. |
| Allegheny, Beaver, Washington, Westmoreland, Pa. |
| Albany, Schenectady, Rensselaer, Saratoga, N.Y. |
| Lackawanna, Pa. |
| Holyoke, Chicopee, Springfield, Mass. |
| Bristol, Newport, Providence, Kent, Washington, R.I. |
| Hartford, Tolland, Conn. |
| Chemung, Tioga, Tompkins, N.Y. |
| Mercer, Pa. |
| Bedford, Fulton, Pa. |
| Monroe, N.Y. |
| Blair, Pa. |
| Middlesex, New Haven, Conn. |
| Warren, N.Y. |
| Midwest |
| Lake, Porter, Cook, Will, Kane, Ill. |
| Cook, DuPage, Kane, Lake, McHenry, Ill. |
| Macomb, Oakland, Wayne, Mich. |
| Milwaukee, Waukesha, Wis. |
| Hennepin, Ramsey, Anoka, Dakota, Washington, Minn. |
| Lake, Cuyahoga, Ohio |
| Franklin, Ohio |
| Buchanan, Mo. |
| Cass, N.Dak.: Clay, Minn. |
| Jefferson, St. Charles, St. Louis, Mo.: Madison, St. Clair, Ill. |
| Bay, Mich. |
| DeKalb-Stueben, Ind.: Branch, Mich. |
| Cass, St. Joseph, Mich. |
| Fayette, Ross, Ohio |
| LaPorte, Marshall, Starke, Ind. |
| Boone, Greene, Iowa |
| Howard, Iowa: Fillmore, Minn. |
| Cass, Clay, Jackson, Platte, Mo. |
| Marion, Ind. |
| Montgomery, Greene, Miami, Ohio |
| Jackson, Mich. |
| Jefferson, Leavenworth, Kans.: Platt, Mo. |
| Brown, Clinton, Ohio |
| Rusk, Wis. |
| South |
| St. Bernard, Jefferson, Orleans, La. |
| Washington, D.C.: Fairfax, Arlington, Va.: Prince Georges, Montgomery, Md. |
| Richland, Lexington, S.C. |
| Knox, Anderson, Blount, Tenn. |
| Roanoke, Va. |
| Chatham, Ga. |
| Hillsborough, Pinellas, Fla. |
| Palm Beach, Fla. |
| Natchitoches, La. |
| Lamar, Marion, Miss. |
| Cabarrus, Stanley, Union, N.C. |
| Hancock, Hamblen, Hawkins, Claiborne, Tenn. |
| Barbour, Ala. |
| Bullock, Jenkins, Ga. |
| Sussex, Del.: Worcester, Md. |
| Fayette, W. Va. |
| Greenville, S.C. |
| New Castle, Del. |
| Jefferson, Ala. |
| Volusia, Fla. |
| Edgefield, Saluda, S.C. |
| Clay, Calhoun, Roane, W. Va. |
| West |
| Orange, Los Angeles, Calif. |
| Los Angeles, Calif. |
| Alameda, Contra-Costa, San Mateo, San Francisco, Solano, Calif. |
| Collin, Denton, Dallas, Ellis, Tex. |
| Bexar, Tex. |
| Pima, Ariz. |
| Douglas, Nebr.: Pottawattamie, Iowa |
| San Diego, Calif. |
| Fresno, Calif. |
| Monterey, Calif. |
| Clallum, San Juan, Wash. |
| Grant, Wash. |
| Gila, Ariz. |
| Avoyelles, La. |
| Ottertail, Minn. |
| Adams, Arapahoe, Denver, Jefferson, Boulder, Colo. |
| Sacramento, Calif. |
| Hunt, Rains, Tex. |
| Mason, Thurston, Wash. |
| Greeley, Nance, Nebr. |
| Camadian, Cleveland, Oklahoma, Okla. |

[1] County, parish, or borough.

in the examination. Whether or not an individual participates is determined by many factors, some of them uncontrollable, and, therefore, the outcome may be reasonably treated as a random event with a particular probability of occurrence. If the probabilities of participation were known and were greater than zero for all persons, then the examined persons would constitute a probability sample from which unbiased estimates of the target population could be derived. In this situation, the effect of nonparticipation would only be to reduce the sample size, thereby increasing the sampling errors of examination findings. In practice, however, a potential for bias due to nonresponse exists because the exact probabilities are never known. A further potential for bias exists if: (1) a sizable proportion of sample persons have a zero probability of participation, that is, they would never agree to participate in an examination survey of the same procedures and inducements, and (2) these persons differ from other sample persons with respect to characteristics under examination. It is for these reasons that intensive efforts were made in NHANES I to develop and implement procedures and inducements that would reduce the number of nonrespondents and thereby reduce the potential of bias due to nonresponse. These procedures and inducements are discussed elsewhere.[4]

NOTE: A list of references follows the text.

