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VITAL and HEALTH STATISTICS

DATA FROM THE NATIONAL HEALTH SURVEY

Glucose Tolerance of Adults

United States - 1960 - 1962

Diabetes prevalence and results of a glucose tolerance test, by age and sex.

Washington, D.C. May 1964

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
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GLUCOSE TOLERANCE
OF ADULTS

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INTRODUCTION

The National Health Survey uses three methods for obtaining information about the health of the U.S. population. The first is a household interview in which persons are asked to give information relating to their health or to the health of other household members. The second is the collection of available health records. The third is direct examination. The Health Examination Survey was organized to use the third procedure, drawing samples of the population of the United States and, by medical examination and with various tests and measurements, undertaking to characterize the population under study.

The initial enterprise of the Health Examination Survey (HES) was the examination of a sample of adults. Its purpose was to obtain information on the prevalence of certain chronic diseases, on dental health, and on the distribution of a number of anthropometric and sensory characteristics. A nationwide probability sample of 7,710 persons aged 18-79 years was drawn. Altogether, 6,672 persons were examined during the course of the Survey which was begun in October 1959 and completed in December 1962. Sample persons received a standard examination, lasting about 2 hours, performed by medical and other staff members of the Survey in specially designed mobile clinics.

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 general plan has already been described;[1] a number of previous publications have dealt with specific methodological investigations of the Survey.

This report deals with glucose tolerance findings. It describes the pertinent parts of the examination, specifies the techniques used, and compares the information obtained in this Survey with that obtained in other surveys. The relationship of findings on glucose tolerance with other findings of the examination or with demographic variables other than age and sex are not dealt with in this report.

Estimates are given for the prevalence of clinically defined diabetes. Two other measures of the tolerance of an oral glucose challenge are also considered—the presence or absence of glucose in the urine and the blood glucose level—and estimates of the prevalence of blood and urine glucose findings are given. The estimating procedures were discussed in a previous report, which dealt also with problems of nonresponse and the probable influence of nonresponse on the Survey results.[2] Response to glucose challenge varies by age and sex and these data are presented and discussed.

Special acknowledgment must be given to Dr. Hugh L. C. Wilkerson for assistance in planning the glucose tolerance test used in the Health Examination Survey and for arranging to have the blood glucose determinations made at the laboratory of the Field Research Unit, Diabetes and Arthritis Branch, Division of Chronic Diseases,

Bureau of State Services, Public Health Service; and to his successor, Dr. John B. O'Sullivan, who, in addition to continuing the arrangements for the laboratory work, also extended his good counsel to the Survey.

THE MEDICAL HISTORY

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. . .?" and if the answer was "Yes" or the examinee uncertain, the interviewer asked a series of related 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 for it, and whether any specific hypoglycemic agent was used in treatment (Appendix I).

The last question asked by the interviewer was whether the examinee had ever had a child who weighed more than 10 pounds at birth, an event which is thought to be related to diabetes. Then the examinee was given a medical history form to complete. Included among the 74 questions in this section were several relating to diabetes—increased thirst, increased urination, recent weight loss, and relatives with diabetes (Appendix I).

DESCRIPTION OF THE GLUCOSE TOLERANCE TEST

Unless there was a clear history of diabetes under medical care, the examinee was offered a drink of 50 grams of glucose with lemon flavoring ("Dextol") which was diluted in 250 cc. of water. An hour after the glucose drink was given, a blood specimen was obtained by venipuncture. A urine specimen was collected about 30 minutes after the venipuncture. The blood specimen was shipped to the laboratory of the Diabetes Field Research Unit in Boston, where determinations of blood glucose concentrations were made, using the Somogyi-Nelson method.[3] The presence of glucose in the urine was evaluated in the mobile clinic itself on a semiquantitative test scale (Testape).

DIABETES ON MEDICAL HISTORY

A history of diabetes was considered definitely diagnostic if the examinee reported the use of insulin or an oral hypoglycemic agent. If the disease was reported to have been diagnosed by a physician but the person was not on medication, the case was accepted as definite known diabetes, unless the blood glucose level was below 138 mg.% without challenge or 148 mg.% with challenge. In most instances the levels were substantially higher (Appendix II). Most of the diabetes reported in the medical history met the tests for definite known diabetes. If a person reported diabetes which did not satisfy the criteria for a definite diagnosis but had seen a physician for the disease within the last 6 months and had a followup medical appointment scheduled within the next 6 months, he was considered a questionable case. Otherwise no diabetes was diagnosed. Less than 9 percent of the examinees reporting diabetes failed to meet the criteria for a definite or questionable diagnosis.

The prevalence of definite known diabetes in adults (18-79 years) was 1.8 percent (table A), or approximately 2 million persons. A history of diabetes was rarely reported under 45 years of age but was more common at older ages. Although the specific rates reported for each age group

Table A. Number of adults with definite known diabetes per 100 persons, by age and sex: United States, 1960-62

Age	Both sexes	Men	Women
	Number of diabetics per 100 persons		
Total-18-79 years-------	1.8	1.3	2.1
18-24 years------	0.3	0.2	0.5
25-34 years------	0.4	0.2	0.6
35-44 years------	0.9	1.1	0.8
45-54 years------	2.0	1.1	2.9
55-64 years------	3.3	3.3	3.2
65-74 years------	4.8	3.2	6.1
75-79 years------	4.7	2.7	6.7

have a high sampling variability, there is clearly a gradient by age. There is also a sex differential, with more women than men reporting diabetes. While the data are insufficient for delineating the sex differential with great precision, they are not inconsistent with a slight excess of diabetes in women at younger ages and a larger excess at older ages.

THE GLUCOSE TOLERANCE TEST—TECHNIQUES

As already noted, a glucose challenge was given each examinee without regard to the time or content of the previous meal, and 1 hour later a venous blood specimen was taken. This procedure, while differing in many respects from a standard clinical test for glucose tolerance, has been shown to provide a satisfactory equivalent (Appendix III).[4] In any event, the standard test was clearly impractical for use in the Health Examination Survey and some reasonable alternative had to be devised.

A blood specimen of 3 ml. was collected in prelabeled B-D "vacutainers" containing 30 mg. of sodium fluoride. Specimens were promptly refrigerated and twice a week the accumulated specimens were shipped on water ice to the Diabetes Field Research Unit in Brighton, Massachusetts for determination of glucose concentration by the Somogyi-Nelson method.

A considerable effort went into attempts to control and measure the technical variability of blood glucose determination during the Survey. This is a much more difficult enterprise than is generally realized, but worth the effort, since the most carefully designed survey can easily be degraded by careless laboratory work. The Survey was especially fortunate in having an excellent laboratory available for blood glucose determinations.

All the standard controls were used in the laboratory work at Brighton, and as the study progressed additional controls were devised. Also several methods were used by the Survey staff to keep informed of what was happening. The first was a comparison of blood glucose levels for different places. While it is impossible to distinguish real place differences from laboratory fluctuations, any systematic change with time was regarded with suspicion. In one instance, a series of reporting errors was uncovered by this means and corrected.

Variations from stand to stand are shown in figure 1. Expected values are calculated for each stand allowing for differences in age-sex distributions but assuming that the levels reported at each age group for all stands combined are what should be expected at any individual stand. Both mean blood glucose levels and the prevalence of a trace or more of urine glucose vary, stand by stand, from expected values. The fact that these two measures tend to deviate in the same direction suggests that most of the observed stand variation reflects differences in the persons examined. When these two measures deviate in opposite directions, the discordance can be attributed partly to the fact that urine glucose and blood glucose levels are not exactly correlated and partly to technical variability. The fact that such discordances do not persist over a series of stands suggests that long-term technical variability is probably not an important factor in this Survey.

