PREVALENCE OF DIABETES, GLYCOSURIA AND RELATED VARIABLES AMONG A WHITE POPULATION IN CAPE TOWN*

W. P. U. JACKSON, M.D., F.R.C.P., A. I. VINIK, F.C.P. (S.A.), B. I. JOFFE, M.R.C.P., AMY SACKS, B. SOC. SCI. AND ISOBEL EDELSTEIN, B. SOC. SCI., *Endocrine Research Group, Department of Medicine, University of Cape Town*

This paper follows our previous studies concerning the prevalence of diabetes and related variables in Bantu, Indian and Malay communities.[1-4] We have attempted to investigate a sample of the White population in the Cape Town area, chosen to be reasonably representative of the general White population of South Africa with regard to age and sex distribution and income grouping, and to contain sufficient Afrikaans- and English-speaking and Jewish people for separate analysis.

We attempted to include every member of every family over the age of 10 years in the survey. The area chosen for survey was Milnerton (every alternate dwelling) and a sub-economic housing scheme in the adjoining suburb of Brooklyn (every fourth house). Details of methods adopted and difficulties encountered will be published elsewhere.

CLINICAL MATERIAL

All selected families were interviewed in order to obtain family data, to record already known diabetics, and to inform families of the 'screening clinics' which all members were required to attend. Screening was performed by urine testing and capillary blood sampling 2 hours after 50 G of glucose had been consumed after at least 4 hours without food. All subjects whose screening blood-sugar level was over 120 mg./100 ml. or who showed glycosuria, together with matched negative-screening controls, were requested to undergo a full oral glucose-tolerance test at the Medical School. The final diagnosis of newly 'discovered diabetes' was made on the result of this glucose-tolerance test if two or more of the following were abnormal (venous plasma, AutoAnalyzer Hoffman method):

Fasting level $\geqslant$ 120 mg./100 ml.
Maximum level $\geqslant$ 185 mg./100 ml.
2-hour level $\geqslant$ 140 mg./100 ml.

The total number of persons over 10 years of age who appear on the family data sheets is 1,650, of whom 1,186 were actually screened (546 males and 640 females), giving a recovery rate of 72%. Of these, 95 proved to be positive and 88 of these received full glucose-tolerance tests. Table I compares the age distribution of the surveyed community with the general population of White South Africans and it is clear that the greatest discrepancy lies in the small proportion of survey subjects between the ages of 15 and 29 years. There is also a deficiency in the survey group of those over 65 years. These discrepancies applied approximately equally to both sexes, both language groups and to the Jewish section. Appropriate age-corrections have therefore been applied to the analysis of results. 'Weight' was calculated as a proportion of the standard weight for height as taken from Documenta Geigy tables,[5] corrected for age. The term 'obese' is applied to those who were at least 15% above their standard weight.

*Paper presented at the 47th South African Medical Congress (M.A.S.A.), Pretoria, July 1969.

TABLE I. AGE DISTRIBUTION OF SELECTED 'POPULATION' COMPARED TO WHOLE WHITE POPULATION OF SOUTH AFRICA (1960 CENSUS),* EXPRESSED AS PERCENTAGE OF TOTAL

	Survey population		
Age in years	*No.*	*%*	*% of whole country*
10–14	261	15·8	13·3
15–19	146	8·8	11·3
20–24	121	7·3	9·7
25–29	122	7·4	8·6
30–34	195	11·8	8·7
35–39	181	11·0	8·2
40–44	164	9·9	7·6
45–49	128	7·8	7·8
50–54	94	5·7	7·0
55–59	86	5·2	5·2
60–64	73	4·4	4·0
65–69	40	2·4	3·2
Over 70	39	2·4	5·3
Total	1,650	100·0	100·0

*Over the age of 10 years.

