VITAL and HEALTH STATISTICS
DATA FROM THE NATIONAL HEALTH SURVEY

Blood Glucose Levels in Adults

United States - 1960 - 1962

A description of the glucose tolerance test, with data on the mean levels of blood glucose by age, sex, and race; and an analysis of differentials by place description, family income, education, marital status, usual activity status, occupation, and industry.

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COOPERATION OF THE BUREAU OF THE CENSUS

In accordance with specifications established by the National Health Survey, the 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.

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CONTENTS

IN THIS REPORT are presented findings on the mean blood glucose levels obtained from Cycle I of the Health Examination Survey. Cycle I consisted of examinations of a nationwide probability sample of persons 18-79 years of age selected from the U.S. civilian, noninstitutional population.

This report describes the glucose tolerance test, presents the data collected, and compares the information collected with that of another survey. The relationship of the blood glucose level to the demographic variables of age, race, sex, family income, education, place description, marital status, usual activity status, occupation, and industry are examined.

The mean blood glucose level rises steadily with age for both sexes; however, the level is consistently slightly higher for women than for men. There is a small racial difference for men. Negro men have slightly higher mean glucose levels than white men. The mean glucose levels also varied by certain other demographic factors. Among the differentials noted was a strong downward trend of blood glucose levels with higher income and with higher education.

SYMBOLS

Data not available	---
Category not applicable	...
Quantity zero	-
Quantity more than 0 but less than 0.05	0.0
Figure does not meet standards of reliability or precision	*

BLOOD GLUCOSE LEVELS IN ADULTS

Caroline C. Garst, *Division of Health Examination Statistics*

This report discusses the levels of blood glucose after challenge for the U.S. adult population by age, sex, race, and other selected demographic characteristics. These data are supplemented in a few instances by information on urine glucose findings and diagnosed diabetes. No estimate is made of the prevalence of unknown cases of diabetes in the United States.

The interest in blood glucose levels lies in the implication that they have for studies on diabetes. Hyperglycemia is ordinarily considered at the very least a precursor of diabetes. The higher the blood glucose level the greater the likelihood that clinical diabetes will appear. By inference groups with higher than average blood glucose levels after challenge may well be suspected of having a higher risk of diabetes, while groups with lower than average blood glucose levels may well have a lower risk of diabetes.

The estimates of the levels of blood glucose in this report are based on examination findings obtained by the Health Examination Survey on 6,672 persons who comprised a probability sample of the civilian, noninstitutional population 18-79 years of age.

This is one of a series of reports describing and evaluating the plan, conduct, and findings of the first cycle of the Health Examination Survey. The descriptions of the general plan and the sample population and response have been published.[1,2] These provide general background for all the reports on findings. Another report in the series is an introductory report on glucose tolerance.[3] The reader may refer to that report for more detailed information on the glucose tolerance test. Two measures of the tolerance of an oral glucose challenge were considered in that report—the presence or absence of glucose in the urine and the blood glucose level. Also estimates were given for the prevalence of clinically defined diabetes.

DESCRIPTION OF THE GLUCOSE TOLERANCE TEST

Upon entering the mobile clinic, each examinee was greeted by a receptionist-interviewer. The first medical question asked was, "Do you have any reason to think you may have diabetes...?" If the answer was "yes" or if the examinee was uncertain, the interviewer asked a series of questions to determine whether a diagnosis of diabetes had been made by a physician, whether the examinee was under a doctor's care for the disease, how frequently he saw a doctor, and whether any specific hypoglycemic agent was used in treatment (Appendix I).

Unless there was a clear history of diabetes with medical care, the examinee was given a drink of 50 grams of glucose with lemon flavoring ("Dextol") which was diluted in 250 cc. of water. The glucose challenge was given each examinee without regard to time or content of his previous meal. An hour after the glucose drink was given, a blood specimen of 3 ml. was collected in prelabeled B-D "vacutainers" containing 30 mg. of sodium fluoride. Specimens were shipped on water ice to the Diabetes Field Research Unit in Boston, Massachusetts, for determination of glucose concentration by the Somogyi-Nelson method.[4]

A considerable effort went into attempts to control and measure the technical variability of blood glucose determination during the Survey. The methods of testing the variability of the determinations have been discussed at length in a previous report.[3] It appears that the variability in the work of individual technicians and among technicians was remarkably low. In addition no evidence was found that the preservative used, the varying length of time between drawing a specimen and measuring it, or the methods of transporting specimens between the field and the laboratory produced any significant effects on the blood glucose level reported.

FINDINGS

This report only discusses the blood glucose level of those who received a glucose challenge. Most of the diagnosed diabetics had, as a conservative estimate, an average glucose level about 100 mg.% higher than nondiabetics and were in the group that did not have the glucose drink. Thus the levels of glucose tolerance reported here are slightly lower than the levels which would have been found had the diabetics been included—particularly those for men and women over 45 years of age.

AGE AND SEX

As it has already been noted,[3] the mean blood glucose level for both men and women increased steadily with age. It rose from 99.7 mg.% at 18-24 years to 166.3 mg.% at 75-79 years. However, for each age group women had a blood glucose level which was, on the average, about 10 mg.% higher than the level for men. This difference in glucose levels between the sexes grew consistently wider with advancing age—for those 18-24 years the difference was 9.5 mg.% and for those 75-79 years the difference was 24.1 mg.% (table 1, fig. 1).

The distribution of glucose levels by age and sex, which was also discussed in a previous report,[3] presents a similar picture. The number of persons with high glucose levels increased with age, and more women than men had high levels for each age group.

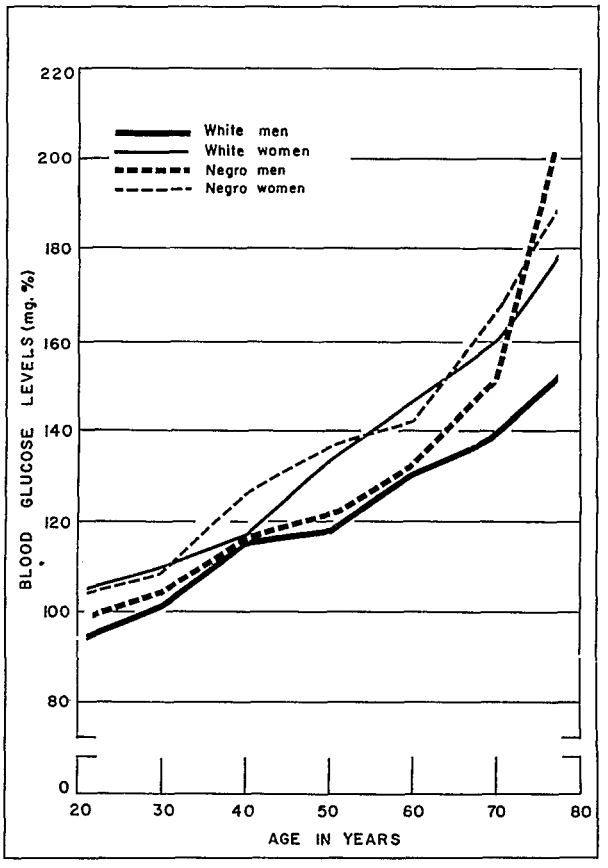

Figure 1. Mean blood glucose levels after challenge in adults, by age, race, and sex.