Table II. Population estimates for examination locations 1-65 by sex, race, and age at examination: United States, 1971-74

| Age at examination | Total | Male: All races | Male: White[1] | Male: Black | Female: All races | Female: White[1] | Female: Black |
|---|---|---|---|---|---|---|---|
| 1-74 years | 193,976,381 | 94,239,866 | 82,740,899 | 10,413,986 | 99,736,515 | 86,867,546 | 11,999,935 |
| 1 year | 3,313,458 | 1,693,074 | 1,401,508 | 280,212 | 1,620,384 | 1,327,657 | 257,289 |
| 2-3 years | 6,963,162 | 3,553,765 | 2,997,107 | 479,362 | 3,409,397 | 2,872,581 | 505,442 |
| 4-5 years | 6,672,346 | 3,378,503 | 2,866,374 | 485,872 | 3,293,843 | 2,755,016 | 511,134 |
| 6-7 years | 7,193,663 | 3,652,322 | 3,060,888 | 573,867 | 3,541,341 | 2,951,927 | 576,578 |
| 8-9 years | 7,696,597 | 3,880,396 | 3,279,649 | 586,419 | 3,816,201 | 3,257,936 | 539,855 |
| 10-11 years | 8,465,793 | 4,381,730 | 3,732,593 | 563,823 | 4,084,063 | 3,424,070 | 617,793 |
| 12-14 years | 12,335,321 | 6,312,519 | 5,397,061 | 879,377 | 6,022,802 | 5,122,189 | 836,252 |
| 15-17 years | 12,318,434 | 6,207,169 | 5,311,596 | 812,321 | 6,111,265 | 5,233,091 | 853,294 |
| 18-19 years | 7,352,200 | 3,673,321 | 3,206,467 | 404,045 | 3,678,879 | 3,158,930 | 504,417 |
| 20-24 years | 17,325,038 | 8,109,775 | 7,094,036 | 866,201 | 9,215,263 | 7,972,486 | 1,073,358 |
| 25-34 years | 26,936,001 | 13,002,514 | 11,594,115 | 1,231,793 | 13,933,487 | 12,160,578 | 1,646,337 |
| 35-44 years | 22,268,477 | 10,675,731 | 9,515,530 | 1,004,953 | 11,592,746 | 10,111,458 | 1,318,050 |
| 45-54 years | 23,313,316 | 11,150,110 | 10,039,124 | 1,056,837 | 12,163,206 | 10,879,167 | 1,237,459 |
| 55-64 years | 19,049,001 | 9,072,586 | 8,274,948 | 702,647 | 9,976,415 | 9,037,157 | 871,098 |
| 65-74 years | 12,773,574 | 5,496,351 | 4,969,903 | 486,257 | 7,277,223 | 6,603,303 | 651,579 |

[1] Includes persons of other races; see appendix II.

NOTE: The numbers in this table constitute estimates and closely approximate the U.S. population as estimated by the U.S. Bureau of the Census as of November 1972.

SOURCE: First National Health and Nutrition Examination Survey nutrition examination sample, 1971-74.

