Screening for Diabetes With the Clinitron

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DURING THE PERIOD October 1, 1956, to May 15, 1959, the Hewson clinitron was employed in a diabetes detection program which tested 7,294 persons coming to the outpatient department of the City of Memphis Hospitals for health card examinations. Most of these persons were referred by employment agencies, public welfare agencies, and employers. Testing for diabetes was performed as part of a multiple screening program which also included tests for syphilis, tuberculosis, uterine cancer, and glaucoma. Urine as well as blood was examined in the preliminary screening tests for diabetes in order that the relative sensitivity and specificity of both test methods could be compared in a separate report.

The present report is concerned only with a comparison of results obtained with use of the clinitron for screening at the preselected levels of 180 mg. percent, 160 mg. percent, and 130 mg. percent, using fingertip blood. Information concerning the Wilkerson-Heftmann method of blood sugar determination (*1*) and the operation of the clinitron (*2*) can be found in the literature and will not be detailed here. Suffice it to say that this instrument can complete as many as 120 tests per hour when it is operated at capacity, indicating, in less than 6 minutes per individual test, whether a specimen contains enough true glucose to exceed the preselected screening level. The solution in which the blood and reagent tablets are placed turns blue when the test is negative and becomes colorless when it is positive. Reagent tablets required for the clinitron are available commercially, and the cost of the four tablets required for each test is approximately 5 cents.

The clinitron is an expensive piece of equipment which lends itself mainly to mass testing programs. For testing on a smaller scale, using the same tablets and technique, a less expensive instrument (the Glover-Edwards Glucose Test Kit) is available. The present study was undertaken to evaluate the relative yield of true and false positives at the three testing levels which can be used with the clinitron. An evaluation of the instrument for small-scale testing is now in progress.

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Procedure

Fingertip blood was drawn from all persons applying for a health card. The amount drawn was either 0.1 or 0.1125 ml., depending on the testing level employed at the time of the examination. Persons showing a positive test were called back for retesting with a modified glucose tolerance test in which two blood sugar determinations, one fasting and the other 2 hours after the administration of 100 grams of glucose, were obtained. Persons showing over 140 mg. (Folin-Wu method) on the 2-hour blood sugar were referred to the City of Memphis Hospitals' medicine clinic for definitive evaluation for diabetes, unless they were ineligible for evaluation by the clinic. The few who were ineligible were referred to private physicians.

For the purposes of this comparison, all persons positive to the retest procedure, that is, showing over 140 mg. on the 2-hour blood sugar determination, were arbitrarily designated as diabetics. In almost all cases, these designations were confirmed by further evaluation. Persons who were positive on the screening test but negative on the retest were designated as false positives in this study.

The three testing levels were not employed concurrently, but consecutively. The 180 mg. level was used between October 1956 and March 1957; the 160 mg. level, between April 1957 and December 1957; and the 130 mg. level, between January 1958 and May 1959. The specific periods are indicated because from time to time we have suspected that the season of the year influenced screening results, although we do not have confirmatory evidence of this.

Characteristics of Study Group

The yield of a detection program is influenced greatly by the characteristics of the population group under study and the extent of unrecognized diabetes. Table 1 indicates the distribution of persons tested, by age, sex, and color. Women constituted approximately four-fifths of the total group, and approximately two-thirds of the total were nonwhite women. Approximately 70 percent of the total group were between the ages of 30 and 50 years, and more than 90 percent were between 30 and 60 years of age. Although the age, race, and sex distribution of populations tested at each of the three screening levels was generally similar, the proportion of nonwhite women under 40 years of age was higher in the group screened at 180 mg. than in the groups screened at either 130 mg. or 160 mg. This relatively large group of young nonwhite women probably has exerted a small downward influence on the yield of new diabetes cases at the 180 mg. testing level.

Table 1. Distribution of persons tested for diabetes, by age, sex, and color, City of Memphis Hospitals, 1956–59

Age group (years)	Total	White		Nonwhite	
		Male	Female	Male	Female
Total	7, 294	500	1, 293	703	4, 798
Under 30	47	3	13	5	26
30–39	2, 778	183	482	231	1, 882
40–49	2, 358	163	411	190	1, 594
50–59	1, 489	107	268	138	976
60–69	452	35	91	84	242
70–79	131	8	25	40	58
80 and over	29	1	0	12	16
Unknown	10	0	3	3	4

Table 2. Time of diabetes test in relation to last meal, City of Memphis Hospitals, 1956–59