RACE

There was, apparently, a slight but statistically significant difference in blood glucose levels between white and Negro men (fig. 1, table 1). When looking at racial differences in the South, where the proportion of Negro to white persons is highest, there was a difference in the same direction for both men and women (as shown below) but it was not statistically significant.

	White	*Negro*
Men	117.8	119.5
Women	128.5	133.8

The sample was too small to estimate blood glucose levels for other nonwhite races.

OTHER DEMOGRAPHIC VARIABLES

In the discussions that follow the population is classified in a variety of ways—e.g., by family income and education—and the mean level of blood glucose in different demographic groups is compared. The demographic groups used in this report are defined in Appendix II. If the population was classified by family income, for example, the level of blood glucose for different income groups was examined to determine whether or not mean levels varied from one income group to another. In making these comparisons, allowances had to be made for the differences from one group to another in the distribution of people by age and sex since the mean blood glucose levels varied by age and sex. Because the sampling variability of age-sex-specific values for any group was usually large, a summary comparison by sex was thought preferable to the presentation of glucose levels specific by age and sex. For this reason the actual glucose level for each group was compared with an expected level. The expected value of a particular group was obtained by weighting age-sex-specific levels for the total United States by the age-sex distribution for that group. The obvious meaning can be attached to differences between actual and expected rates with the understanding that differences may arise by chance. A positive difference, for example, indicated that the glucose level for that group was higher than expected. In general, where there was no statistically significant difference between the actual and expected values for a group, differences for individual age-sex groups exhibited only random fluctuations.

Residence

Women in the South had significantly high levels of blood glucose (table 2). This might be due to the high proportion of persons in the South who have low income or educational levels. As will be shown later, persons fitting into either of these demographic categories seemed to have had blood glucose levels which were higher than average. The high glucose level in the South was corroborated by the prevalence both of higher than expected positive urine glucose and diagnosed diabetes for these women, although these excesses were not in themselves statistically significant (tables 3 and 4).

Mean glucose levels by residence tended to be higher than expected for those in urban areas and lower than expected for those in rural areas. These differences between the actual and expected glucose levels were not statistically significant, but they were fairly consistent in all the demographic divisions of residence—place description, population size, and urban-rural residence (tables 5-7). This tendency was more pronounced for women than for men; and indeed if the data for men were considered alone, no such point could have been made at all. In fact, when looking at place description, there was a definite trend for women—ranging from low glucose levels in the central city to high glucose levels in rural, farm areas.

Income and Education

When allowance was made for age, the mean blood glucose level decreased steadily for both men and women as the amount of family income increased (table 8, fig. 2). For men with incomes of less than $2,000 the mean blood glucose level was 4.6 mg.% greater than expected, and for those with incomes of $10,000 or more the blood glucose level was 2.9 mg.% less than expected—a difference of 7.5 mg.%. For women this difference was 6.6 mg.%. There was also a trend associated with the number of completed years of education, but it was not as pronounced (table 9, fig. 3). Those with less than a fifth grade education had distinctly high blood glucose levels; persons with 5-8 years of schooling had somewhat lower levels; and persons with a high school education had still lower levels. However, persons who had gone to college had a higher level than those with between 9 and 12 years of schooling but a lower level than those with less education. This trend was stronger for women than for men.

About 70 percent of the diabetics did not receive the challenge and thus were not included in the reported levels of blood glucose by income. If the prevalence of known diabetics had an increasing trend with income, as might be expected from the fact that doctor visits increase with income,[5] this exclusion could have produced an