TABLE II. PROCEDURAL SHEET

Total survey population		1,650
Known diabetic	13	
Screened at clinic		1,186 (72%)
Screened positive	95	
Received GTT	88	
Control neg. screenees	47	
Diagnosed diabetic	22	

RESULTS

Blood Sugar at Screening and Body-Weight (Figs. 1 and 2)

The distribution of 2-hour blood-glucose screening values was very similar for all ages over 15 years, the mode in all these age-groups being between 60 and 70 mg./100 ml. The curves were approximately Gaussian, with an increasing tail to the right with age. The 10 - 14-year-old curve was distinctly further to the right than the others, except that there were no values over 140 mg./100 ml. The highest blood-sugar value recorded was 280 mg./100 ml., in an asymptomatic 65-year-old woman.

Mean blood-sugar levels in decades are shown in Fig. 2. Women were slightly higher at all ages, though not significantly so at any one age.

There was no significant correlation between blood-sugar level at screening and body-weight. Over the age of 15 years, 23% of women and 16% of the men were obese. The Jewish subjects were more obese than non-Jews, 31% of women and 36% of men being more than 15% over standard weight. The difference between male Jews and male non-Jews is significant ($p < \cdot 01$).

Among women over 40 years (247 subjects) we found a positive correlation between blood sugar and the birth of a 10-lb. baby ($r = \cdot 170$, $p = 0 \cdot 01$), but no correlation between blood sugar and parity, miscarriages or stillbirths in the women's obstetrical histories.

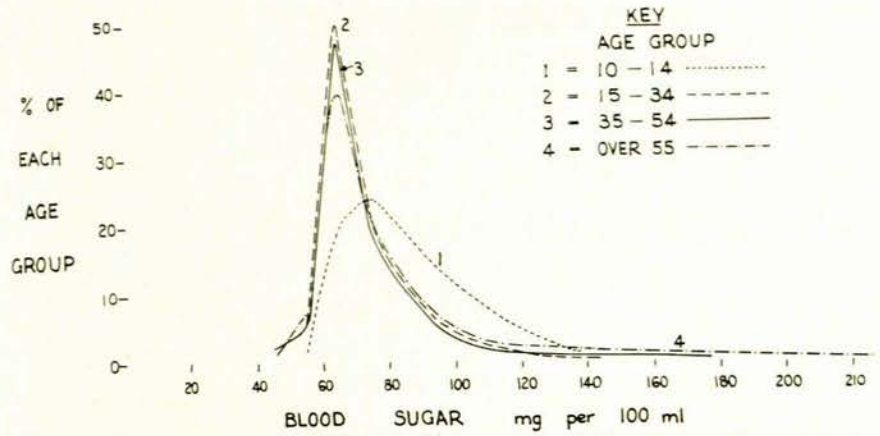

Fig. 1. The youngest age-group has the highest range of blood sugars, but no levels over 140 mg./100 ml. The distribution curves do not change with age, except for increasing numbers to the extreme right.

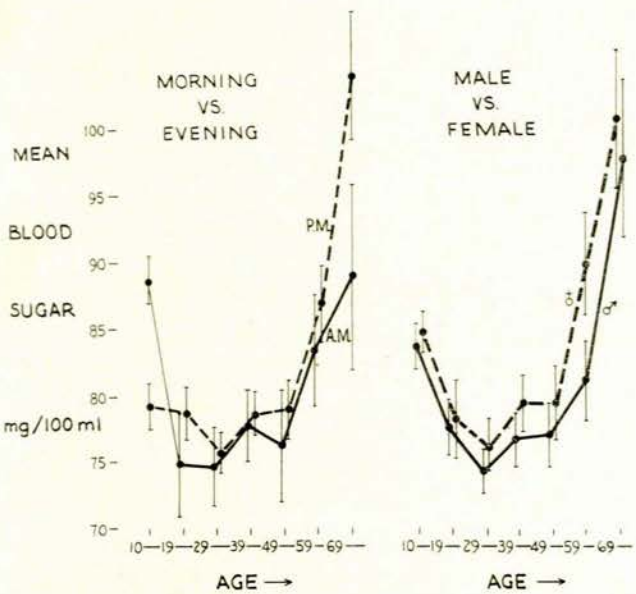

Fig. 2. Evening blood-sugar levels are in general slightly higher than morning ones, and female levels slightly higher than male. Increase in mean levels with age occurs only over 60 years. (The high over-70 figure in the left-hand graph is not significant because of small numbers—see large SEM. See text for discussion of high mean value given by the 10 - 19-year-old group who were tested in the morning.)