Time since eating (hours)	Persons tested	Percent of total
Total	7, 294	100. 0
Less than 1	775	10. 6
1 to 2	1, 518	20. 8
2 to 3	1, 663	22. 8
3 or more or fasting	3, 325	45. 6
Unknown	13	. 2

Table 2 indicates the time of testing in relation to the last food intake. Since persons applied for tests throughout the day, no control could be exerted over the time interval between testing and the last food eaten. No attempt was made to adjust the screening level in relation to the time of last food intake. Thus this study provided an opportunity for comparing the yields of new diabetes cases from testing done at random intervals after eating when a single testing level was employed. The high proportion of our study group (45.6 percent) tested while in a fasting state should be noted, since fasting blood specimens are generally considered undesirable for such testing (*2*), and our yield of new cases has undoubtedly been influenced by this factor. However, because the distribution of persons tested by time since eating was essentially the same at each screening level, this factor did not affect the comparability of results at the three levels.

Analysis of Results

New diabetes cases found as the result of all tests performed during the study period are shown, by age group, in table 3. Of all persons tested (7,294), 1.6 percent were found to have

Table 3. Yield of new diabetes cases, by age, City of Memphis Hospitals, 1956–59

Age group (years)	Persons tested	New diabetes cases	
		Number	Percent of total
Total	7, 294	115	1. 6
Under 30	47	0	0
30–39	2, 778	16	0. 6
40–49	2, 358	32	1. 4
50–59	1, 489	38	2. 6
60–69	452	24	5. 3
70 and over	131	5	3. 8

previously unrecognized diabetes. The percentage of new cases increased with increasing age up to 70 years, and ranged from 0.6 in the 30- to 39-year group to 5.3 in the 60- to 69-year group.

To examine the relative prevalence in the different race and sex groups, age-specific rates were calculated, based on the total known and new diabetics and adjusted to the age distribution of all persons tested. The age-adjusted rates are as follows:

Race and sex	*Rate per 100*
All	4. 3
White male	2. 7
White female	2. 2
Nonwhite male	3. 1
Nonwhite female	5. 3

While these rates are based on small numbers in several age brackets, they follow the same pattern of higher diabetes mortality rates shown in national statistics for nonwhites compared with whites. The higher rate indicated above for nonwhite women than for nonwhite men also bears out the male-female relationship in national mortality data. This relationship does not hold for whites in our survey; however, only 500 white men were tested.

Table 4 shows the influence of the time interval between testing and the last food intake on new diabetes cases found and on false positive results. Tests performed on persons in a fasting state showed the lowest yield (1.1 percent) of new cases, whereas the highest yield (2.7 percent) was observed in tests performed between 1 and 2 hours after eating. Of total persons screening positive, those tested between 1 and 2 hours after eating also produced the lowest percentage (28.1) of false positives. The highest percentage (53.3) of positive screening results subsequently identified as false positive occurred in tests performed within 1 hour after eating. The same patterns of yield and false positives in relation to these intervals between food intake and testing were observed in the results obtained at all three screening levels.

One of the main objectives of this study was to compare the relative yields of true and false positives at the three screening levels employed with the clinitron. Our results are summarized in table 5. Screening at the 130 mg. level yielded a higher return (2.4 percent new cases) than when screening was done at the 160 mg. level (1.1 percent new cases) or at the 180 mg. level (0.5 percent new cases). The difference between the results of screening at 160 and 180

Table 4. Time of test after eating in relation to yield of new diabetes cases and false positives, City of Memphis Hospitals, 1956–59

Time since eating (hours)	Persons tested	New diabetes cases		False positives		
		Number	Percent of total tested	Number	Percent of total tested	Percent of total screening positive
Less than 1	775	14	1. 8	16	2. 1	53. 3
1 to 2	1, 518	41	2. 7	16	1. 0	28. 1
2 to 3	1, 663	23	1. 7	19	1. 1	45. 2
3 or more or fasting	3, 325	37	1. 1	21	. 6	36. 2
Unknown	13	0	0	0	0	0

Table 5. Screening level in relation to new diabetes cases and false positives, City of Memphis Hospitals, 1956–59

Screening level (mg./100 ml.)	Persons tested	New diabetes cases		False positives		
		Number	Percent of total tested	Number	Percent of total tested	Percent of total screening positive
130	3,315	81	2.4	66	2.0	38.4
160	2,483	26	1.1	4	0.2	13.3
180	1,496	8	0.5	2	0.1	16.7

mg. was not statistically significant, but the yield of new cases using the 130 mg. level was significantly greater ($P=.05$) than when the higher screening levels were employed.