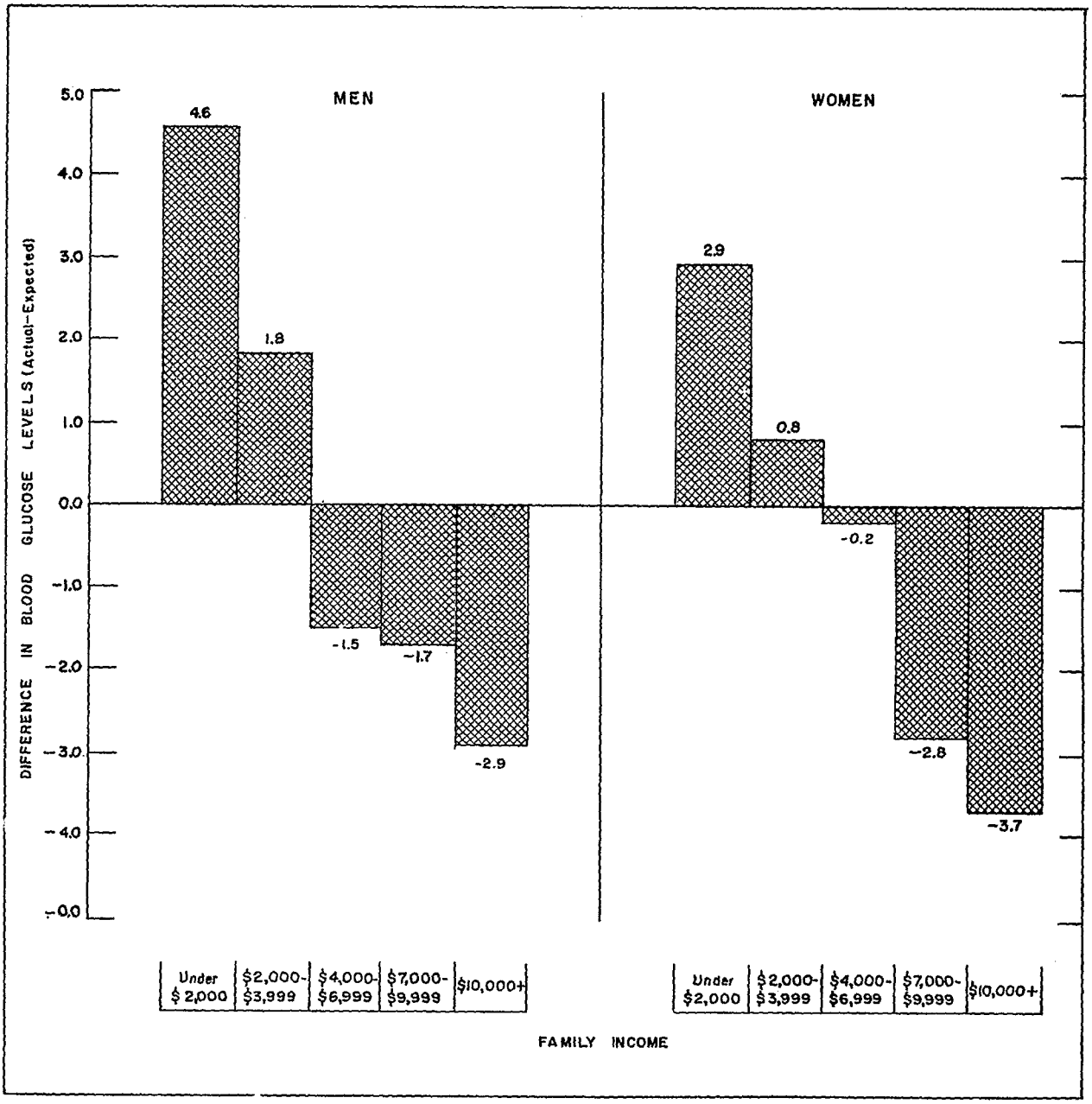

Figure 2. Differences between actual and expected mean blood glucose levels in men and women, by family income.

artifact which would have caused the decrease in blood glucose levels at higher incomes. However, this was not the case, for the prevalence of known diabetes in this survey fluctuated randomly with changes in income (table 10).

Pell and D'Alonzo[6] conducted a study of the prevalence of diabetes by income in a large industry. Their criterion for the diagnosis of diabetes was a blood glucose level after challenge above a specified level. They found that there was a reduction in the prevalence of diabetes with increasing income which indicated that they found, as this Survey found, that the mean blood glucose levels were lower at higher incomes.

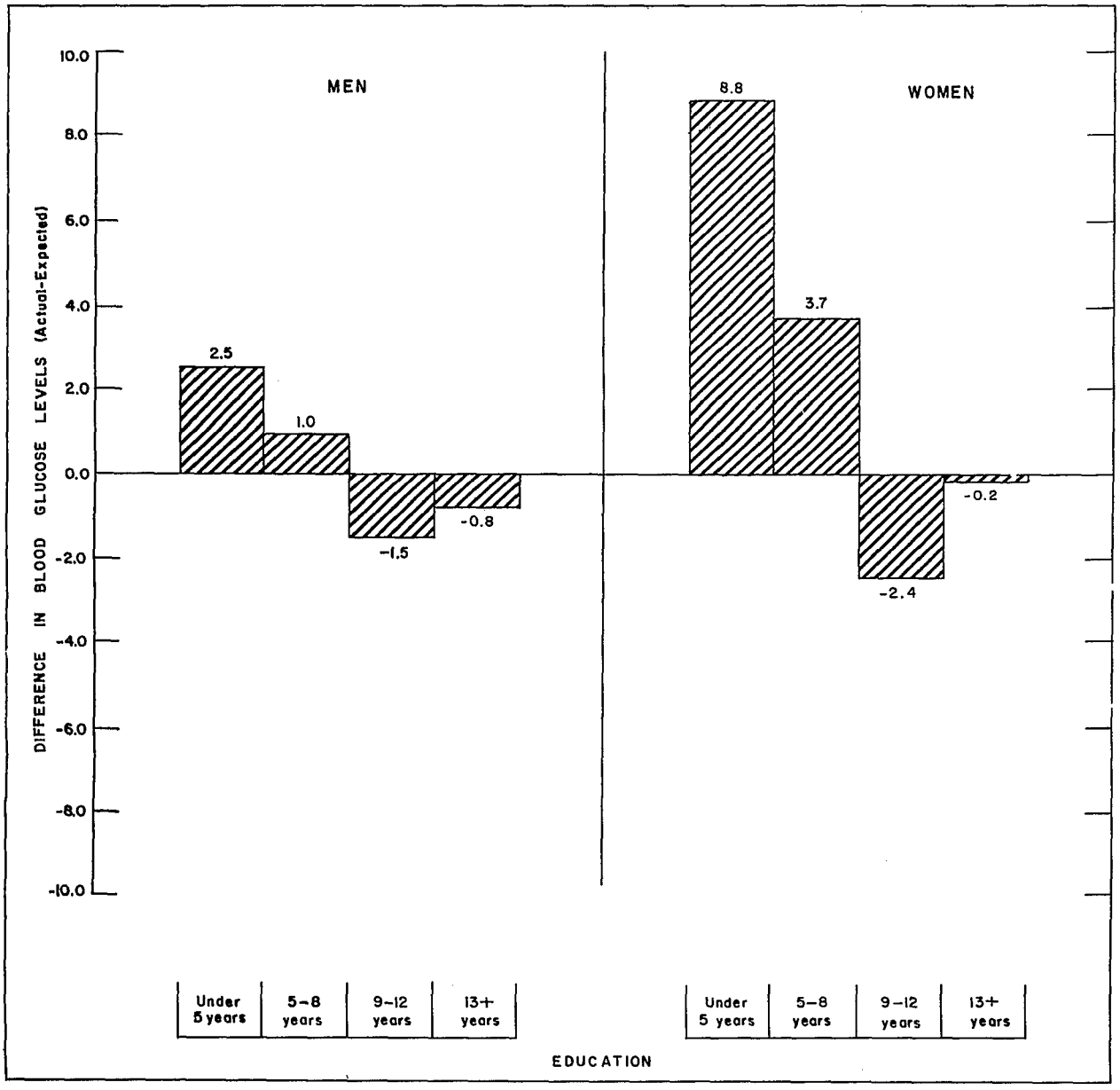

Figure 3. Differences between actual and expected mean blood glucose levels in men and women, by education.

Income and Education by Race

After age distributions had been standardized, the differences between the mean blood glucose levels for white and Negro adults varied with increasing income or education (table 11). For adults with an income of less than $2,000 or an education of less than 5 years, the glucose level was higher for white persons than for Negro. With higher income or more completed years of education, the blood glucose level became higher for Negro than for white persons. None of the specific differences were statistically significant but they were consistent, being true for both men and

women. From the available data it was not possible to explain this trend in the differences between the glucose levels of white and Negro adults. Because proportionally few Negro adults had family incomes exceeding $7,000 per year or education beyond high school, mean blood glucose levels could be meaningfully compared only for incomes of less than $7,000 or for schooling below the college level.

Marital Status

Men who were separated from their spouses had a higher than expected blood glucose level (table 12). There did not appear to be any significant differences in levels of glucose associated with any other marital status. There may have been other differences, but they were small or exhibited too great a variance to be deemed significant.