The mean blood-sugar values for English- (n = 574) and Afrikaans-speaking people (n = 325) over the age of 15 years were almost identical (80·3 and 79·0 mg./100 ml. respectively). Jews (n = 137) had a higher mean blood-sugar value (83·7) than non-Jews, despite the fact that there was a smaller proportion of Jews over the age of 40 years. This difference just fails to reach statistical significance at the 5% level.

The two highest income groups (n = 408) had a slightly higher mean blood-sugar level (82·6) than the two lowest income groups (n = 408) had a slightly higher 100 ml.).

Diabetes

The youngest previously known diabetic in the survey was a man of 43 years. The over-all prevalence of known diabetes was 0·8%, the prevalence over 55 years of age being 5% (Table III). The over-all prevalence of newly discovered diabetes was 1·9%; being 6·3% over the age of 55 years. The youngest discovered diabetic was a man aged 34 years. Diabetes, both known and discovered, was more common in men than in women.

Considering only those over the age of 15 years (for easier comparison with other racial groups) the total diabetes prevalence was 3·2% (4·0% for male and 2·5% for female, Table IV); over the age of 55 it was 11·8%. Age-correction for the general White population increases the over-15-years prevalence figure to 3·7%.

Afrikaans- and English-speaking people had virtually the same frequency of diabetes (Table V), but known diabetes was considerably more common among Jews (4·3%).

Obesity was present in 5 out of 12 men with 'discovered diabetes' and in 5 of the 10 women. Nine 'discovered diabetics' screened positive with glycosuria, but negative on blood sugar (i.e. below 120 mg./100 ml.). Six screened positive with blood-sugar levels over 120 without glycosuria and 7 screened positive in both blood and urine. Glycosuria was present at some stage in all but 3 of the 22 'discovered diabetics', and the fasting blood-sugar level was over 120 mg./100 ml. in 12. Only 4 gave a positive family history for diabetes.

Glycosuria

Results of testing for glycosuria at screening are shown in Table VI. The frequency of glycosuria in both sexes rose

TABLE III. ALREADY KNOWN DIABETES AND 'DIABETES' DISCOVERED AT SURVEY

	Known diabetes						*Discovered diabetes*					
	Male		*Female*		*Both sexes*		*Male*		*Female*		*Both sexes*	
Age-group	*No.*	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%
10–34	0	0	0	0	0	0	1	0·4	0	0	1	0·2
35–54	1	0·3	0	0	1	0·2	7	3·7	3	1·4	10	2·5
Over 55	7	6·3	5	3·9	12	5·0	4	5·6	7	7·4	11	6·3
All ages	8	1·0	5	0·6	13	0·8	12	2·2	10	1·6	22	1·9

TABLE IV. TOTAL DIABETES (KNOWN AND DISCOVERED; OVER AGE 15)

Age-group	Male		Female		Both sexes		Age corrected	
	No.	%	No.	%	No.	%	No.	%
15–34	1	0·2	0	0	1	0·1	1	0·1
35–54	8	4·0	3	1·4	11	2·7	10·0	2·7
Over 55	11	12·3	12	11·3	23	11·8	28·8	11·8
All ages	20	4·0	15	2·5	35	3·2	40	3·7

TABLE V. DIABETES PREVALENCE AMONG DIFFERENT GROUPS OVER AGE 15 YEARS (AGE CORRECTED)

	Known		Discovered		Total diabetic	
Subjects	Total at risk	Diabetic	Total	Diabetic	No.	%
Afrikaans-speaking (non-Jew)	429	3 (0·7%)	318	7 (2·2%)	10	2·9
English-speaking (non-Jew)	856	6 (0·7%)	561	12 (2·1%)	18	2·8
Jewish	93	4 (4·3%)	67	1 (1·5%)	5	5·8