Table III. Population estimates for examination locations 1-100 by sex, race, and age at examination: United States, 1971-75

| Age at examination | Total | Male: All races | Male: White[1] | Male: Black | Female: All races | Female: White[1] | Female: Black |
|---|---|---|---|---|---|---|---|
| 25-74 years | 106,639,033 | 50,586,997 | 45,303,260 | 4,693,184 | 56,052,036 | 49,582,632 | 5,963,002 |
| 25-34 years | 28,296,796 | 13,663,092 | 12,122,508 | 1,302,502 | 14,633,704 | 12,712,842 | 1,736,498 |
| 35-44 years | 22,302,278 | 10,761,322 | 9,578,852 | 1,023,520 | 11,540,956 | 10,003,331 | 1,391,510 |
| 45-54 years | 23,548,824 | 11,288,375 | 10,131,455 | 1,095,092 | 12,260,449 | 10,921,890 | 1,262,609 |
| 55-64 years | 19,345,852 | 9,191,996 | 8,336,468 | 768,237 | 10,153,856 | 9,164,012 | 905,874 |
| 65-74 years | 13,145,283 | 5,682,212 | 5,133,977 | 503,833 | 7,463,071 | 6,780,557 | 666,511 |

[1] Includes persons of other races; see appendix II.

NOTE: The numbers in this table constitute estimates and closely approximate the U.S. population as estimated by the U.S. Bureau of the Census as of February 1974.

SOURCE: First National Health and Nutrition Examination Survey detailed examination sample, 1971-75.

Despite these intensive efforts, 26 percent of the sample persons from the 65-location nutrition examination sample and 30 percent of the sample persons from the 100-location detailed examination sample were not examined. Consequently, the potential for a sizable bias does exist in the estimates in this publication. From what is known about the nonrespondents and the nature of nonresponse, it is believed that the likelihood of sizable bias is small.

Efforts have been made using data from NHANES I and from an earlier survey to examine possible health-related differences between examined and nonexamined persons. Reasons for nonparticipation in NHANES I were investigated[29] on a sample of 325 persons (209 examined persons, 35 persons who had made appointments for the examination but who never came to the mobile examination center for the examination, and 81 persons who refused to participate in the survey). The sample persons for this study came from four stand locations: St. Louis, Monterey, New York, and Philadelphia. They were asked to indicate why they did not choose to be examined. The primary reasons given were that they had no need for a physical (48 percent), or that the examination times were inconvenient because of work schedules or other demands (15 percent). Only 6 percent of those persons not examined in NHANES I indicated that they refused the examination because of sickness, and 3 percent based their refusal on fears of possible findings.

NOTE: A list of references follows the text.

Data on both examined and nonexamined (but interviewed) persons were analyzed[30] by using information from the first 35 stands of NHANES I. For the health characteristics compared, the two groups were quite similar. For example, 20 percent of the examined persons reported that a doctor had told them they had arthritis, compared with 17 percent of the unexamined persons. Similarly, 18 percent of both the examined and the nonexamined persons had been told by a doctor that they had high blood pressure. Twelve percent of both groups reported that they were on a special diet, and 6 percent of both groups said that they regularly used medication for nerves.

A study[31] of factors relating to response in a health examination survey, based on data from Cycle I of the Health Examination Survey,[30] showed that 36 percent of the unexamined people in that survey viewed themselves as being in excellent health, compared with 31 percent of the examined people. A self-appraisal of being in poor health was made by 5 percent of the nonexamined persons and by 6 percent of those who were examined. Additionally, a different study of Cycle I data[32] showed that comparisons between two extreme groups—those who participated in the survey with no persuasion and those who participated only after a great deal of persuasion—indicated that differences between the two groups generally had little effect on estimates based on numerous selected examination and questionnaire items. This was interpreted as evidence that no large bias exists between the two groups for the items investigated and was offered as further support for the belief that little bias is introduced to the findings because of differences in health characteristics between examined and nonexamined persons.

As noted earlier, the data in this report are based on weighted observations, and one of the components of the weight assigned to an examined person was an adjustment for nonresponse. Because the probabilities of participation are not known for sample persons in NHANES I, a procedure was adopted that multiplies the reciprocal of the probability of selection of sample persons by a factor that brings estimates based on examined persons up to a level that would have been achieved if all sample persons had been examined. This nonresponse adjustment factor is the ratio of the sum of sampling weights for all sample persons within a relatively homogeneous class defined by age, sex, and income within each stand to the sum of sampling weights for all responding sample persons within the same homogeneous class from the same stand. If homogeneous groups can be defined that are also homogeneous with respect to the characteristics under study, the procedure can be effective in reducing the potential bias from nonresponse.

NOTE: A list of references follows the text.