Usual Activity Status, Occupation, and Industry

Women who work had a significantly low mean blood glucose level (table 13). However, among employed women there was no significant difference between the actual and expected levels for women associated with any particular occupational or industrial group (tables 14 and 15). The only group of men with a low blood glucose level were "private household and service workers." There was no indication of a difference for men associated with either their usual activity status or industrial classification. There may have been other differences, but they were either small or the variance of the estimates was too large to consider the differences significant.

SUMMARY

The mean blood glucose level after challenge rose steadily with age for both sexes. However, this level was, on the average, about 10 mg.% higher for women than for men.

Negro men had mean blood glucose levels which were slightly higher than the mean levels of white men.

Women in the South had significantly higher mean levels of blood glucose than expected. Mean glucose levels tended to be higher than expected for those in urban areas and lower than expected for those in rural areas. This tendency was stronger for women than for men.

There was a strong downward trend of blood glucose levels with higher income and education. However, there was a stronger trend associated with income than with education.

Women who work had a lower glucose level than expected, but this did not appear to be due to any particular occupational or industrial group.

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[5]National Center for Health Statistics: Volume of physician visits by place of visit and type of service: United States, July 1963-June 1964. *Vital and Health Statistics*. PHS Pub. No. 1000-Series 10-No. 18. Public Health Service. Washington. U.S. Government Printing Office, June 1965.

[6]Pell, S. and D'Alonzo, C. A.: Diabetes in an employed population. *J.A.M.A.* 172:1000-1006, Mar. 1960.

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DETAILED TABLES

Table 1. Mean glucose levels, by age, race, and sex for men and women: United States, 1960-62

Age	All races		White		Negro	
	Men	Women	Men	Women	Men	Women
	Mean glucose levels in mg.%					
Total, 18-79 years	115.7	126.4	115.4	126.5	118.5	126.1
18-24 years	94.6	104.1	94.4	104.3	99.1	104.0
25-34 years	101.5	109.6	100.2	109.6	103.5	107.9
35-44 years	115.2	117.6	115.2	116.5	115.8	126.0
45-54 years	118.2	133.2	118.1	132.6	121.1	136.3
55-64 years	130.1	145.2	130.2	145.5	131.7	141.9
65-74 years	139.9	159.7	139.0	159.5	150.8	166.2
75-79 years	154.6	178.7	151.6	177.5	201.1	187.2

Table 2. Actual and expected mean glucose levels in men and women, by geographic region: United States, 1960-62

Region	Men			Women		
	Actual	Expected	Difference	Actual	Expected	Difference
	Mean glucose levels in mg.%					
Northeast	113.1	115.4	-2.3	123.7	126.5	-2.8
South	118.0	114.9	3.1	129.7	125.1	4.6
West	116.6	116.5	0.1	126.3	127.3	-1.0

NOTE: Expected values explained in Appendix III.

Table 3. Actual and expected prevalence of men and women with a trace or more of urine glucose, by geographic region: United States, 1960-62

Region	Men			Women		
	Actual	Expected	Difference	Actual	Expected	Difference
	Rate per 100 adults					
Northeast	16.0	18.1	-2.1	10.1	10.9	-0.8
South	17.8	17.7	0.1	11.5	10.5	1.0
West	20.2	18.1	2.1	10.9	11.0	-0.1

NOTE: Expected values explained in Appendix III.

Table 4. Actual and expected prevalence of diagnosed diabetes[1] in men and women, by geographic region: United States, 1960-62

Region	Men			Women		
	Actual	Expected	Difference	Actual	Expected	Difference
	Rate per 100 adults					
Northeast	1.8	1.4	0.4	2.0	2.2	-0.2
South	1.4	1.4	0.0	3.0	2.1	0.9
West	1.0	1.4	-0.4	1.7	2.2	-0.5

[1]Persons with diagnosed diabetes are those who reported the use of insulin or an oral hypoglycemic agent or, if not on medication, reported previous diagnosis by a physician and had blood glucose levels 138 mg.% or above without challenge or 148 mg.% or above with challenge.

NOTE: Expected values explained in Appendix III.

Table 5. Actual and expected mean glucose levels in men and women, by place description: United States, 1960-62

Place description	Men			Women		
	Actual	Expected	Difference	Actual	Expected	Difference
	Mean glucose levels in mg.%					
SMSA—central city	116.2	116.2	0.0	124.6	127.1	-2.5
SMSA—not central city	115.0	114.7	0.3	124.9	125.7	-0.8
Urban—not SMSA	112.5	114.5	-2.0	126.3	125.6	0.7
Rural farm	121.7	119.4	2.3	133.1	127.0	6.1
Rural nonfarm	116.3	116.1	0.2	130.7	126.7	4.0

NOTE: Expected values explained in Appendix III.

Table 6. Actual and expected mean glucose levels in men and women, by population-size group: United States, 1960-62

Population-size group	Men			Women		
	Actual	Expected	Difference	Actual	Expected	Difference
	Mean glucose levels in mg.%					
Giant metropolitan areas	115.7	116.3	-0.6	125.0	127.1	-2.1
Other very large metropolitan areas	113.6	115.4	-1.8	127.0	126.0	1.0
Other standard metropolitan statistical areas	116.2	114.8	1.4	123.4	125.9	-2.5
Other urban areas	117.0	115.1	1.9	128.1	124.9	3.2
Rural areas	115.4	116.7	-1.3	129.6	127.5	2.1

NOTE: Expected values explained in Appendix III.

Table 7. Actual and expected mean glucose levels in men and women, by urban-rural residence: United States, 1960-62

Urban-rural residence	Men			Women		
	Actual	Expected	Difference	Actual	Expected	Difference
	Mean glucose levels in mg.%					
Urban	115.5	115.6	-0.1	125.5	126.8	-1.3
Rural	116.1	115.8	0.3	128.4	125.4	3.0

NOTE: Expected values explained in Appendix III.

Table 8. Actual and expected mean glucose levels in men and women, by family income: United States, 1960-62

Family income	Men			Women		
	Actual	Expected	Difference	Actual	Expected	Difference
	Mean glucose levels in mg.%					
Under $2,000	128.5	123.9	4.6	138.0	135.1	2.9
$2,000-$3,999	119.1	117.3	1.8	127.8	127.0	0.8
$4,000-$6,999	111.2	112.7	-1.5	121.5	121.7	-0.2
$7,000-$9,999	110.9	112.6	-1.7	120.1	122.9	-2.8
$10,000 and over	113.1	116.0	-2.9	121.7	125.4	-3.7
Unknown	119.4	116.1	3.3	133.4	130.3	3.1

NOTE: Expected values explained in Appendix III.

