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Report of a WHO Expert Committee

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WHO EXPERT COMMITTEE ON DIABETES MELLITUS

Geneva, 24-30 November 1964

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CONTENTS

		Page
1.	Introduction	5
2.	Natural history of diabetes mellitus and its causes	6
	2.1 Definitions of diabetes mellitus and related states	7
	2.2 Definition of laboratory criteria in the diagnosis of diabetes mellitus	9
	2.3 Classes of diabetes mellitus	13
3.	Prevention of diabetes mellitus	15
	3.1 Genetics	15
	3.2 Congenital factors	16
	3.3 Nutrition	16
	3.4 Diet and prevention of diabetic complications	17
4.	Control of diabetes mellitus as a public health problem	19
	4.1 Screening methods and procedures for early case detection	19
	4.2 The principles of treatment of diabetic patients	22
	4.3 Organization of services	25
4.	Employment and placement of diabetics	31
	5.1 General recommendations—young diabetics	32
	5.2 General recommendations—adult cases	33
	5.3 Driving permits	34
	5.4 Life assurance	35
6.	Research	35
7.	Recommendations	37
Annex 1.	Summary of results of diabetes detection surveys in various countries, 1946-1964	39
Annex 2.	Blood-sugar readings of 1000 glucose tests for pregnant women, by trimester of pregnancy, Boston, Mass., USA, 1954-55	41
Annex 3.	Testing techniques	42

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DIABETES MELLITUS

Report of a WHO Expert Committee

A WHO Expert Committee on Diabetes Mellitus met in Geneva from 24 to 30 November 1964. Dr G. W. McDonald was elected Chairman, Professor J. P. Hoet, Vice-Chairman, and Professor W. J. H. Butterfield, Rapporteur.

Dr P. Dorolle, Deputy Director-General, opened the session and welcomed the members of the Committee and representatives from the International Labour Office and the International Diabetes Federation. In his opening address, Dr Dorolle stressed the necessity for a wide review of current knowledge on diabetes mellitus at this meeting and expressed the hope that the Committee would recommend definitions of the various terms currently used in application to this disorder in the interests of international uniformity. He also urged that practical considerations for the prevention and control of diabetes mellitus should be given particular attention.

1. INTRODUCTION

In an initial exchange of views between the various members of the Expert Committee, it was immediately apparent that there was general agreement about the signs of increasing prevalence of diabetes mellitus in most parts of the world.

Thus, in contrast to the well-documented evidence of reduced incidence of diabetes mellitus in the adult when the food intake was restricted in many countries during the Second World War — a repetition of the phenomenon observed by Bouchardat in Paris nearly a hundred years ago — there are now indications of a rapid increase in the disease that are in complete accord with the recognized clinical association between diabetes and increased food consumption, reduced physical exertion and obesity. The increase continues despite the special foods now often available.

After some years, diabetes mellitus becomes associated with various complications : a proportion of patients suffer disability due to changes in the eye, kidneys, blood vessels, and nervous and other systems. The Committee was particularly concerned about these trends, since many

new cases could be prevented through education and practical public health measures. Furthermore, it strongly emphasized that the new cases receiving medical care represent only a small fraction of those that remain undetected in all communities today. This has been repeatedly confirmed by population screening programmes and recent epidemiological studies in many countries, of which a sample was reviewed and summarized for the Committee by the WHO Health Statistics Division (see Annex 1).[1] The Committee was also unanimously convinced, from personal knowledge and observation, of the existence of this trend in many other countries and communities, as exemplified by, for example, the appearance now in some parts of the world of diabetes among all social classes; at the turn of the century the disease was unknown except among the wealthy.

As far as can be ascertained, therefore, the new situation is probably the same in all countries; and it should not be ascribed simply to increasing numbers of diabetic cases found among the elderly and attributable to increasing longevity, since there appears to be a similar trend among younger age-groups. It can be predicted that diabetes, with its chronic vascular complications, will impose an increasing burden on the health resources of the world.