Table 5 also indicates the false positive results occurring at each of the testing levels in relation to all persons tested and to all persons screening positive. The retest load at each screening level is thereby delineated. Thus, when the 130 mg. level was used, it was necessary to identify as nondiabetic by retest 2 persons out of every 100 originally screened in order to obtain the yield of 2.4 percent new diabetics. Expressed the other way, approximately 38 persons out of each 100 who screened positive at this level and were therefore retested were found to be nondiabetic. At the other extreme, when the 180 mg. level was employed, only about 1 person per 1,000 screened was falsely reported as positive, and only 17 persons out of each 100 screening positive turned out to be nondiabetic. However, the yield of new cases of diabetes was low at 180 mg., being approximately one-fifth as great (0.5 percent) as that observed when the 130 mg. level was used (2.4 percent).

Discussion

In conducting a diabetes screening program, primary consideration must be given to factors which increase the yield of previously unrecognized cases and also to factors which increase the need for retesting in order to identify properly those persons who screen positive but do not have diabetes. Although optimum performance, in terms of maximizing the former and minimizing the latter, is a desirable objective, administrative considerations may occasionally necessitate a compromise which falls short of achieving such optimum results. For example, in one situation an unlimited load of retesting can be undertaken, thereby making it possible to achieve a high yield of new cases discovered. Testing with the clinitron at the 130 mg. level would be appropriate under these conditions. In the light of our findings and in view of our circumstances, we shall employ this level of testing in our health card program in the future. Others (*3,4*) have also found that this level produces optimum casefinding results.

Under different circumstances, the volume of retesting required by use of the 130 mg. level with the clinitron may be unacceptable. For example, we have encountered the resentment of some patients who were screened in other programs and who incurred considerable expense when they were referred to private physicians because of what turned out to be false positive screening tests. Physicians as well as patients tend to lose confidence in a detection program which necessitates reassuring many persons through further study that diabetes is not present in spite of a positive screening test. We have been able to obviate this factor to some extent by performing modified glucose tolerance tests on persons screening positive before referring them to private physicians. To minimize this factor in some programs, it may be necessary to use a higher screening level, such as 160 mg. or 180 mg., even at a sacrifice of yield.

Some of the factors affecting the performance of a diabetes screening program may be beyond administrative control. The total prevalence of diabetes, the prevalence of the component of unrecognized diabetes, and the age, color, and sex distribution of the population studied are factors of this nature. Factors which lend themselves to administrative control are selection of age groups for testing and selection of testing levels when the clinitron is used. Selection of the time interval between eating and testing may or may not be subject to control.

We have not been able to control this factor in our program.

It should also be recognized that fingertip blood is capillary blood which is practically arterial blood. Arterial blood shows much higher sugar readings after food than venous blood. Screening results employing fingertip blood would therefore be expected to be more sensitive at 1 and 2 hours after eating. In the fasting state venous and capillary blood have similar amounts of sugar, and the differences in sensitivity between fasting and 3-hour specimens would be negligible. These factors should be taken into consideration when venous blood is employed with the clinitron instead of fingertip blood as in our study.

Summary

Seven thousand two hundred and ninety-four persons applying for health cards were screened for diabetes, using testing levels of 130 mg., 160 mg., and 180 mg. with the clinitron, during consecutive periods of time. Retests with a modified glucose tolerance test were performed on all persons screening positive.

The percentage of persons tested who were found to have previously unrecognized diabetes ranged from 0.6 in the 30- to 39-year age group to 5.3 in the 60- to 69-year group. Age-adjusted rates based on the total number of known and new diabetics revealed higher rates in nonwhites than in whites, with nonwhite women showing the highest rate of any group (5.3 percent).

The highest yield of new diabetes cases (2.7 percent) was observed when testing was done between 1 and 2 hours after eating. Tests performed during this interval after eating also produced the lowest percentage of false positives in relation to total positive screening results.

The percentage of new cases found when the 130 mg. level was employed (2.4) was significantly higher than when higher screening levels were used. However, a significantly higher retesting load was encountered with use of the 130 mg. level than when the other levels were employed.

Selection of the appropriate screening level for use with the clinitron in a diabetes detection program hinges, in each case, on individual circumstances, of which the feasibility of retesting is an important example.

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Correction

In the Statement on Oral Poliovirus Vaccine in the October issue of *Public Health Reports*, p. 871, last column, last two lines, the name of the chairman of the Public Health Service Committee on Live Poliovirus Vaccine should be Roderick Murray, M.D.