The second method consisted of drawing two blood specimens from the same person, sending the original to Brighton as a routine specimen and sending the duplicate to an independent laboratory. Again, this provides no absolute check, since good laboratories do differ and it is seldom possible to agree on which is "right," but gross deviations serve to alert a laboratory to possible unsuspected difficulties. The third method was to provide blind aliquots to the Brighton laboratory to determine the consistency of the work of the laboratory.

Some of the details from these comparisons are given in Appendix IV. The conclusions drawn from the various comparisons may be summarized briefly.

Laboratories and technicians in the same laboratory tend to operate at different levels. Thus, in a series of 272 comparisons undertaken in February and March 1961 the Brighton laboratory determinations averaged 7.8 mg.% higher than those from the comparison laboratory, and on comparisons made between June 1961 and May 1962 the Brighton laboratory averaged 0.3 mg.% lower than another laboratory on 103 specimens, although if one highly aberrant series were eliminated the Brighton laboratory would be 2.0 mg.%

higher. While each technician tended to be highly consistent in a single laboratory run, two technicians might on occasion differ in the level of their blood glucose determinations by as much as 7 mg.% despite the regular use of control specimens and standard techniques. So far as can be determined, this difference may arise in the handling of whole blood without appearing at all in determinations made on the usual aqueous or serum controls.

Changes within a laboratory over a period of time are exceedingly difficult to discover and control. During a study conducted between January and May 1962, it was concluded that the effective technical variation did not exceed 5 mg.% at the Brighton laboratory.[4] Included in this were variability in the work of individual technicians, among technicians, and between different laboratory runs over the entire time period. This is a remarkably low figure and no claim is made that it covers the entire span of the first cycle of the Health Examination Survey, although another series of comparisons for a longer period of time suggests that the long-term variability is not much greater.

Finally, 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.

These observations summarize the findings from the various quality checks made on blood glucose determinations. No similar checks were made of urine glucose determinations. When reasonable attention to instructions is given, the technique used in this Survey has been shown to be quite reliable.[5,6] The high correlation of urine

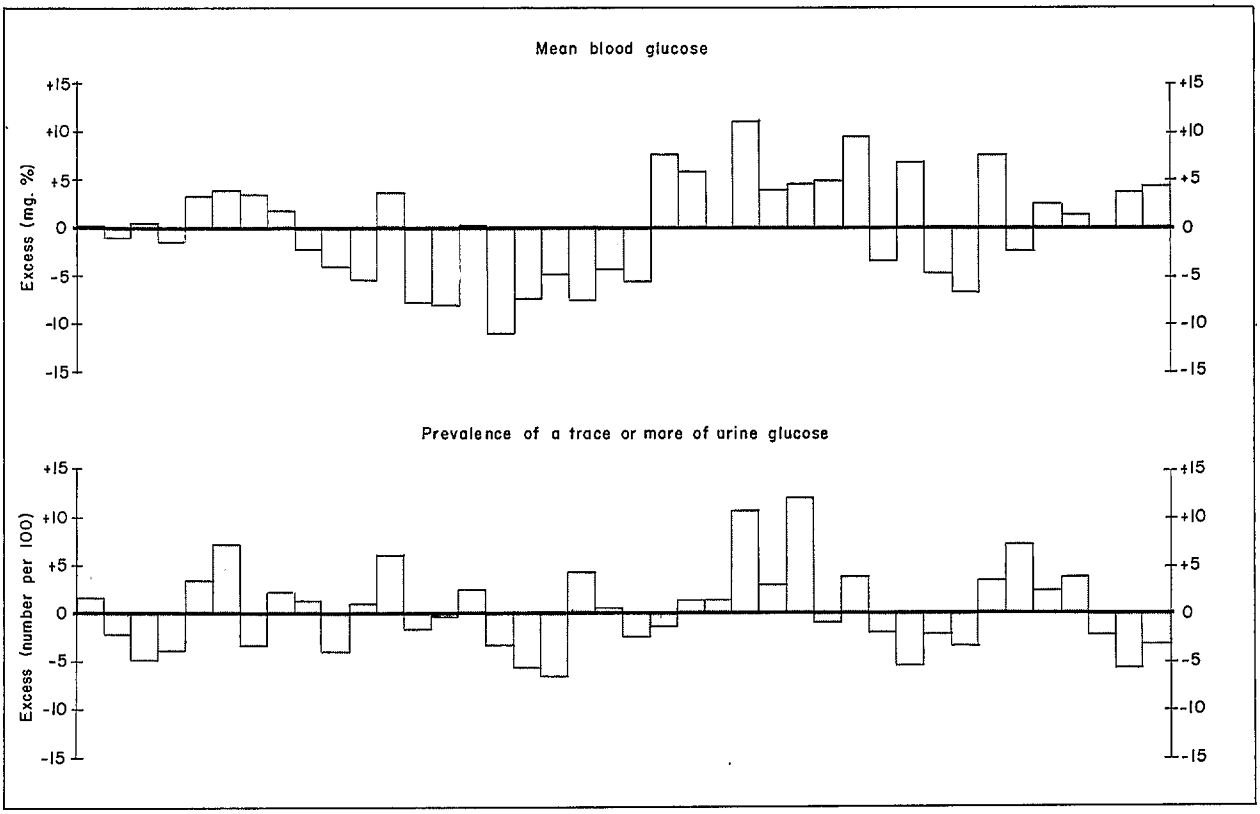

Figure 1. Excess of actual over expected levels of blood and urine glucose, by stand: Health Examination Survey, 1960-62.

Table B. Mean blood glucose levels after challenge in adults, by age and sex: United States, 1960-62

Age	Both sexes	Men	Women
	Mean blood glucose levels in mg.%		
Total-18-79 years-------	121.3	115.7	126.4
18-24 years------	99.7	94.6	104.1
25-34 years------	105.7	101.5	109.5
35-44 years------	116.5	115.2	117.6
45-54 years------	125.8	118.2	133.1
55-64 years------	137.8	130.1	145.2
65-74 years------	150.7	139.8	159.7
75-79 years------	166.3	154.4	178.7

Table C. Number of adults with urine glucose after challenge per 100 persons, by age and sex: United States, 1960-62

Age	Both sexes	Men	Women
	Number of adults with urine glucose per 100 persons		
Total-18-79 years-------	14.3	17.9	10.8
18-24 years------	8.7	11.4	6.3
25-34 years------	11.1	13.8	8.7
35-44 years------	15.3	20.0	10.9
45-54 years------	16.2	20.4	12.0
55-64 years------	14.8	17.3	12.4
65-74 years------	19.3	26.4	13.4
75-79 years------	23.1	21.8	24.4

NOTE: Urine glucose was considered present if a trace or more of glucose was found in the urine.

glucose determinations with blood glucose levels for the same persons, independently determined, tends to corroborate the precision of both measurements.

FINDINGS OF THE GLUCOSE TOLERANCE TEST

On the average, the blood glucose concentration after challenge was higher the older the examinee (table B, fig. 2). Overall, the level for women was about 10 mg.% higher than that for men, being somewhat less at younger ages and somewhat greater at older. The age gradient for either sex was quite steep. For men 18-24 years of age, the mean glucose level was 94.6 mg.%; for men 75-79 years, it was 154.4 mg.%. There was a similar age gradient for women.