Table 9. Actual and expected mean glucose levels in men and women, by education: United States, 1960-62

Education	Men			Women		
	Actual	Expected	Difference	Actual	Expected	Difference
	Mean glucose levels in mg.%					
Under 5 years	128.7	126.2	2.5	148.2	139.4	8.8
5-8 years	123.9	122.9	1.0	138.7	135.0	3.7
9-12 years	109.8	111.3	-1.5	118.9	121.3	-2.4
13 years and over	112.6	111.8	0.8	122.6	122.8	-0.2
Unknown	127.1	125.4	1.7	141.4	146.7	-5.3

NOTE: Expected values explained in Appendix III.

Table 10. Actual and expected prevalence of diagnosed diabetes[1] in men and women, by family income: United States, 1960-62

Family income	Men			Women		
	Actual	Expected	Difference	Actual	Expected	Difference
	Rate per 100 adults					
Under $2,000	1.7	2.0	-0.3	3.0	3.1	-0.1
$2,000-$3,999	1.2	1.5	-0.3	2.8	2.3	0.5
$4,000-$6,999	1.4	1.2	0.2	1.6	1.7	-0.1
$7,000-$9,999	2.1	1.1	1.0	2.4	1.8	0.6
$10,000 and over	0.3	1.4	-1.1	1.9	2.0	-0.1
Unknown	1.6	1.5	0.1	1.5	2.5	-1.0

[1]Persons with diagnosed diabetes are those who reported the use of insulin or an oral hypoglycemic agent or, if not on medication, reported previous diagnosis by a physician and had blood glucose levels 138 mg.% or above without challenge or 148 mg.% or above with challenge.

NOTE: Expected values explained in Appendix III.

Table 11. Mean glucose levels, by sex, race, family income, and education: United States, 1960-62

Family income and education	Men		Women	
	White[1]	Negro	White[1]	Negro
	Mean glucose levels in mg.%			
Family income				
Under $2,000	127.8	123.0	133.4	129.3
$2,000-$3,999	116.4	115.2	121.1	123.0
$4,000-$6,999	109.4	121.1	119.4	127.0
Education				
Under 5 years	132.6	125.0	153.5	146.5
5-8 years	118.0	124.1	133.5	130.5
9-12 years	105.9	109.7	112.1	115.1

[1]Adjusted to the age distribution of Negro men or women in the same income or educational group.
NOTE: Adjusted values explained in Appendix III.

Table 12. Actual and expected mean glucose levels in men and women, by marital status: United States, 1960-62

Marital status	Men			Women		
	Actual	Expected	Difference	Actual	Expected	Difference
	Mean glucose levels in mg.%					
Married	116.2	116.9	-0.7	124.3	124.2	0.1
Widowed	140.2	137.7	2.5	154.5	151.1	3.4
Divorced	113.1	120.8	-7.7	126.1	128.1	-2.0
Separated	135.8	118.1	17.7	118.7	121.5	-2.8
Never married	106.7	104.2	2.5	111.5	114.4	-2.9

NOTE: Expected values explained in Appendix III.

Table 13. Actual and expected mean glucose levels in men and women, by usual activity status: United States, 1960-62

Usual activity status	Men			Women		
	Actual	Expected	Difference	Actual	Expected	Difference
	Mean glucose levels in mg.%					
Usually working	113.7	113.6	0.1	120.6	124.1	-3.5
Keeping house	*	*	*	129.9	128.1	1.8
Retired	143.2	141.6	1.6	*	*	*
Other	105.3	107.9	-2.6	110.1	111.5	-1.4

NOTE: Expected values explained in Appendix III.

Table 14. Actual and expected mean glucose levels in men and women, by occupation: United States, 1960-62

Occupation	Men			Women		
	Actual	Expected	Difference	Actual	Expected	Difference
	Mean glucose levels in mg.%					
Professional, technical, and managerial	115.6	114.1	1.5	117.7	120.8	-3.1
Farmers and farm managers	123.7	121.1	2.6	*	*	*
Clerical and sales workers	112.2	112.5	-0.3	117.3	117.1	0.2
Craftsmen, foremen, and kindred workers	112.9	113.1	-0.2	*	*	*
Operatives and kindred workers	109.6	109.7	-0.1	120.7	120.4	0.3
Private household and service workers	107.1	114.4	-7.3	124.1	122.3	1.8
Farm and other laborers (except mine)	112.5	111.4	1.1	*	*	*

NOTE: Expected values explained in Appendix III.

Table 15. Actual and expected mean glucose levels in men and women, by industry: United States, 1960-62

Industry	Men			Women		
	Actual	Expected	Difference	Actual	Expected	Difference
	Mean glucose levels in mg.%					
Agriculture, forestry, and fisheries	121.5	117.0	4.5	126.8	119.4	7.4
Mining and construction	109.2	113.4	-4.2	*	*	*
Manufacturing	112.2	112.2	0.0	117.4	118.5	-1.1
Transportation, communications, and public utilities	111.6	112.1	-0.5	*	*	*
Wholesale and retail trade	113.2	112.1	1.1	118.0	120.7	-2.7
Finance, insurance, and real estate	112.2	112.6	-0.4	120.7	118.4	2.3
Service and miscellaneous	115.6	113.6	2.0	121.1	120.8	0.3
Government	108.1	111.8	-3.7	*	*	*

NOTE: Expected values explained in Appendix III.

APPENDIX I

ITEMS ON THE MEDICAL HISTORY RELATING TO GLUCOSE TOLERANCE

1. a. Do you have any reason to think that you may have diabetes, sometimes called sugar diabetes or sugar disease? (IF YES or ?) YES NO ?

b. Did a doctor tell you that you had diabetes? YES NO

c. How long ago did you start having it?

1 year | 1-5 years | over 5 years

d. Do you take insulin? YES NO

e. (IF TAKE INSULIN:) How many units a day? _____

f. Do you take any medicine by mouth for diabetes? YES NO

g. Do you know the name of the medicine?
(Name) _____

h. When did you last visit your doctor for diabetes?
(date) _____

i. When is your next appointment to visit your doctor for your diabetes?
(date) _____ ☐ No appointment

2. a. When did you have your last meal? Time _____ AM TODAY / PM YESTERDAY

	YES	NO
b. Did you have meat or fish	☐	☐
c. Eggs or cheese	☐	☐
d. Bread, cereal, potatoes	☐	☐
e. Cake, pie, sweet rolls, ice cream	☐	☐

	YES	NO
3. a. Have you had anything to eat or drink since that meal?	☐	☐
(IF YES) What was it? b. Coffee?	☐	☐
With cream?	☐	☐
With sugar?	☐	☐
c. Other (Specify)	☐	☐

_____

7. a. Have you ever had any children of your own (not including adopted children)? YES NO
(IF YES)
b. Did any of your children weigh more than 10 lbs at birth? YES NO ?

69. Have you had any recent increase in being thirsty (drink a lot of water)? YES NO ?

70. Have you had any recent increase in urination (pass a lot of water)? YES NO ?

71. a. Have you lost any weight recently (without trying to)? YES NO ?