### Missing data

Examination surveys are subject to the loss of information not only through the failure to examine all sample persons, but also from the failure to obtain and record all items of information for examined persons (item nonresponse). In the case of laboratory findings, missing data can result from such occurrences as equipment failure, laboratory accidents, poor specimen preparation, and loss of specimens in the mail between the examination locations and testing laboratories.

Differential leukocyte count data are not available for 1,059 persons, or 15.3 percent of the 6,913 adults who received the detailed examination during the 100-location sample. White blood cell (WBC) counts for 2,072 sample persons could not be reported from the NHANES I nutrition examination sample (stands 1-65), and the counts for an additional 280 persons were discarded during quality control procedures discussed in appendix IV.

After inspecting the age, sex, and race characteristics of that portion of the sample for whom WBC and/or differential leukocyte count data are missing, and after comparing these characteristics with those of the larger portion of the sample for which data are available, the assumption was made that the missing data accounts for little bias because of the nonsystematic nature of the reasons for missing laboratory data. Consequently, the weighted estimates that appear in this report as means or percents reflect an imputation for missing data; that is, the findings are presented as if information had been gathered for all sample persons.

### Small numbers

In tables 2-5 magnitudes are shown for cells for which the sample size is so small that the sampling error may be several times as great as the statistic itself. In such instances the numbers have been included to convey an overall impression.

### Reliability of estimates

Since the statistics presented in this report are based on a sample, they will differ somewhat from the figures that would have been obtained if the survey had been conducted on the complete population. In other words, the statistics are subject to sampling variability.

The standard error is primarily a measure of sampling variability, but it may also include part of the variation that arises in the measurement process. The standard errors presented in tables 1, 7, and 9 have been calculated by a technique referred to as balanced repeated replication. The need for this specialized technique for estimating standard errors arises because of the complexity of the sample design of NHANES I.

Estimates of standard errors are themselves subject to errors that may be large if the number of cases which the estimates are based is small.

### Utilization of standard errors

Two examples can illustrate the use of the standard errors presented in tables 1, 7, and 9.

The first example demonstrates the use of the standard error in testing the difference between estimated mean white blood cell (WBC) counts for two population groups: white males ages 65-74 years and black males in the same age group. A $z$ statistic will be computed as follows:

| *Population group* | *Mean WBC* $(\bar{X})$ | *Standard error of mean* $(\sigma_{\bar{X}})$ |
|---|---|---|
| White males ages 65-74 years[1] ....... | 7.6 | 0.19 |
| Black males ages 25-74 years[2] ....... | 5.8 | 0.43 |

[1]From tables 6 and 7.
[2]From tables 8 and 9.

First an approximation of the standard error of the difference between the two mean values is calculated as follows:

Standard error of difference:

$$\sigma_{\bar{X}_1-\bar{X}_2} = \left(\sigma_{\bar{X}_1}^2 + \sigma_{\bar{X}_2}^2\right)^{1/2}$$

or

$$\sigma_{\bar{X}_1-\bar{X}_2} = \left[(0.19) + (0.43)\right]^{1/2} = 0.47.$$

Then the $z$ statistic is computed as follows:

$$z = \frac{\bar{X}_1 - \bar{X}_2}{\sigma_{\bar{X}_1-\bar{X}_2}}$$

or

$$z = \frac{7.6 - 5.8}{0.47} = 3.83.$$

As a matter of convenience, in this study a difference between two means was considered significant when $z$ was equal to or greater than 2.00. Since $z$ is greater than 2.00 ($z$ = 3.83), the difference between mean WBC counts for white and black males ages 25-74 years is considered significant at the 95-percent confidence limit.

In the second example, the standard error is employed to construct a confidence interval around the estimated mean WBC count for white males ages 65-74 years as follows:

| *Population group* | *Mean WBC* $(\bar{X})$ | *Standard error of mean* $(\sigma_{\bar{X}})$ |
|---|---|---|
| White males ages 65-74 years ........ | 7.6 | 0.19 |

A 95-percent confidence interval is constructed as follows:

$$\bar{X} \pm 1.96\,\sigma_{\bar{X}}$$

or

$$7.6 \pm 1.96\,(0.19),$$

which results in a confidence interval of 7.2-8.0.

In other words, the probability that the population value for the estimated mean WBC count for white males ages 65-74 years lies between 7.2 and 8.0 is 95 percent.