The indicated shift in mean levels by age corresponds to a shift in the distribution curves, with the appearance of an increasing number of high glucose values at older ages (fig. 3). Excluding known diabetics, only 0.8 percent of men under 35 years of age had levels in excess of 200 mg.%, whereas 9.7 percent of men 65-79 years had values this high. For women, the comparable figures were 0.9 and 14.0 percent.

It should be noted that the levels reported are those obtained after challenge. Most diabetics,

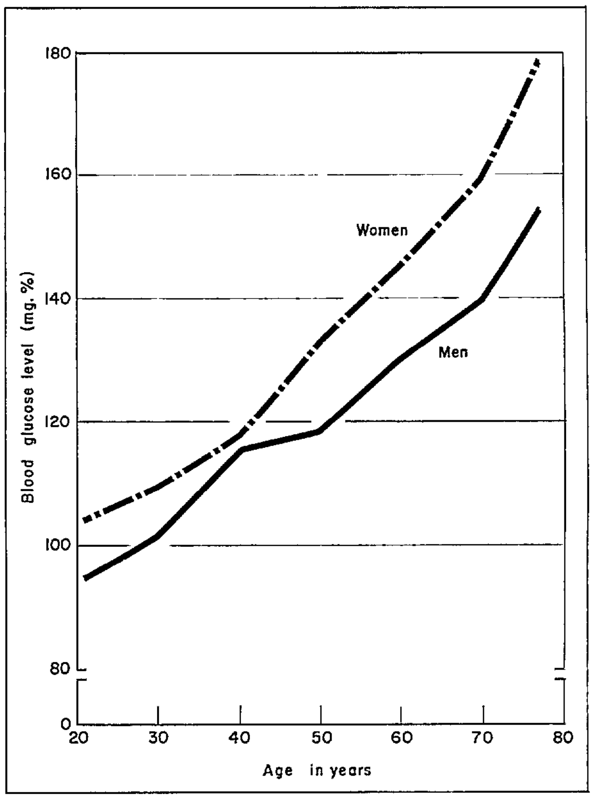

Figure 2. Mean blood glucose levels after challenge in adults, by age and sex: United States, 1960-62.

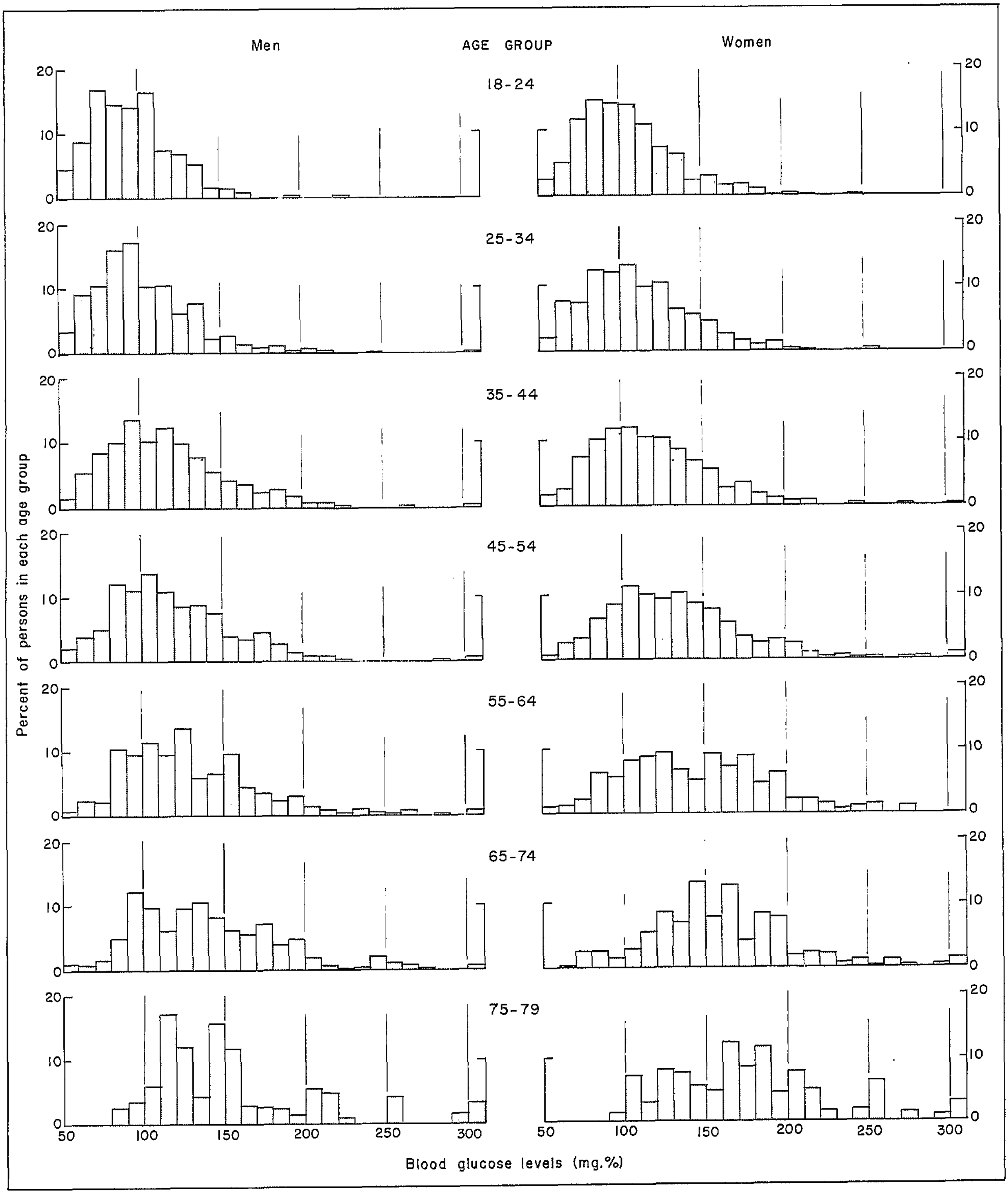

Figure 3. Percent distribution of blood glucose levels in adults, by age and sex: United States, 1960-62.

then, are not included in the population covered by tables B and C, since most diabetics were not given a glucose challenge. These diabetics would have blood glucose levels after challenge substantially higher than those for nondiabetics—100 mg.% higher is probably a conservative estimate—and practically all of the male diabetics and the majority of the female diabetics could be expected to have positive urine specimens after a glucose challenge. Therefore, if all diabetics had been given a glucose challenge, the values shown in tables B and C would have been slightly higher than those reported, especially in age groups over 45 years.

The prevalence of urine specimens with a trace or more of glucose, on the other hand, showed weaker differentials by age and sex (table C). While the proportion of urine specimens with a detectable amount of glucose increased with age, the increases were not comparable with the increased proportion of high blood glucose levels. There was roughly a twofold increase from ages 18-24 years to 65-79 years in the percentage of persons with a trace or more of glucose in their urine after a glucose challenge—from 11.4 to 25.4 percent for men, from 6.3 to 15.4 percent for women. This implies, of course, that the probability of "spilling" glucose at any given concentration of blood glucose decreases with age, and this is indeed what was found. (Defining glucose as present only if the urine concentration was 1 plus or greater would reduce overall prevalence some 30 percent but would not significantly alter the reported differentials by age and sex. A definition based on a concentration of 2 plus or more would lead to an overall prevalence of only 45 percent of that reported.)

It is interesting to note that women, despite higher blood glucose levels, were distinctly less likely to have glucose in their urine than were men. In fact, overall, only 10.8 percent of the women, as against 17.9 percent of the men, had a trace or more of glucose in their urine specimens. This sex differential, as might be expected, holds for all levels of blood glucose concentration. In particular, when the blood glucose concentration was 220 mg.% or more, 92.4 percent of the men, while only 64.1 percent of the women, showed evidence of urine glucose. There does not seem to be any precedent for this finding, although it is implicit in the reports of several other studies, and unpublished data from at least one study show an even larger sex differential.