2. NATURAL HISTORY OF DIABETES MELLITUS AND ITS CAUSES

Diabetes mellitus is associated with hyperglycaemia due to a disturbance in the relationship between glucose in the blood and insulin, the hormone responsible for its assimilation by tissues. All modern data about this disease, which runs in families and may be genetic, show that it exists for a long time (often years) before symptoms develop. These symptoms may not be recognized as due to diabetes and vary in different parts of the world; for example, thirst or tiredness are symptoms in some countries, and skin infections in others. Furthermore, the breakdown of the blood-sugar/insulin relationship characteristic of the disease can fluctuate, making it necessary to distinguish various phases in a diabetic's life. All these features are of importance from the clinical and public health points of view. Thus, every clinician interested in the care of diabetic patients will know of cases where the hyperglycaemia has come and gone, for example, in a susceptible female during pregnancy, or in a susceptible

[1] The Committee considered it desirable that the compilation of the results of such surveys should be kept up to date and be made widely available.

person of either sex following a period of inactivity or over-eating or under the stress of disease.

There are therefore many possible etiological factors that might affect carbohydrate disposal in man — for example, the biosynthesis of relatively inefficient insulins of abnormal amino-acid sequence, impaired circulation to the β-cells of the islets of Langerhans, where insulin is formed, inadequate β-cell numbers, impaired insulin release, abnormal insulin-antagonistic blood proteins, altered capillary basement membranes, or changes in the metabolic response of the tissues induced by competition between glucose and other substrates such as non-esterified fatty acids. Physiological, endocrinological and psychological factors may all affect this chain of events. Until present knowledge is considerably extended so that it will be possible to settle (*a*) whether there is a single inherited cause, or many causes, of hyperglycaemia, and (*b*) whether or not all hyperglycaemic states lead inevitably to the vascular, renal, neurological, ocular and other complications of the disease, it seems prudent to recommend definitions that would apply present knowledge to the classification of individual diabetics. It is to be hoped that the acceptance of such clinical definitions will quickly remove terminological differences that hinder the accumulation of the accurate information urgently needed to clarify the public health problems of diabetes, and so motivate action to resolve them.

2.1 Definitions of diabetes mellitus and related states[1]

Potential diabetics

These are persons in whom diabetes may be prognosticated with reasonable reliability. They respond normally to a glucose tolerance test (G.T.T.),[2] but there is a clear risk of their developing diabetes. Potential diabetics include :

(1) The identical twin of a diabetic;

(2) A person with both parents diabetic;

(3) A person with one diabetic parent whose other, non-diabetic, parent has or had a diabetic parent, sibling, or offspring, or a sibling with a diabetic child;

(4) A woman who has given birth to a live or stillborn child weigh-

[1] Derived from : Fitzgerald, M.G. & Keen, H. (1964) *Lancet*, **1**, 1325.

[2] See page 9 for the Committee's views on glucose tolerance tests.

ing 4.5 kg or more at birth,[1] or to a stillborn child showing hyperplasia of the pancreatic islets not due to rhesus incompatibility.

Latent diabetics

(1) A person in whom the G.T.T. has produced a normal result but who is known to have been diabetic according to the G.T.T. at some time during pregnancy, during infection, when under some other stress, or when obese.

(2) A person who has abnormal blood-glucose responses (similar to those found in diabetes mellitus) to provocative tests, such as the cortisone-augmented G.T.T. (The Committee considered that these tests should at present be largely confined to research.)

Asymptomatic (sometimes referred to as subclinical or chemical) diabetics

(1) A person with a diabetic response to the G.T.T. whose fasting true blood-sugar is below 130 mg/100 ml (capillary) or 125 mg/100 ml (venous).

(2) As above, but with fasting true blood-sugars above the stated values.

Clinical diabetics

A person with an abnormal response to the G.T.T. and with the symptoms or complications of diabetes.