TABLE VI. GLYCOSURIA AT SCREENING

	Male		Female		Both sexes	
Age	Diabetic glycosuria	Non-diabetic	Diabetic	Non-diabetic	Diabetic	Non-diabetic
10-14	0	1%	0	1%	0	1%
15-34	1%	5%	0	2%	1%	3%
35-54	2%	6%	1%	5%	2%	5%
Over 55	3%	20%	4%	4%	4%	13%
All ages over 15	2·6%	10·2%	1·3%	2·9%	1·9%	5·6%
Total glycosuria	12·8%		4·2%		7·5%	

with age, and this applied also after diabetics were excluded (1% of the 10 - 40-year-old non-diabetics had glycosuria, rising to 13% in the over-55 year group). Glycosuria was much more common in men than in women. More glycosuria was non-diabetic than diabetic; the overall chance of glycosuria indicating diabetes was approximately 2 in 7, or 30%. Because the screening blood sugar was estimated only at 2 hours after oral glucose was taken, it was not possible to attempt any separation of non-diabetic glycosuria into 'renal', 'lag curve', and 'borderline diabetes'.

Twenty out of 22 'discovered diabetics' had glycosuria on one or other test, but only 16 showed glycosuria at screening.

DISCUSSION

The unexpectedly high blood-sugar levels at screening in schoolchildren are seen in Fig. 2 and account for the high mean morning level in the first graph for the 10 - 19-year-old group and high levels for both males and females in the same age-group in the second graph. In Fig. 1 these high levels cause a shift of the blood-sugar distribution curve to the right compared with other age-groups—except that in this age range there was no screening value over 140 mg./100 ml. The reasons for the high screening levels in schoolchildren are not clear, but we think they may be related to the emotion associated with mass screening.

It was further surprising to find that, over the age of 15 years, the blood-sugar distribution curves did not change with age; except that there were more individuals with abnormally high levels in older age-groups. These few high figures accounted for the small rise in mean blood-sugar levels which occurred after the age of 40 years as shown in Fig. 2.

Although the mean blood-glucose screening levels were consistently slightly higher in women than in men, we found more diabetes, both known and discovered, among men (4·0% compared with 2·5% over the age of 15 years; not a statistically significant difference). This finding seems to follow a world trend—the well-known female preponderance of diabetes in early decades of this century among White people is diminishing or abolished.[6] It is actually doubtful whether an excess of diabetic females ever existed in non-White communities.

As usual in population surveys, we found no correlation between blood-sugar values at screening and bodyweight. We also observed no correlation of blood-sugar values with parity—in line with our previous conclusion that childbearing is not diabetogenic.[7] The birth of a 10-lb. baby is a strong suggestion that the mother will later develop diabetes. It was interesting that this phenomenon should correlate with the screening blood-sugar level.

The over-all prevalence of already known diabetes of 0·8% is similar to that found in White communities in several countries, including Britain, the USA, Canada, Norway and Sweden,[8-10] but is considerably less than that among Cape Indians.[3,4] As expected, the prevalence of known diabetes rose with age—in fact almost all known diabetics were over 55 years of age.

The over-all discovered diabetes rate of 1·9% (6·3% over 55 years of age) was lower than we had expected. The prevalence of total diabetes over the age of 15 years was 3·2% (or 3·7% age-corrected); this compares closely with the 3·6% for Cape Bantu.[3,4] It thus appears that urbanized Bantu suffer from diabetes as frequently as White South Africans, at least in Cape Town. This White diabetes rate of 3·2% was much lower than that among Cape Indians (10·2%; if age corrected 19·1%) and Cape Malays (7·3%).[4]