COMPARATIVE DATA

While many medical surveys include tests for diabetes, to our knowledge there has been only one systematic canvass of a well-defined population group using techniques comparable with those of the Health Examination Survey.[7] Glucose tolerance data from this survey have not yet been published. There have been, of course, numerous screening programs for unrecognized diabetes and some of these have involved canvassing well-defined population groups; but it is exceedingly difficult to compare their results or to define a table of equivalents between their glucose tolerance findings and those from the Health Examination Survey.

A number of surveys, however, have measured the prevalence of known (diagnosed) diabetes in well-defined populations. A few examples are of interest for comparative purposes. By putting the reported statistics, so far as possible from the published data, on a population base comparable to that used in this Survey (the civilian, noninstitutional U.S. population aged 18-79 years as of October 1, 1961), the following prevalence figures per 1,000 may be cited:

	Men	Women
United States (1960-62)	13	21
Oxford, Massachusetts (1946-47)[8]	14	22
Newmarket, South Porcupine, and Hawkesbury, Canada (1951, 1953)[9,10]	14	17
Bergen, Norway (1956)[11]	9	5
Ibstock, Great Britain (1958)[12]	5	16
Birmingham, Great Britain (1962)[13]	7	7

It is seen that the United States and Canadian surveys reported essentially the same prevalence of known diabetes, while the Norwegian and British surveys reported a lower prevalence.

Another source of information for the prevalence of known diabetes is the Health Interview Survey of the National Health Survey, which derives its information from household morbidity interviews. The health interview appears to lead to a net understatement of the number of persons with diagnosed diabetes (Appendix II), but it is not unreasonable to assume that the amount of understatement is approximately the same for every age-sex group. At least, the available evidence from the Health Examination Survey, scanty though it is, is not inconsistent with such a conclusion. Since the sample used for the Health Interview Survey is so much larger than that used for the Health Examination Survey, the Health Interview Survey reports probably constitute the best source for information on differentials of diagnosed diabetes by age and sex for the United States.[14]

Unlike reports on the prevalence of known diabetes, there are few usable data on blood glucose levels in general population groups. The Oxford survey used as its test of glucose tolerance a venous blood specimen (and urine specimen) obtained about 1 hour after the midday or evening meal, without any additional glucose loading. So far as can be inferred from the published data, not more than two persons in every hundred aged 18-79 years who were supposedly free of diabetes were found to have blood glucose levels of 170 mg.% or more. The laboratory method used by the Oxford survey yielded blood glucose levels roughly 20 mg.% higher than those obtained by the laboratory method in use by the Health Examination Survey.[15]

Allowance must also be made for differences in the methods of challenge, since each examinee of the Health Examination Survey was given a drink of 50 grams of glucose 1 hour before a blood specimen was drawn. A study undertaken by the Health Examination Survey[4] suggests that this would yield specimens with levels roughly 10 mg.% higher than those obtained by the challenge used in the Oxford survey. (This assumes that in the Oxford survey blood specimens were always taken 1 hour after a meal. Were they frequently taken at a longer interval a slightly larger difference—say 15 mg.%—should be allowed.)

Thus, the screening level used in the Oxford survey corresponds approximately to a level of 160 mg.% in the Health Examination Survey. The Health Examination Survey found 16 percent of the persons without known diabetes to have blood glucose levels after challenge at least that high, as contrasted with the 2 percent found by the Oxford survey. In fact, 2 percent of the persons in the Health Examination Survey had blood glucose levels of 200 mg.% or more.

Without going into similar detail for other studies, it appears that even when due allowance is made for differences in technique, the number of persons with elevated blood glucose levels is greater in the Canadian surveys cited than in the Oxford survey and greater in the Bergen survey than in the Canadian. In none of these surveys, however, are there as many persons with elevated blood glucose levels as were found by the Health Examination Survey.

These differences are very puzzling. The methodological study of the HES as well as the work of others indicates that a regular meal constitutes a reasonable equivalent to a standard glucose challenge, if due allowance is made for differences in absolute levels. Nonetheless, even after making this allowance there remains a considerable gulf between HES findings and findings previously published. The most careful check of HES data is convincing that the data are valid and reliable, and unpublished data from other sources suggest that HES findings may, in fact, be conservative. It would appear that there are some factors involved in the usual screening survey that tend to lead to unreasonably conservative results.

That this possibility should be seriously considered is suggested by data from the Bergen survey. Capillary blood levels 1 to 2 hours after a meal for persons over 30 years of age were approximately 108 mg.%. As a methodological check, standard glucose tolerance tests were performed on a sample of persons who were negative in the initial screening. Their levels 1 hour after challenge were approximately 152 mg.%. When an allowance for a difference of 25 mg.% between glucose concentrations in capillary and venous specimens is made,[16] these levels are not greatly different from those found in the Health Examination Survey. On the other hand, the difference between levels after a meal and levels after a standard challenge is much greater in the Bergen group than would be expected. This subject merits further investigation.

UNKNOWN DIABETES

It is obvious that by current standards there are a large number of people in the United States who have elevated blood glucose levels after challenge (tables 1-4). The translation of these findings into estimates of the prevalence of unknown diabetes is another matter, however. Most investigators would hesitate to make a diagnosis of diabetes without more extended tests of glucose tolerance than were undertaken by the Health Examination Survey. On the other hand, the higher the blood glucose level after challenge, the greater the likelihood that diabetes would be found to be present on a more extended medical workup. Thus, the probability that diabetes is present is very low if the blood glucose level after challenge is 100 mg.% and very high if it is 300 mg.%. Opinions would differ, however, as to the proportion of persons at each blood glucose level who should be diagnosed as diabetic—if for no other reason than that the criteria for diagnosis are variable.

The following data, however, will serve to give some idea of the very large number of persons in the United States who have some evidence of impaired glucose tolerance. There are more than an estimated 4 million persons aged 18-79 years in the United States who have blood glucose levels of 200 mg.% or greater after challenge. Of these, 2.9 million have urine glucose as well. There are an estimated 6.4 million persons with findings of glucose in the urine who have blood glucose levels of 170 mg.% or more after challenge (tables 1,3).

Does this mean that there are a large number of undiagnosed diabetics in the United States? Perhaps it does. Or perhaps it means that current standards for a normal blood glucose level are unrealistically low. In the practice of medicine this is an important question. The use of routine tests for diabetes and of screening surveys means that the suspicion of disease is raised in persons who have no presenting signs or symptoms other than an elevated blood glucose level on challenge. Under these circumstances it is especially important to have a realistic measure of the usual blood glucose level in a symptom-free population. It is hoped that the data from the Health Examination Survey will serve that purpose.

Obviously, this Survey cannot answer many of the questions it raises. For example, it is seen that blood glucose levels after challenge rise with age even in a symptom-free population. Is this "normal" or is it a mark of an increasing amount of hidden pathology? Women have distinctly higher blood glucose levels than men, and the distinction is especially marked at older ages. Is this a "normal" sex difference? If so, it may mean that the blood glucose levels used in diagnosing diabetes should be higher for women than for men; in other words, the reported sex difference in diagnosed diabetes is based on unrealistic standards. Alternatively, it may mean that women actually do have diabetes more than men.

Clearly it is outside the scope of this Survey to answer these questions, but it is within the scope of the Survey to raise them. In any case, it is hoped that the findings presented in this report may stimulate and guide other studies in the field of glucose tolerance.