IF YES:

b. How much weight have you lost?_____lbs.

c. Over what period of time have you lost this weight?_____

72. a. Has any of your relatives ever had diabetes? YES NO ?

IF YES:

b. Please give relationship of this person or these persons to you:_____

APPENDIX II

DEMOGRAPHIC TERMS

Age.—The age recorded for each person is the age at last birthday. Age is recorded in single years.

Race.—Race is recorded as "white," "Negro," or "other." "Other" includes American Indian, Chinese, Japanese, and so forth. Mexican persons are included with "white" unless definitely known to be Indian or of another nonwhite race.

Population size.—The five classes comprising this characteristic were derived from the design of the sample, which accomplished a stratification of the primary sampling units by population size in each of three broad geographic locations. Because the survey was started in 1960, the primary sampling units within each of the five population-size classes were necessarily based on populations and definitions of the 1950 census. The name of each selected primary sampling unit within each population-size class and geographic location, along with other selected sample data, is presented in an earlier report.[2]

The definitions for each of the five population-size classes are as follows:

Giant metropolitan areas.—This class includes primary sampling units defined in the census as standard metropolitan statistical areas (SMSA's) having a population of 3,000,000 persons or more.

Other very large metropolitan areas.—Included in this class are standard metropolitan statistical areas with a population of 500,000 to 3,000,000 as defined by the 1950 census.

Other standard metropolitan statistical areas.—This class includes other SMSA's.

Other urban areas.—This includes primary sampling units which are highly urban in composition but are not defined as SMSA's.

Rural areas.—This includes primary sampling units which are primarily rural in composition according to census definitions.

Region.—For the purpose of classifying the population area, the United States was divided into three major regions. This division was especially made for the design of the HES sample. The regions and the States included are as follows:

Region	*States Included*
Northeast	Maine, Vermont, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Ohio, and Michigan
South	Delaware, Maryland, District of Columbia, West Virginia, Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, and Texas
West	Washington, Oregon, California, Idaho, Nevada, Montana, Utah, Arizona, Wyoming, Colorado, New Mexico, North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, Illinois, and Indiana

Urban and rural.—For the first six primary sampling units where examinations were conducted, the definition of urban and rural is the same as that used in the 1950 census. These locations are Philadelphia, Pa., Valdosta, Ga., Akron, Ohio, Muskegon, Mich., Chicago, Ill., and Butler, Mo. For the remainder of the sampling units the 1960 census definitions are used.

The change from 1950 to 1960 definitions is of small consequence in the survey, since only six locations are affected. The major difference is the designation in 1960 of urban towns in New England and of urban townships in New Jersey and Pennsylvania.

According to the 1960 definition, the urban population comprises all persons living in (a) places of 2,500 inhabitants or more incorporated as cities, boroughs, villages, and towns (except towns in New England, New York, and Wisconsin); (b) the densely settled urban fringe, whether incorporated or unincorporated, of urbanized areas; (c) towns in New England and townships in New Jersey and Pennsylvania which contain no incorporated municipalities as subdivisions and have either 25,000 inhabitants or more or a population of 2,500-25,000 and a density of 1,500 persons or more

per square mile; (d) counties in States other than the New England States, New Jersey, and Pennsylvania that have no incorporated municipalities within their boundaries and have a density of 1,500 persons or more per square mile; and (e) unincorporated places of 2,500 inhabitants or more not included in any urban fringe. The remaining population is classified as rural.

Place description.—In this survey the urban population is classified as living "in the central city" or "outside the central city" of an SMSA. The remaining urban population is classified as "not in SMSA."

The definitions and titles of standard metropolitan statistical areas are established by the U.S. Bureau of the Budget with the advice of the Federal Committee on Standard Metropolitan Statistical Areas.

The definition of an individual standard metropolitan statistical area involves two considerations: first, a city or cities of specified population to constitute the central city and to identify the county in which it is located as the central county; and, second, economic and social relationships with contiguous counties which are metropolitan in character so that the periphery of the specific metropolitan area may be determined.

Persons "in the central city" of an SMSA are therefore defined as those whose residency is in the city appearing in the stand and metropolitan statistical area title. Persons residing in an SMSA but not in the city appearing in the SMSA title are considered to be residing "outside the central city."

The remaining population is allocated into rural-farm and rural-nonfarm groups. The farm population includes all persons living in rural territory on places of 10 acres or more from which sales of farm products amounted to $50 or more during the previous 12 months or on places of less than 10 acres from which sales of farm products amounted to $250 or more during the preceding 12 months. Other persons living in rural territory are classified as nonfarm. Persons are also classified as nonfarm if their household paid rent for the house but their rent did not include any land used for farming.

Employment status.—This term applies to the employment status of persons during the 2-week period prior to the week of interview. It is not intended that this term define the labor force or provide estimates of the employed or unemployed population at the time of the survey.

Persons who report that they either worked at or had a job or business at any time during the 2-week period prior to the week of interview are considered employed. This includes paid work as an employee of someone else, self-employment in business, farming, or professional practice, and unpaid work in a family business or farm. Persons on layoff from a job and those absent from their job or business because of temporary illness, vacation, strike, or bad weather are considered employed if they expect to work as soon as the particular event causing their absence no longer exists. Free-lance workers are considered as currently employed if they have a definite arrangement with one or more employers to work for pay according to a weekly or monthly schedule either full time or part time. Excluded are such persons who have no definite employment schedule but work only when their services are needed. Also excluded are (1) persons receiving revenue from an enterprise in whose operation they do not participate, (2) persons doing housework or charity work for which they receive no pay, and (3) seasonal workers during the portion of the year they are not working. (It should be noted that these data were not collected for Philadelphia.)

Occupation.—A person's occupation may be defined as his principal job or business. For the purposes of this survey the principal job or business of a respondent is defined in one of the following ways. If the person worked during the 2-week-reference period of the interview or had a job or business, the question concerning his occupation (or what kind of work he was doing) applies to his job during that period. If the respondent held more than one job, the question is directed to the one at which he spent the most time. When equal time is spent at each job, the question refers to the one he considers most important. A person who has not begun work at a new job, is looking for work, or is on layoff from work is questioned about his last full-time civilian job. A full-time job is defined as one at which the person spent 35 hours or more per week and which lasted 2 consecutive weeks or more. A person who has a job to which he has not yet reported and has never had a previous job or business is classified as a "new worker."

The occupational groups are shown below with the appropriate census code categories.

Occupational title	*Census code*
Professional, technical, and managerial	R, 000-195, 250-285
Farmers and farm managers	N, 222
Clerical and sales workers	S, Y, Z, 301-395
Craftsmen, foremen, and kindred workers	Q, 401-545
Operatives and kindred workers	T, W, 601-721
Private household and service workers	P, 801-803, 810-890
Farm and other laborers (except mine)	U, V, X, 901, 905, 960-973
Unknown (including new workers)	995 and all other codes

(U.S. Bureau of the Census, 1960 Census of Population, Classified Index of Occupation and Industries, U.S. Government Printing Office, Washington, D.C., 1960.) This information was not collected for Philadelphia and Valdosta.