# Appendix II

# Definitions of Certain Terms Used in This Report

*Age.*—Two ages were recorded for each examinee: age at last birthday at the time of examination and age at the time of the census interview. The age criterion for inclusion in the sample used in this survey was defined as age at the time of census interview. The adjustment and weighting procedures used to produce national estimates were based on the age at interview. Data in the detailed tables and text of the report are shown by age at the time of the examination, except that those few who became 75 years old by the time of the examination are included in the 65-74-year age group.

*Race.*—Race was recorded as "white," "black," or "other." "Other" includes Japanese, Chinese, American Indian, Korean, Eskimo, and all races other than white or black. Mexicans were recorded as "white" unless definitely known to be American Indian or of a race other than white. When a person of mixed racial background was uncertain about his or her race, the father's race was recorded. In this report people of "other" races have been included under the designation "white."

*Smoking status.*—Smoking status was derived from questionnaire material in the following manner:[4]

| | |
|---|---|
| Never smoked: | Examinee has smoked less than 100 cigarettes in lifetime. |
| Former smoker: | Examinee has smoked at least 100 cigarettes in lifetime but was not smoking at the time of the NHANES I survey. |
| Current smoker: | Examinee has smoked more than 100 cigarettes in lifetime and was smoking at the time of the NHANES I survey. |

NOTE: A list of references follows the text.

# Appendix III

# Data Collection Methodology

### White blood cell counts

White blood cell (WBC) counts were determined in duplicate on the Coulter Fn, operated according to the Coulter instruction manual.[33] In the Coulter Fn, particles suspended in an electrolyte solution are forced by a mercury siphon through an aperture of 100 microns. A current flows between an electrode inside the aperture tube and a second electrode outside the tube. As a particle passes through the aperture, an equal volume of electrolyte is displaced, and the resistance in the path of the current changes. This produces a voltage drop, the magnitude of which is proportional to the volume of the particle. The voltage pulses are fed into a threshold circuit, which differentiates them by generating count pulses for only the particles that exceed the threshold level, thus counting the number of particles in passage. A correction factor for coincidence must be employed for counts over 10,000.

Forty $\mu$L of blood were aspirated by a Coulter Diluter II[34] and dispersed into 20 $\mu$L of Isoton for a 1 : 500 dilution. Six drops of Zapoglobin were added to the 1 : 500 dilution, and the instrument count for white cells was performed. Corrections were made for readouts above 10,000 with the Coulter coincidence chart. The (corrected) readout was multiplied by the appropriate factor to obtain the WBC count in $N \times 10^9/L$ (or, $N \times 10^3/\mu L$). Duplicate dilutions were tested, and results had to agree within a strict tolerance level. Additionally, samples with mean values below 3.0 or above $15.0 \times 10^9/L$ were retested, and the results were called to the attention of the person's examining physician.

The Coulter counter was monitored daily with commercially available control materials. Background counts were less than 100, and maintenance was performed at each location, or stand. If the technician had reason to suspect that the instrument was not performing correctly (for example, because of nearby electrical interference) he or she was instructed to note this on the laboratory recording form.

Personnel from the Hematology Division, Centers for Disease Control (CDC) visited the mobile vans to ensure that procedures were properly performed. Duplicate peripheral blood smears were made from blood preserved with EDTA by the wedge technique within an hour after the sample was collected. Smears were air dried and stained by using an Ames Hema-Tek slide stainer equipped with the Hema-Tek stain pack;[35] this modified polychrome methylene blue stain is based on the original stain proposed by Romanowsky.[36] During the time span covered, five qualified medical technologists performed the 100-cell differential leukocyte counts. All data were reported to the National Center for Health Statistics (NCHS) for coding and storing on computer tapes. Abnormal results reported to NCHS were also forwarded to the examinee's physician.

### Peripheral blood smears: Cell-typing criteria

Although some degree of subjectivity on the part of the technologist performing the differential leukocyte count cannot be denied, in general, the following terms and cell-typing criteria were adhered to:

| | |
|---|---|
| Blast (myeloblast): | With a large round or oval nucleus and nongranular dark blue staining cytoplasm. No nuclear folds, fine purple-red chromatin strands, usually one or more nucleoli. |
| Promyelocyte: | Resembling myeloblast but with primary bluish-to-purple granules of various sizes and shapes in the cytoplasm. |
| Myelocyte: | With round, oval, or flattened, nonindented, nonfolded, nonlobulated nucleus with ill-defined chromatin |

NOTE: A list of references follows the text.

strands. Lightly stained reddish secondary granules have appeared among the darkly stained primary ones.