SUMMARY

Approximately 2 million persons in the United States have definite evidence of diabetes and know they have it.

Blood glucose levels after challenge and the prevalence of findings of urine glucose after challenge increase with age.

Blood glucose levels after challenge are higher for women than for men; the prevalence of urine glucose findings is lower for women than for men.

The likelihood of urine glucose being manifested at a given level of blood glucose is less at older ages than at younger and less for women than for men.

The number of persons with what is generally considered evidence of "unknown diabetes" is substantially greater than the number of known diabetics.

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DETAILED TABLES

Table 1. Number of adults according to blood glucose level after challenge, by age and sex: United States, 1960-62

[Excludes known diabetics—definite or questionable]

Blood glucose level in mg.%	Total-18-79 years	18-24 years	25-34 years	35-44 years	45-54 years	55-64 years	65-74 years	75-79 years
Both sexes	Number of adults in thousands							
All levels[1]-------	111,087	15,568	21,573	23,697	20,576	15,638	11,164	2,871
150 or more-------------	23,220	903	2,097	3,778	4,649	5,590	4,790	1,414
160 or more-------------	17,202	525	1,332	2,611	3,392	4,130	4,021	1,191
170 or more-------------	12,900	330	903	1,891	2,472	3,269	3,040	992
180 or more-------------	9,372	173	630	1,242	1,695	2,352	2,436	846
190 or more-------------	6,612	98	418	744	1,166	1,846	1,698	643
200 or more-------------	4,277	73	247	442	756	1,149	1,040	571
210 or more-------------	3,037	43	144	287	447	875	842	399
220 or more-------------	2,151	30	93	134	300	661	676	257
230 or more-------------	1,757	15	93	94	266	523	535	231
Men								
All levels[1]-------	52,744	7,139	10,281	11,373	10,034	7,517	4,972	1,428
150 or more-------------	8,604	191	784	1,700	1,712	2,040	1,665	512
160 or more-------------	6,219	91	514	1,250	1,321	1,332	1,360	353
170 or more-------------	4,717	32	387	873	988	1,024	1,101	313
180 or more-------------	3,353	32	286	657	569	781	749	279
190 or more-------------	2,303	32	178	367	314	625	541	247
200 or more-------------	1,525	16	139	192	186	416	345	231
210 or more-------------	1,051	16	71	129	124	296	259	155
220 or more-------------	756	16	41	70	62	233	226	109
230 or more-------------	640	-	41	41	47	199	213	100
Women								
All levels[1]-------	58,343	8,430	11,291	12,325	10,542	8,121	6,192	1,443
150 or more-------------	14,616	712	1,313	2,078	2,936	3,550	3,125	902
160 or more-------------	10,982	434	819	1,361	2,071	2,798	2,661	840
170 or more-------------	8,183	301	516	1,018	1,485	2,246	1,939	679
180 or more-------------	6,019	141	344	585	1,126	1,571	1,686	567
190 or more-------------	4,309	66	240	377	853	1,221	1,156	396
200 or more-------------	2,753	57	108	250	570	732	695	340
210 or more-------------	1,986	28	73	157	323	579	583	243
220 or more-------------	1,396	15	52	64	238	428	450	148
230 or more-------------	1,117	15	52	54	220	324	322	131

[1]Entries for "All levels" are counts of the total population in the specified age-sex group, including diabetics. Percentages displayed in table 2 are computed with these counts as the base.

NOTE: Many numbers in this table have large sampling errors, entries in the smallest cells being so unstable that they should be interpreted only as indicating that the true number is small. They have been printed, nonetheless, in the belief that by so doing a better overall pattern is reflected. See table III for illustrative sampling errors.

Table 2. Percent of adults according to blood glucose level after challenge, by age and sex: United States, 1960-62

[Excludes known diabetics—definite or questionable]

Blood glucose level in mg.%	Total-18-79 years	18-24 years	25-34 years	35-44 years	45-54 years	55-64 years	65-74 years	75-79 years
	Percent of adults							
Both sexes								
150 or more	20.9	5.8	9.7	15.9	22.6	35.7	42.9	49.3
160 or more	15.5	3.4	6.2	11.0	16.5	26.4	36.0	41.5
170 or more	11.6	2.1	4.2	8.0	12.0	20.9	27.2	34.6
180 or more	8.4	1.1	2.9	5.2	8.2	15.0	21.8	29.5
190 or more	6.0	0.6	1.9	3.1	5.7	11.8	15.2	22.4
200 or more	3.9	0.5	1.1	1.9	3.7	7.3	9.3	19.9
210 or more	2.7	0.3	0.7	1.2	2.2	5.6	7.5	13.9
220 or more	1.9	0.2	0.4	0.6	1.5	4.2	6.1	9.0
230 or more	1.6	0.1	0.4	0.4	1.3	3.3	4.8	8.0
Men								
150 or more	16.3	2.7	7.6	14.9	17.1	27.1	3[illegible] 5	35.9
160 or more	11.8	1.3	5.0	11.0	13.2	17.7	27.4	24.7
170 or more	8.9	0.4	3.8	7.7	9.8	13.6	22.1	21.9
180 or more	6.4	0.4	2.8	5.8	5.7	10.4	15.1	19.5
190 or more	4.4	0.4	1.7	3.2	3.1	8.3	10.9	17.3
200 or more	2.9	0.2	1.4	1.7	1.9	5.5	6.9	16.2
210 or more	2.0	0.2	0.7	1.1	1.2	3.9	5.2	10.9
220 or more	1.4	0.2	0.4	0.6	0.6	3.1	4.5	7.6
230 or more	1.2	-	0.4	0.4	0.5	2.6	4.3	7.0
Women								
150 or more	25.1	8.4	11.6	16.9	27.9	43.7	50.5	62.5
160 or more	18.8	5.1	7.3	11.0	19.6	34.5	43.0	58.2
170 or more	14.0	3.6	4.6	8.3	14.1	27.7	31.3	47.1
180 or more	10.3	1.7	3.0	4.7	10.7	19.3	27.2	39.3
190 or more	7.4	0.8	2.1	3.1	8.1	15.0	18.7	27.4
200 or more	4.7	0.7	1.0	2.0	5.4	9.0	11.2	23.6
210 or more	3.4	0.3	0.6	1.3	3.1	7.1	9.4	16.8
220 or more	2.4	0.2	0.5	0.5	2.3	5.3	7.3	10.3
230 or more	1.9	0.2	0.5	0.4	2.1	4.0	5.2	9.1

NOTE: See footnotes on table 1.