Compared with other White communities the figure for total diabetes of 3·2% is virtually the same as that found in the original survey at Oxford, Massachusetts, by Wilkerson and Krall.*[9] This survey, however, was based on postprandial blood-sugar screening and very stringent criteria for diagnosis; in other words their estimate was certainly too low by our standards. Our 3·2% is higher than that found in many reported surveys in which glycosuria or other insensitive means of screening were used—as in the case of the 1·9% from Norway, 1·4% from Ibstock, England, 0·95% from Forfar, Scotland, 1·3% from Sweden,[8] 1·3% from Canada,[9] and so on. However, in the few surveys that have been based on postglucose blood-sugar estimations (i.e. some modification of the glucose-tolerance test) the estimates have been far higher—around 10% in the Birmingham and Bedford areas in Britain[12,13] (though in both cases these were indeed estimates rather than true surveys), in a nationwide study in the USA,[14] and in restricted studies at Tecumseh[15] and in Pennsylvania.[16] Our own results can thus be compared with these, although the criteria of eventual diagnosis differed in each region. Even using the most lax of the various published

*Provided glycosuria is not included in the criteria for a positive diagnosis.[11]

criteria for 'diabetes' our White prevalence figures are lower than these. Assuming that our survey is representative of the whole country it would thus appear that diabetes, diagnosed by present-day methods, is less common among White people in South Africa than in Britain or America. Nevertheless, by our criteria something approaching 100,000 White South Africans have diabetes without knowing it.

The similarity of the findings among English- and Afrikaans-speaking people does not necessarily apply to the whole country—the state of affairs may be different in the predominantly Afrikaans farming areas for instance. It has long been believed that diabetes is particularly common among Western Jews[17] (of Ashkenazi origin[18]), but as far as we are aware no other survey has attempted to investigate this by comparing Jews and non-Jews in the same area. The present figures suggest a higher prevalence of known diabetes, but no more 'discovered diabetes'. Perhaps our Jewish subjects are more diabetes-conscious and are thus diagnosed earlier. On the other hand, the Jewish community had higher mean blood-sugar levels on screening than non-Jews at all ages though none of these differences was statistically significant. There was also considerably more obesity among Jews, especially in men.

Some of the characteristics of the 22 diabetics who were newly discovered at the survey are important. Half were obese in a community in which one-fifth was designated obese by our definition. The fasting blood-sugar level was greater than 120 mg./100 ml. in over half—some might view this as confirming the diagnosis of diabetes. Particularly surprising was the finding that 19 out of 22 had glycosuria at one or both testings. We had expected to find far more non-glycosuric hyperglycaemia. On the other hand, because of individual fluctuations, the blood-sugar values of 9 of our diabetics did not reach the cut-off level at screening, and screened positive only by reason of glycosuria. It is thus clear that valid results for screening for diabetes can be obtained only if blood and urine are both examined.

Another surprising factor was that a positive history of diabetes in the family was obtained in only 4 of 22 discovered diabetics, and 3 of the 13 already known diabetics. Being lower than those reported in other surveys, these figures are compatible with the finding that diabetes itself is actually less common in our community or, alternatively, that our White people are sadly lacking in health knowledge relating to their families.

A further interesting feature was the absence of any young discovered diabetics. This is similar to our findings among the Bantu, but in contrast to the Indians, among whom 1% of the 15 - 20-year age-group were clearly diabetic.

Glycosuria

The frequency of glycosuria after ingestion of glucose was higher in men than in women, was very similar to that found in our Coloured racial groups in Cape Town, and rose with age. Non-diabetic glycosuria rose from 1% in children to 13% in the over-55-year group, with very little change in blood-sugar levels. We have previously contended that the renal threshold for glucose frequently diminishes with age.[3]

The over-all likelihood that glycosuria at screening indicated diabetes was approximately 30%—analyses of previous surveys have shown that the predictive value of glycosuria rises with age and is higher among women.[3] In these surveys only 4% of young men with glycosuria proved to be diabetic, as against 77% of women over 55 years of age.

SUMMARY

A representative community of White people in Cape Town was surveyed in order to ascertain the prevalence of diabetes and related variables. The selected sample consisted of 1,650 persons over the age of 10 years, of whom 72% were screened by blood-sugar level and testing for glycosuria 2 hours after a glucose load. The mean blood-sugar values obtained were highest in the 10 - 14-year age-group (reasons for which are uncertain), otherwise the distribution of blood-sugar levels was virtually the same for all ages, both sexes, and English- and Afrikaans-speaking people. There were slightly more abnormally high values in the older age-groups. Jewish people had higher blood-sugar levels at all ages than non-Jews, and also more previously known diabetes. Blood-sugar levels did not correlate with body-weight or parity but correlated with heavy babies in the mothers' obstetric history.