Metamyelocyte: With indented or bean-shaped nucleus in which the chromatin is more clumped. The primary granules have disappeared.

Band forms (stab neutrophils): With nuclei indented but not yet clearly separated into interconnected lobes.

Segmented forms (polymorphonuclear neutrophils): With clearly lobulated nuclei. The lobes are interconnected by means of threadlike filaments or strips, within the margins of which no nuclear chromatin is visible. The chromatin within the lobes is lumped and darkly stained.

Eosinophils: With bright red-orange spherical granules and a nucleus segmented into two to three lobes.

Basophils: With predominantly dark blue, densely stained granules of various sizes, unevenly distributed and also overlying the nucleus.

Monocyte: With bluish-gray cytoplasm and numerous small dustlike granules causing an opaque, ground-glass-like appearance. The nucleus may be round, oval, indented, or lobulated, with brainlike convolutions.

Lymphocyte: Pale to bright blue staining, abundant or sparse cytoplasm and rounded nucleus with dense, clumped chromatin. No within-lymphocyte differentiation was reported, such as atypical or reactive.

# Appendix IV

# Quality Control

### Review of white blood cell count data

Mean white blood cell (WBC) counts by stands were calculated, graphed, and examined. Mean values at each stand were computed and examined for plausibility and were compared with preliminary results from NHANES II. All WBC counts less than $3.3 \times 10^9/L$ or greater than $14.2 \times 10^9/L$ were reviewed for transcription or keypunch errors. Daily runs were evaluated in conjunction with conditions in the mobile examination centers. Data from daily runs were excluded if the equipment malfunctioned and when control values were outside the limits of the manufacturer's expected results. Data were also excluded if manual dilutions caused shifts in the mean. Of the 23,808 cases for evaluation, 2,292 were missing, primarily because of equipment failure, and 280 were excluded because of questionable quality.

### Peripheral blood smears

Quality control in the usual sense could not be implemented on a daily basis because the stained slides were accumulated at each survey location and sent to the Centers for Disease Control (CDC) about once a month. In CDC's Hematology Division the slides were classified as satisfactory and read, or they were reported as unsatisfactory. If unsatisfactory slides were received recurrently, additional onsite training was given to the technicians. If differential results were outside the accepted normal values,[25] an additional 100 white blood cells were classified. In addition, the morphologic evaluations of the slides were compared with Coulter results.

All differential results were computer checked to ascertain that the sum of the frequencies of the different cell types totaled 100, and discrepant results were checked for transcription or keypunch errors. If no errors were found, the differential leukocyte count was redone.

All results were further checked for plausibility according to the following criteria.[18,25] When uncommon cell types including blast cells, promyelocytes, myelocytes, and metamyelocytes were reported, the results were verified. If the percents of other cell types reported fell outside the acceptable ranges, these results were also reviewed. The acceptable ranges are as follows:

| *Cell type* | *Acceptable range* |
|---|---|
| Band neutrophils | 0-10 percent |
| Segmented neutrophils | 27-85 percent |
| Eosinophils | 0-12 percent |
| Basophils | 0-3 percent |
| Monocytes | 0-12 percent |
| Lymphocytes | 10-70 percent |

A computer reject-listing of 65 results was obtained. A number of transcription or keypunch errors were found, one case of chronic lymphocytic leukemia and one case of chronic myelocytic leukemia were identified, and 47 results were verified—15 by 200-cell differential counts. Of 6,913 persons examined in the 100 stands, satisfactory slides were obtained for 5,854 persons (85 percent). The 1,059 examinees for whom data are not presented were excluded for the following reasons: no slide obtained, slide obtained but not read because of poor cell distribution, slide broken in the mail, or slide lost in the mail. The largest loss was from poor slide preparation, as mentioned earlier. This necessitated excluding all slides from three entire stands.

NOTE: A list of references follows the text.

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