Table 3. Number of adults with a trace or more of urine glucose according to blood glucose level after challenge, by age and sex: United States, 1960-62

[Excludes known diabetics—definite or questionable]

Blood glucose level in mg.%	Total-18-79 years	18-24 years	25-34 years	35-44 years	45-54 years	55-64 years	65-74 years	75-79 years
Both sexes	Number of adults in thousands							
All levels[1]-------	15,114	1,334	2,386	3,581	3,132	2,180	1,936	565
150 or more-------------	8,389	362	955	1,789	1,637	1,591	1,527	527
160 or more-------------	7,277	247	708	1,531	1,483	1,401	1,435	472
170 or more-------------	6,375	158	603	1,201	1,328	1,316	1,317	451
180 or more-------------	5,054	110	444	911	945	1,089	1,136	418
190 or more-------------	3,947	82	293	592	713	938	972	356
200 or more-------------	2,886	73	166	414	524	645	724	340
210 or more-------------	2,174	43	99	258	366	496	638	273
220 or more-------------	1,582	30	48	119	258	369	560	199
230 or more-------------	1,419	15	48	79	235	325	518	199
Men								
All levels[1]-------	9,119	813	1,419	2,182	2,009	1,244	1,194	258
150 or more-------------	4,220	109	471	966	814	764	877	220
160 or more-------------	3,507	39	327	836	714	619	807	165
170 or more-------------	3,042	16	274	655	623	582	729	165
180 or more-------------	2,350	16	208	540	382	464	575	165
190 or more-------------	1,741	16	130	286	232	428	485	165
200 or more-------------	1,241	16	102	176	139	339	319	149
210 or more-------------	954	16	59	114	109	266	259	132
220 or more-------------	688	16	27	54	62	203	226	100
230 or more-------------	589	-	27	25	47	176	213	100
Women								
All levels[1]-------	5,995	521	967	1,399	1,123	936	742	307
150 or more-------------	4,169	253	484	824	824	827	650	307
160 or more-------------	3,769	208	381	695	768	782	628	307
170 or more-------------	3,333	143	329	548	705	734	588	287
180 or more-------------	2,704	95	237	371	564	625	561	253
190 or more-------------	2,206	66	163	306	481	510	488	192
200 or more-------------	1,645	57	63	238	384	306	405	192
210 or more-------------	1,220	28	40	144	257	230	379	142
220 or more-------------	894	15	20	64	197	166	333	99
230 or more-------------	830	15	20	54	188	149	305	99

[1]Entries for "All levels" are counts of the total population in the specified age-sex group, including diabetics. Percentages displayed in table 4 are computed with "All levels" counts from table 1 as the base.

NOTE: Many numbers in this table have large sampling errors, entries in the smallest cells being so unstable that they should be interpreted only as indicating that the true number is small. They have been printed, nonetheless, in the belief that by so doing a better overall pattern is reflected. See table III for illustrative sampling errors.

Table 4. Percent of adults with a trace or more of urine glucose according to blood glucose level after challenge, by age and sex: United States, 1960-62

[Excludes known diabetics—definite or questionable]

Blood glucose level in mg.%	Total-18-79 years	18-24 years	25-34 years	35-44 years	45-54 years	55-64 years	65-74 years	75-79 years
Both sexes	Percent of adults							
150 or more	7.6	2.3	4.4	7.5	8.0	10.2	13.7	18.4
160 or more	6.6	1.6	3.3	6.5	7.2	9.0	12.9	16.4
170 or more	5.7	1.0	2.8	5.1	6.5	8.4	11.8	15.7
180 or more	4.5	0.7	2.1	3.8	4.6	7.0	10.2	14.6
190 or more	3.6	0.5	1.4	2.5	3.5	6.0	8.7	12.4
200 or more	2.6	0.5	0.8	1.7	2.5	4.1	6.5	11.8
210 or more	2.0	0.3	0.5	1.1	1.8	3.2	5.7	9.5
220 or more	1.4	0.2	0.2	0.5	1.3	2.4	5.0	6.9
230 or more	1.3	0.1	0.2	0.3	1.1	2.1	4.6	6.9
Men								
150 or more	8.0	1.5	4.6	8.5	8.1	10.2	17.6	15.4
160 or more	6.6	0.5	3.2	7.4	7.1	8.2	16.2	11.6
170 or more	5.8	0.2	2.7	5.8	6.2	7.7	14.7	11.6
180 or more	4.5	0.2	2.0	4.7	3.8	6.2	11.6	11.6
190 or more	3.3	0.2	1.3	2.5	2.3	5.7	9.8	11.6
200 or more	2.4	0.2	1.0	1.5	1.4	4.5	6.4	10.4
210 or more	1.8	0.2	0.6	1.0	1.1	3.5	5.2	9.2
220 or more	1.3	0.2	0.3	0.5	0.6	2.7	4.5	7.0
230 or more	1.1	-	0.3	0.2	0.5	2.3	4.3	7.0
Women								
150 or more	7.1	3.0	4.3	6.7	7.8	10.2	10.5	21.3
160 or more	6.5	2.5	3.4	5.6	7.3	9.6	10.1	21.3
170 or more	5.7	1.7	2.9	4.4	6.7	9.0	9.5	19.9
180 or more	4.6	1.1	2.1	3.0	5.4	7.7	9.1	17.5
190 or more	3.8	0.8	1.4	2.5	4.6	6.3	7.9	13.3
200 or more	2.8	0.7	0.6	1.9	3.6	3.8	6.5	13.3
210 or more	2.1	0.3	0.4	1.2	2.4	2.8	6.1	9.8
220 or more	1.5	0.2	0.2	0.5	1.9	2.0	5.4	6.9
230 or more	1.4	0.2	0.2	0.4	1.8	1.8	4.9	6.9

NOTE: See footnotes on table 3.

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? [YES] [NO] [?]
(IF YES or ?)

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

DIABETES—DOCUMENTATION

Of the 6,672 sample persons examined, 114 were diagnosed as having definite known diabetes and 11 as having questionable known diabetes. The persons with questionable known diabetes gave a history of disease and reported that the diagnosis had been made by a physician. Furthermore, all reported having seen a physician for the disease within the previous 6 months. None, however, were taking any hypoglycemic medication. Because they reported they were under close medical supervision, none were given a glucose challenge. Their blood glucose levels ranged from 74 mg.% to 122 mg.%. Only one was found to have urine glucose and his blood glucose level was 74 mg.%. These cases are excluded from tables A-C and 1-4.

The 114 persons diagnosed as having definite known diabetes either reported they were on medication or were found to have elevated blood glucose levels. Of the total, 82 were using hypoglycemic agents of some sort, 33 using insulin alone, 5 using both insulin and an oral hypoglycemic, and 44 using only an oral hypoglycemic. Of the 32 persons not on hypoglycemic medication, 24 received a challenge and 8 did not. Blood glucose levels for these 32 persons ranged from 148 to 412 mg.% with challenge and from 138 to 364 mg.% without challenge. Five cases of definite known diabetes were persons who gave a history of diabetes but denied that it had been diagnosed by a physician. Since their blood glucose levels ranged from 218 to 412 mg.% it was assumed that these cases had, in fact, been medically diagnosed.

The distribution of blood glucose levels in mg.% in persons having definite known diabetes was as follows:

	Total	Less than 150	150-169	170-199	200-299	300+
Not on hypoglycemic medication						
Challenge----------	24	1	2	6	11	4
No challenge------	8	1	2	3	1	1
On hypoglycemic medication						
Challenge----------	8	1	-	-	2	5
No challenge------	[1]74	34	4	2	18	12

[1]For 4 persons no specimen was available.

In order to identify the sample group for the Health Examination Survey, a household interview was conducted at each sample household. This made available a large amount of information both for persons subsequently examined and for sample persons who were not examined. Included in that information were data derived from a morbidity questionnaire.

Reports of diabetes from the household interview are in close correspondence with the final diagnoses made from the health examination. Altogether 107 examined persons were reported to have diabetes on the household interview, as compared with 125 with definite or questionable known diabetes on the examination. In 96 cases the two sources agreed. There were 29 cases found on examination but not reported on household interview and 11 cases reported on the interview but not diagnosed on the examination. Of the latter, 2 persons gave a history of diabetes on the examination but the diagnoses could not be confirmed by the evidence available, while 9 persons gave no such history on the examination. Although the two sources yield comparable information on diabetes, the household interview can be considered as providing a net understatement of the prevalence of known diabetes in the population. This is in accord with a previous study of this subject, which found 88 cases of diabetes reported by household interview for every 100 identified from medical sources (National Health Survey: *Health Interview Responses Compared With Medical Records.* Series D-5, PHS Publication No. 584-D5, Public Health Service, Washington, D.C., June 1961).