The prevalance of known diabetes at all ages was 0·8% and of 'discovered diabetes' 1·9%. The total diabetes prevalence over the age of 15 years was 3·2%. Diabetes was more common in men (4·0%) than in women (2·5%) and rose with age—it was 11·8% over 55 years. Hyperglycaemia sufficient for the diagnosis of diabetes was not found in any young person under 30 years, in contrast to results among the Indians. The prevalence of diabetes, both 'known' and 'discovered' among the White people was the same as among the Cape Bantu, but much less than among Cape Indians.[2]

Glycosuria in the White community was very similar to that in the non-White people. The frequency was higher in men than women, and rose with age. Non-diabetic glycosuria occurred at screening in 1% of schoolchildren and 13% of people over the age of 55 years, and was more common than glycosuria caused by diabetes. Glycosuria was found in 9 subjects later defined as 'discovered diabetics', who screened negative on blood-sugar levels.

We wish to thank the many people who helped us with various aspects of this work, particularly our laboratory staff, Messrs I. O'Reilly, S. Hendricks and Mrs D. Zarenda. We are grateful for time on the University computer. This study was supported by the South African Council for Scientific and Industrial Research and by grants from the US Public Health Service (Grant AM 09052) and by Messrs Hoechst Pharmaceuticals, and it forms part of the work of the joint University/CSIR Endocrine Research Group.

REFERENCES

1. Jackson, W. P. U., Marine, N. and Vinik, A. I. (1968): Lancet, **1**, 933.
2. Jackson, W. P. U., Goldberg, M. D., Marine, N. and Vinik, A. I. (1968): *Ibid.*, **1**, 1101.
3. Goldberg, M. D., Marine, N., Ribeiro, F., Campbell, G. D., Vinik, A. I. and Jackson, W. P. U. (1969): S. Afr. Med. J., **43**, 733.
4. Marine, N., Vinik, A. I., Edelstein, I. and Jackson, W. P. U. (1969): Diabetes (in the press).
5. Documenta Geigy (1962): *Scientific Tables*, 6th ed., p. 623. Basle: J. R. Geigy.
6. Malins, J. M., Fitzgerald, M. and Wall, M. (1965): Diabetologia (Basel), **1**, 121.
7. Jackson, W. P. U. (1961): Lancet, **2**, 1369.
8. Jorde, R. (1969): *Diabetes: Proceedings of the 6th Congress of the International Diabetes Federation*, p. 669. Amsterdam: Ostman & Milner.
9. Kenny, A. J. and Chute, A. L. (1953): Diabetes, **2**, 187.
10. Wilkerson, H. L. C. and Krall, L. P. (1947): J. Amer. Med. Assoc., **135**, 209.
11. O'Sullivan, J. B., Wilkerson, H. L. C. and Krall, L. P. (1966): Amer. J. Publ. Hlth, **56**, 742.
12. Working Party appointed by the College of General Practitioners (1963): Brit. Med. J., **2**, 655.
13. Butterfield, W. J. H. (1964): Proc. Roy. Soc. Med., **57**, 96.
14. Gordon, T. (1964): *Glucose Tolerance of Adults, United States, 1960 - 1962*. National Center for Health Statistics, series 11, No. 2. Washington, DC: US Public Health Service.
15. Hayner, N. S., Kjelsberg, M. O., Epstein, F. H. and Francis, T. (1965): Diabetes, **14**, 413.
16. West, K. M. and Kalbfleisch, J. M. (1966): *Ibid.*, **15**, 9.
17. Joslin, E. P., Root, H. F., White, P. and Marble, A. (1959): *The Treatment of Diabetes Mellitus*, 10th ed. Philadelphia: Lea & Febiger.
18. Cohen, A. M. (1961): Metabolism, **10**, 50.