Industry.—The industry in which a person was reportedly working is classified by the major activity of the establishment in which he worked.

The only exceptions to the above are those few establishments classified according to the major activity of the parent organization, and they are as follows: laboratories, warehouses, repair shops, and places for storage.

The industry groupings are shown below. (Data on industries were not collected for Valdosta and Philadelphia.) The census code (the Classified Index of Occupation and Industries) and the Standard Industrial Classification (SIC) code components are also listed.

Industry title	*Census code*	*SIC code*
Agriculture, forestry, and fisheries	A, 017, 018	C1, 02, 07 (excludes 0713), 08, 09
Mining and construction	C, 126-156	10-14, 15-17
Manufacturing	B, M, 206-459	19-39, 0713
Transportation, communication, and other public utilities	L, 507-579	40-49
Wholesale and retail trade	D, F, G, 606-696	50, 52-59
Finance, insurance, and real estate	706-736	60-67
Service and miscellaneous	E, H, K, 806-898	70, 72, 73, 75, 76, 78, 82, 84, 86, 88, 89
Government	J, 906-936	91-94
Unknown (including new workers)	999	99

The industry "government" differs somewhat from the usual industrial classification of government, since it is limited to the postal service and to Federal, State, and local public administrations. This category includes only uniquely governmental functions and excludes those activities which may also be carried out by private enterprise. For example, teachers in public educational facilities and nurses engaged in medical services of governmental agencies are included with the "service and miscellaneous" group.

Usual activity status.—All persons are classified according to their usual activity status during the 12-month period prior to the week of interview. The usual activity status, in case more than one is reported, is the one at which the person spent the most time during the 12-month period.

The categories of usual activity status used are *usually working, usually keeping house, retired,* and *other.* For several reasons these categories are not comparable with somewhat similarly named categories in official Federal labor force statistics. First, the responses concerning usual activity status are accepted without detailed questioning, since the objective of the question is not to estimate the numbers of persons in labor force categories but to identify crudely certain population groups which may have differing health problems. Second, the figures represent the usual activity status over the period of an entire year, whereas official labor force statistics relate to a much shorter period, usually 1 week. Finally, in the definitions of specific categories which follow, certain marginal groups are classified differently to simplify procedures.

Usually working includes persons who are paid employees; self-employed in their own business, profession, or in farming; or unpaid employees in a family business or farm. Work around the house or volunteer or unpaid work, such as for a church, is not counted as working.

Usually keeping house includes women whose major activity is described as "keeping house" and who cannot be classified as "working."

Retired includes persons 45 years of age and over who consider themselves retired. In case of doubt a person 45 years of age and over is counted as retired if he or she has either voluntarily or involuntarily stopped working, is not looking for work, and is not described as "keeping house." A retired person may or may not be unable to work.

Other in this report includes men not classified as "working" or "retired" and women not classified as "working," "keeping house," or "retired." Persons who are going to school are included in this group.

Education.—Each person is classified by education in terms of the highest grade of school completed. Only grades completed in regular schools, where persons are given a formal education, are included. A "regular" school is one which advances a person toward an elementary or high school diploma or a college, university, or professional school degree. Thus, education in vocational, trade, or business schools outside the regular school system is not counted in determining the highest grade of school completed.

Income of family or unrelated individuals.—Each member of a family is classified according to the total income of the family of which he is a member. Within the household all persons related to each other by

blood, marriage, or adoption constitute a family. Unrelated individuals are classified according to their own income.

The income recorded is the total of all income received by members of the family in the 12-month period preceding the week of interview. Income from all sources is included, e.g., wages, salaries, rents from properties, pensions, and help from relatives.

Marital status.—The categories of marital status are *married, widowed, divorced, separated,* and *never married.* Persons with common-law marriages are considered to be married. *Separated* refers to married persons who have a legal separation, those living apart with intentions of obtaining a divorce, and other persons permanently or temporarily estranged from their spouse because of marital discord.

APPENDIX III

STATISTICAL NOTES

The Survey Design

The first cycle of the Health Examination Survey employed a highly stratified multistage probability design in which a sample of the civilian, noninstitutional population of the conterminous United States 18-79 years of age was selected. At the first stage, a sample of 42 primary sampling units (PSU's) was drawn from among the 1,900 geographic units into which the United States was divided. Random selection was controlled within regional and size-of-urban-place strata into which the units were classified. As used here a PSU is a standard metropolitan statistical area of one to three contiguous counties. Later stages result in the random selection of clusters of typically about four persons from a neighborhood within the PSU. The total sample included some 7,700 persons in 29 different States. The detailed structure of the design and the conduct of the Survey have been described in previous reports.[1,2]

Reliability

The methodological strength of the Survey derives especially from its use of scientific probability sampling techniques and highly standardized and closely controlled measurement processes. This does not imply that statistics from the Survey are exact or without error. Data from the Survey are imperfect for three major reasons: (1) results are subject to sampling error (2) the actual conduct of a survey never agrees perfectly with the design, and (3) the measurement processes themselves are inexact even though standardized and controlled.

The first-stage evaluation of the Survey was reported in reference 2, which dealt principally with an analysis of the faithfulness with which the sampling design was carried out. This study notes that out of the 7,700 sample persons the 6,670 who were examined—a response rate of over 86 percent—gave evidence that they were a highly representative sample of the civilian, noninstitutional population of the United States. Imputation of nonrespondents was accomplished by attributing to nonexamined persons the characteristics of comparable examined persons as described in reference 2. The specific procedure used amounted to inflating the sampling weight for each examined person in order to compensate for sample persons at that stand of the same age-sex group who were not examined.

There were 6,672 persons who came in for examination. Of these, 108 did not receive the glucose drink, 64 were not given the glucose test, and 60 did not have a glucose level recorded. Thus a total of 6,440 received a glucose level. The distribution of these persons by age and sex is given in table I.

Sampling and Measurement Error

In the present report, reference has been made to efforts to minimize bias and variability of the measurement techniques.

The probability design of the Survey makes possible the calculation of sampling errors. Traditionally the role of the sampling error has been the determination of how imprecise the survey results may be because they come from a sample rather than from the measurement of all elements in the universe.

The estimation of sampling errors for a study of the type of the Health Examination Survey is difficult for at least three reasons: (1) measurement error and "pure" sampling error are confounded in the data—it is not easy to find a procedure which will either completely include both or treat one or the other separately, (2) the survey design and estimation procedure are complex and, accordingly, require computationally involved techniques for the calculation of variances, and (3) from the survey are coming thousands of statistics, many for subclasses of the population for which there are a small number of sample cases. Estimates of sampling error are obtained from the sample data and are themselves subject to sampling error when the number of cases in a cell is small or, even occasionally, when the number of cases is substantial.