APPENDIX III

CASUAL ASPECTS OF THE GLUCOSE TOLERANCE TEST

The glucose tolerance test used in the Health Examination Survey required that the examinee be given a challenge of 50 grams of glucose shortly after beginning the examination and that 1 hour later a venous blood specimen be taken. In that sense the glucose tolerance test was standardized. There were a number of respects, however, in which the glucose tolerance test was not standardized. For example, an examinee might appear for examination at any time of the day, from early morning until late in the evening. Or, he might arrive either just after eating or many hours after his last meal. And the content of his last meal, as well as his usual diet, was entirely uncontrolled by the Survey. Given all these variables it might well be asked, "How standardized was the glucose tolerance test used by the Health Examination Survey?"

To answer this question, at least in part, the Health Examination Survey, with the help of staff members of the Tecumseh Community Health Study, instituted a special study to investigate the effect on blood glucose levels of differences in the size of the glucose challenge, time of day, and time since last meal.[4] The study was undertaken with a group of 24 prisoners who were given a series of glucose tolerance tests under a variety of conditions, extending over a period of 16 weeks. It was found that with a challenge of 50 grams of glucose the blood glucose level 1 hour after challenge was affected to no discernible extent by the time between the last meal and challenge, but that levels after the midday meal were higher than levels after the morning meal. It was also found that any standard test procedure yielded results comparable to any other standard procedure. Response to any given procedure, as with most biological behavior, tended to vary from one time to the next.

In part, the same factors can be examined on the basis of the examination findings themselves. All examinees were asked when they had last eaten. The time of challenge was noted. Mean blood glucose levels are presented in table I by sex, in broad age groups, according to the time of day that the examinee was given the glucose drink, and according to the interval between his last meal and the glucose drink. These data are for examined persons only and do not constitute estimates for the population of the United States. The data are restricted to persons who came in for examination 1 to 4 hours after the meal, since such persons account for the majority of all examinees. When differences in blood glucose level associated with time of challenge and interval since last meal are measured against differences between people, the following conclusions are reached:

1. Persons given 50 grams of glucose 2 to 3 hours or 3 to 4 hours after the morning meal had higher blood glucose levels after challenge than persons given the same glucose challenge between 1 and 2 hours after the same meal.
2. So far as can be judged from the data, no similar effect is discernible for the midday or evening meals.
3. The blood glucose level after challenge also varied with time of day. Levels were higher after the midday meal than after the morning or evening meals.

Except for the effect on blood glucose levels of time after the morning meal, these findings are consistent with those from the special study[4] and may be considered extensions from the very restricted and special group of 24 male prisoners to the population as a whole.

It is of interest to examine table I for age and sex differentials on the possibility that differences between the various age-sex groups in time of appearance for the examination may somehow introduce an artifact when the data are consolidated. This is not the case. Even in data specific for time of day and time since last meal there is strong gradient by age and a definite, though weaker, sex differential, just as there is in the consolidated data.

Table I. Mean blood glucose levels, by time of day challenge was given, specified intervals between last meal and challenge, sex, and age: Health Examination Survey, 1960-62

Interval between last meal and challenge, sex, and age	Time of day challenge was given		
	8-11 a.m.	12-5 p.m.	6 p.m. or later
<u>60-119 minutes</u>		in mg.%	
Men			
18-39 years	87.4	95.8	98.1
40-54 years	108.5	127.3	110.0
55+ years	130.6	155.1	106.5
Women			
18-39 years	92.7	105.7	100.5
40-54 years	107.7	125.1	116.1
55+ years	118.1	148.5	131.3
<u>120-179 minutes</u>			
Men			
18-39 years	103.3	101.0	97.4
40-54 years	115.1	116.5	113.6
55+ years	129.1	135.0	117.3
Women			
18-39 years	102.1	108.8	98.8
40-54 years	121.0	118.7	119.7
55+ years	146.6	153.5	135.4
<u>180-239 minutes</u>			
Men			
18-39 years	107.7	99.0	94.5
40-54 years	119.5	113.6	110.7
55+ years	130.5	142.8	137.8
Women			
18-39 years	110.1	114.0	100.0
40-54 years	144.2	131.5	101.8
55+ years	150.3	148.8	124.8

NOTE: Values in this table do <u>not</u> constitute estimates for the population of the United States.

APPENDIX IV

QUALITY OF BLOOD GLUCOSE DETERMINATIONS

During the period between January and May 1962, in the course of conducting a special study of glucose tolerance tests, the Health Examination Survey instituted a series of quality checks on the work of the laboratory responsible for the blood glucose determinations of the Survey—the laboratory of the Field Research Unit, Diabetes and Arthritis Branch, Division of Chronic Diseases, Bureau of State Services, U.S. Public Health Service, at Brighton, Massachusetts. The results of these checks were highly favorable. Full details are available in the report of that study.[4]

Both before and after this period, quality checks of the laboratory determinations at Brighton had been undertaken in connection with the routine field collection of specimens. The first series of checks occurred during the period between February 9 and March 3, 1961. Aliquots were obtained of 272 specimens collected routinely during the field work at San Jose and San Francisco, California. One aliquot was treated as a regular specimen and shipped to the Brighton laboratory for determination. The other was sent to a special laboratory of the Metabolic Unit of the University of California by special arrangement with Dr. Peter Forsham. The technicians at the Brighton laboratory were unaware that a comparison study was in progress, arrangements having been made through Dr. Hugh Wilkerson for this undertaking. As a subsidiary inquiry, 60 specimens were obtained in triplicate, one aliquot going to the Brighton laboratory, the second going promptly to the San Francisco laboratory, and the third being held and sent to the San Francisco laboratory 6 to 9 days later. The conclusions from these comparisons were as follows:

1. There was no definite evidence that any artifacts were introduced in the measurement of blood glucose by HES methods of transporting the specimens or by the delay between drawing the blood and measuring it.
2. Blood determinations by a single technician on a single run were highly consistent, in a sense to be specified later.
3. There were differences in the levels between technicians, runs, and laboratories; in other words, the measurement of blood glucose on the 272 specimens in this comparison was not fully standardized.
4. No change in glucose concentration was demonstrated even when the specimen was kept as long as 6 to 9 days before being measured.

There was a distinct difference in levels between the two laboratories. The mean glucose concentrations for the 272 specimens were 117.0 mg.% at the Brighton laboratory and 109.2 mg.% at the San Francisco laboratory. During this period, two technicians were working on these specimens at the Brighton laboratory. One tended to measure close to the level of the San Francisco laboratory, whereas the other tended to be distinctly higher; the apparent difference between the levels for the two technicians was about 5 mg.%.

The first 104 measurements by one of the technicians at the Brighton laboratory were compared with measurements on the same specimens by the San Francisco laboratory. These determinations represented six runs at the Brighton laboratory and nine runs at the San Francisco laboratory. If every measurement at San Francisco were increased by 6.3 percent, 9 out of 10 of the Brighton measurements would come within 5 mg.% of the San Francisco measurement; that is, if a fixed difference in measurement level is assumed, there is a remarkably high consistency between (and consequently within) the measurements at the two laboratories.

The basis for the difference in laboratory levels was never satisfactorily elucidated. Both laboratories used essentially the same laboratory techniques. Both were well controlled. There were no obvious criteria for choosing between them. Control specimens were sent the two laboratories and for these the determinations made by the Brighton laboratory were closer to the alleged glucose concentrations. On the other hand, the levels obtained by the San Francisco laboratory on these specimens tended to be slightly higher than those obtained by the Brighton laboratory. In other words, the comparisons between the laboratories were in the opposite direction from those that were obtained during the rest of the series and only confuse the issue.