Estimates of approximate sampling variability for selected statistics used in this report are presented in tables II and III. These estimates have been prepared by a replication technique which yields overall variability through observation of variability among random subsamples of the total sample. The method reflects both "pure" sampling variance and a part of the measurement variance.

Table I. Number of persons examined and number on whom glucose levels after challenge are available: Health Examination Survey, 1960-62

Age	Number examined		Number with glucose levels	
	Men	Women	Men	Women
Total, 18-79 years	3,091	3,581	3,008	3,432
18-24 years	411	534	400	515
25-34 years	675	746	665	725
35-44 years	703	784	687	766
45-54 years	547	705	534	671
55-64 years	418	443	401	413
65-74 years	265	299	252	278
75-79 years	72	70	69	64

Table II. Standard errors in mean blood glucose levels after challenge, by age and sex: United States, 1960-62

Age	Men	Women
Total, 18-79 years	0.82	0.89
18-24 years	1.77	1.80
25-34 years	1.61	1.59
35-44 years	1.63	1.66
45-54 years	1.87	1.88
55-64 years	2.25	2.30
65-74 years	3.43	2.90
75-79 years	5.98	8.48

In accordance with usual practice, the interval estimate for any statistic may be considered the range within one standard error of the tabulated statistic, with 68 percent confidence; or the range within two standard errors of the tabulated statistic, with 95 percent confidence.

Expected Values

In tables 2-10 and 12-15 the actual prevalence rates for the various demographic variables are compared with the expected. The computation of the expected values was done as follows:

Suppose that in a subgroup the Health Examination Survey estimates that there are N_i persons in the i^{th} age-sex group ($i = 1 - 14$, sum of $N_i = N$).

Suppose the Health Examination Survey estimates that the mean blood glucose level for the United States in the i^{th} age-sex group is X_i. Then the expected mean blood glucose level subgroup is

$$\frac{1}{N} \sum N_i \bar{X}_i$$

Comparison of an actual value for, say, a region with the expected value for that region is undertaken on the assumption that a meaningful statement can be made which holds in some average way for all persons in the region. This may or may not be true. The specified region may have higher values for younger persons and lower values for older persons than are found in other regions.

In that case, an average comparison will obliterate one or both of these differentials. A similar remark may be made with respect to values computed for all races together, since relationships found in one race may not be found in another. In arriving at the general conclusions expressed in the text, an effort was made to consider all the specific data, including data not to be presented in this report; but it must be recognized that balancing such evidence is a qualitative exercise rather than a quantitative one. The standard error of the difference between an actual and expected value may be approximated by the standard error of the actual value (table III).

Table III. Standard errors in mean blood glucose levels after challenge in adults, by sex and selected characteristics: United States, 1960-62

Characteristic	Men	Women
Region		
Northeast	1.38	1.41
South	2.77	2.05
West	1.38	1.38
Population-size group		
Giant metropolitan areas	2.16	1.98
Other very large metropolitan areas	3.78	3.36
Other standard metropolitan statistical areas	2.01	2.03
Other urban areas	3.09	3.14
Rural areas	3.36	1.59
Place description		
SMSA-in central city	1.72	1.81
SMSA-outside central city	1.74	1.67
Urban, not SMSA	3.08	2.68
Rural farm	2.93	4.80
Rural nonfarm	2.85	2.58
Residence		
Urban	0.24	0.38
Rural	1.47	1.90
Usual activity status		
Usually working	0.95	1.70
Keeping house	*	1.23
Retired	2.86	*
Other	2.44	4.52
Industrial		
Agriculture, forestry, and fisheries	2.98	5.67
Mining and construction	2.54	*
Manufacturing	1.18	2.87
Transportation, communications, and other public utilities	2.84	*
Wholesale and retail trade	2.23	2.69
Finance, insurance, and real estate	4.79	4.75
Service and miscellaneous	2.58	2.20
Government	2.86	*
Occupation		
Professional, technical, and managerial	0.82	2.35
Farmers and farm managers	3.71	*
Clerical and sales workers	2.41	1.66
Craftsmen, foremen, and kindred workers	1.71	*
Operatives and kindred workers	1.70	2.70
Private household and service workers	2.85	2.32
Farm and other laborers (except mine)	2.30	*

Table III. Standard errors in mean blood glucose levels after challenge in adults, by sex and selected characteristics: United States, 1960-62—Con.

Characteristic	Men	Women
Education		
Under 5 years	4.07	4.64
5-8 years	2.11	1.91
9-12 years	1.34	0.84
13 years and over	1.95	2.12
Unknown	5.47	9.76
Family income		
Under $2,000	3.33	1.38
$2,000-$3,999	1.77	1.81
$4,000-$6,999	1.36	1.72
$7,000-$9,999	1.72	1.70
$10,000 and over	1.79	2.75
Unknown	3.29	3.13
Marital status		
Married	0.82	1.04
Widowed	4.50	3.35
Divorced	5.03	3.19
Separated	7.95	5.24
Never married	2.02	2.62

Adjusted Values

In table 11, the mean glucose levels for white persons in a specified income or educational group were adjusted to the age distributions of the Negroes in the same group. The adjusted mean glucose level for white persons in the k^{th} sex-income or educational group X_k was computed as follows:

Let x_{ik} be the estimated mean glucose level for white persons in the sex-income group k who are in the i^{th} age group.

Let n_{ik} be the number of Negro persons in that group.

Then $\hat{x}_k = \sum \frac{x_{ik} n_{ik}}{n_k}$ where $\sum_i n_{ik} = n_k$.

Small Numbers

In some tables 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. Obviously in such instances the statistic has no meaning in itself except to indicate that the true quantity is small. Such numbers, if shown, have been included to convey an impression of the overall story of the table.

Tests of Significance

Tests of significance for the demographic variables were performed in two ways. The first was to divide the difference between the actual and expected values by the standard error of the actual value. For example, for working women the actual value was 3.5 percent lower than the expected and the standard error was 1.1 percent. Since the difference was more than three times its standard error, it may be deemed statistically significant.

The second method was to examine the age-specific differences (not published) between the prevalence for the specified group and the prevalence for all persons. Thus for men with annual incomes of less than $2,000, the mean glucose level for 6 out of every 7 age groups was higher than the overall level for these age groups. The probability of such an occurrence is 0.06, and the difference is considered statistically significant. In this instance the difference between the actual and expected values (which is really a weighted average of the age-specific differences) is 1.39 times its standard error which (using tables of the normal distribution) was a probability of 0.16 and is not statistically significant.

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