Interlaboratory comparison is a harsh test of any laboratory. The general conclusion was that blood glucose determinations are not so well standardized as is commonly thought and that additional work in standardization is highly desirable. Although the results of this series were in some respects equivocal, by any realistic standards the laboratory work being done on specimens from the Health Examination Survey was quite reliable.

Between June 1961 and May 1962, a series of aliquots from specimens collected in the field were sent at regular intervals to the laboratory of the Framingham Heart Study, by arrangements with Dr. Thomas R. Dawber, Director. Except for one aberrant set of comparisons the Brighton laboratory averaged slightly higher than the Framingham. Of more interest, perhaps, is the variability of measurement. This may be represented by the statistic $s = \sqrt{w}$, where $w = \frac{\sum d_i^2}{2n}$

d_i being the difference between determinations by the Boston and Framingham laboratories on the same specimen, and n being the number of specimens. The overall value of s was 8.0 mg.%, or 5.9 mg.% if the one aberrant set were omitted. When it is considered that this figure includes variability arising from differences between laboratories, between technicians within laboratories, and between laboratory runs over a period of 1 year, the results are very encouraging.

APPENDIX V

SURVEY DESIGN, MISSING DATA, AND VARIANCE

The Survey Design

The Health Examination Survey is designed as a highly stratified multistage sampling of the civilian, noninstitutional population of the conterminous United States, aged 18-79 years. The first stage of the plan is a sample of 42 primary sampling units (PSU's) from among 1,900 such geographic units into which the United States has been divided. A PSU is a standard metropolitan statistical area or one to three contiguous counties. Later stages result in the random selection of clusters of about four persons from a small neighborhood within the PSU. The total sample included 7,710 persons in the 42 PSU's 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 of Probability Surveys

The Survey draws strength from the fact that it is a probability sample of its total target population, and from the fact that the measurement processes which were employed were highly standardized and closely controlled. This does not mean, of course, that the correspondence between the real world and survey results is exact. Data from the Survey are imperfect for three important 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 process itself is inexact, even when standardized and controlled.

The faithfulness with which the study design was carried out has been analyzed in a previous report.[2] Of the 7,710 sample persons, the 6,672 who were examined—a response rate of over 86 percent—give evidence that they are a highly representative sample of the adult civilian, noninstitutional population of the United States. Imputation for the nonrespondents was accomplished by attributing to nonexamined persons the characteristics of comparable examined persons. The specific procedure used[2] consisted of inflating the sampling weight for each examined person to compensate for sample persons at that stand and of the same age-sex group who were not examined.

While it is impossible to be certain that the prevalence of diabetes is the same in the examined and the nonexamined groups, the available evidence indicates that it is. One source of information on this question is a household interview obtained for every sample person. The prevalence of diabetes reported for nonexamined persons on the household interview agreed very closely with that reported for examined persons of the same age and sex. Another source of information is a special inquiry sent to the physicians of nonexamined persons and to the physicians of a matching set of examined persons. Again, the diabetes prevalence reported for the examined and nonexamined groups was in very close agreement.

In addition to persons not examined, there were some persons whose examinations were incomplete in one particular or another. Age and sex were known for every examined person, but for a number of people either a blood or urine specimen was not available. Most of the losses were accidental. The extent of missing information is indicated in table II.

The method for dealing with this missing information in tables 1-4 was to attribute to a person for whom a blood or urine determination was not available the information available for a comparable person with such a determination. For example, if a urine specimen was determined but a blood specimen was not, a person of the same age and sex and with the same urine glucose finding was selected at random and his blood glucose determination was used for the missing value. If a blood specimen was available but a urine finding was not, a person of the same age-sex group with the same blood glucose level was chosen as a substitute.

In other tables the mean of known values was used. This assumes that missing values have the same mean as the present values.

Sampling and Measurement Error

In this report and its appendices, several references have been made to efforts to evaluate both 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 measurement of all elements in the universe.

The task of presenting 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 calculation of variances. (3) Thousands of statistics come from the survey, many for subclasses of the population for which there are small numbers of sample cases. Estimates of sampling error are obtained from the sample data and are themselves subject to sampling error, which may be large when the number of cases in a cell is small, or even occasionally when the number of cases is substantial.

As variances are estimated for larger numbers of statistics from the Health Examination Survey, it is hoped that an increasing amount of information can be presented in published reports. In the present report, estimates of approximate sampling variability for selected statistics are presented in table 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 measurement variance.

In accordance with usual practice, a 68 percent confidence interval may be considered that range within one standard error of the tabulated statistic and a 95 percent confidence interval that range within two standard errors. An overestimate of the standard error of a difference $d = x - y$ of two statistics x and y is given by the formula $s_d = \left[x^2 V^2_x + y^2 V^2_y\right]^{1/2}$, where V^2_x and V^2_y are relvariances respectively of x and y or the squares of the relative errors shown in table III. For example, table B shows x = 115.70 mg.% for men and y = 126.35 mg.% for women, while from table III relvariances are found to be:

$V^2_x = 0.000064$ and $V^2_y = 0.000049$. The formula yields the estimate of standard error of the difference (d = 10.65) as $s_d = 1.3$ mg.%. Thus, as the observed difference is more than eight times its sampling error, it can be concluded with near certainty that the evidence from this Survey shows that blood glucose is higher among females than males.

Small Numbers

In some tables magnitudes are shown for cells for which 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.

Table II. Number of examined persons, by challenge and diagnosis, and completeness of glucose tolerance data: Health Examination Survey, 1960-62

Challenge and diagnosis	Total	Complete glucose tolerance data	Partial glucose tolerance data			
			Total	Blood only	Urine only	Blood and urine
Total	6,672	6,410	262	124	134	4
Challenged	6,570	6,314	256	120	132	4
Unchallenged	102	96	6	4	2	-
Diabetic[1]	93	88	5	4	1	-
Nondiabetic	9	8	1	-	1	-

[1]Definite or questionable.

Table III. Approximate relative standard errors for selected statistics on glucose tolerance: Health Examination Survey, 1960-62

Age and sex	Approximate relative standard error (in percent)			Percent of persons with blood glucose> 200 mg.%	
	Diabetes prevalence (table A)	Mean blood glucose (table B)	Urine glucose prevalence (table C)	Table 2	Table 4
Both sexes	8.0	0.4	5.0	8.0	10.0
Men	12.0	0.8	5.0	10.0	10.0
18-24 years	(1)	1.5	20.0	(1)	(1)
25-34 years	(1)	1.5	10.0	40.0	40.0
35-44 years	40.0	1.5	10.0	30.0	30.0
45-54 years	40.0	1.5	10.0	30.0	30.0
55-64 years	40.0	1.5	10.0	30.0	30.0
65-74 years	40.0	2.5	10.0	30.0	30.0
75-79 years	(1)	2.5	20.0	40.0	50.0
Women	12.0	0.7	10.0	12.0	15.0
18-24 years	(1)	1.5	20.0	(1)	(1)
25-34 years	(1)	1.5	15.0	30.0	30.0
35-44 years	50.0	1.5	15.0	30.0	30.0
45-54 years	30.0	1.5	15.0	30.0	30.0
55-64 years	30.0	1.5	15.0	20.0	30.0
65-74 years	30.0	1.5	15.0	20.0	30.0
75-79 years	50.0	4.0	20.0	40.0	40.0

(1) Not estimated.

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