Notes on diabetic states

Pre-diabetes. This is a term that can be used retrospectively when reviewing a case. The definitions above differ slightly from those adopted by many physicians, who would classify as pre-diabetics the identical twin of a diabetic, and the children of two diabetic parents. However, it is recommended that the term " pre-diabetes " should be reserved for the period of time from conception to the diagnosis of an episode of diabetes (of any defined severity), and that it should be used in research rather than in clinical situations. It is well known that in the pre-diabetic stage increased levels of insulin and/or insulin antagonists may be found in the blood, some vascular changes may be present or it may be found that women have given birth to babies of high birth weight. However, pre-diabetes should exclude impairment of glucose tolerance by definition.

Potential diabetes. It was pointed out that certain persons were potential diabetics from the moment of conception, so that any steps

[1] In some countries, with lower average birth weights, 4 kg may be more appropriate.

that might be taken, such as control of maternal diabetes during pregnancy, to alleviate or reduce the chances of the early development of diabetes should be strongly recommended on preventive grounds.

Diabetes. It was also recognized that the diagnostic label " diabetes " as defined above was really inadequate; in the early future consideration should be given to a fuller and more meaningful descriptive classification. This might include such facts as : age, sex and parity (where appropriate), recognized time of onset and its relation to growth and puberty, body shape (e.g.,lean, normal, obese), dependence on insulin injections, presence of complications (ocular, renal, etc.) and perhaps even diet and exercise.

2.2 Definition of laboratory criteria in the diagnosis of diabetes mellitus

It must be borne in mind that establishing the diagnosis of diabetes mellitus depends on the clinical history, the evaluation of symptoms and the findings on physical examination, as well as on laboratory aids. The Committee recognized the difficulties posed by attempting to make world-wide recommendations about these laboratory tests, particularly with respect to the G.T.T. blood-sugar values that are to be taken as criteria for the diagnosis of diabetes. The firmness of the following suggestions reflects the reliability of current information on the different aspects discussed.

Glycosuria and fasting blood-sugar

Glycosuria is not a reliable index of hyperglycaemia, since 2 %-4 % of the population have a low renal threshold for glucose (so-called " renal " diabetes in some countries). The Committee was unanimously agreed that, whereas glycosuria and a fasting true blood-sugar level over 130 mg/100 ml must be taken as indications that are of positive value in alerting the responsible physician to the probability of diabetes mellitus, under no circumstances should the absence of glycosuria or a lower fasting blood-sugar be allowed to rule out the diagnosis.

Glucose tolerance tests

The loading dose. The Committee therefore endorsed the generally accepted view that after three days on diets of not less than 250 g carbohydrate per day some form of glucose tolerance test must be applied, but was not prepared, on present evidence, to recommend any single test as deserving world-wide acceptance to the exclusion of all others for the diagnosis of diabetes. With the proviso that control population studies (see below) should be recognized as of paramount importance in defining the *precision* and, therefore, the *value* of any form of glucose

tolerance test in each country, and noting that the hyperglycaemic response one to two hours after either of the single oral glucose loads (as given below) was surprisingly similar, the Committee urged that one of the following loads be accepted wherever feasible, in the hope that, by so restricting the number of possibilities, the accumulation of worth-while control data would be proportionately hastened.

Each test should be performed in accordance with the general procedures laid down in the relevant medical literature. The diet and physical activity should be unrestricted for at least three days before the test. After the subject has fasted for twelve hours overnight and has spent half an hour sitting quietly, a fasting sample of capillary or venous blood is drawn. Thereafter the tolerance test is performed with a minimum of disturbance, the subject remaining seated or reclining throughout and refraining from smoking. The oral loads recommended below should be drunk within five minutes from the moment the subject starts drinking.[1]

Two loads are regarded as acceptable :

(1) 50 g glucose (dextrose monohydrate), given as a 10%-20% solution with suitable non-caloric flavouring where possible to avoid nausea. For children (or grossly underweight, small adults—i.e., adults more than two standard deviations below national weight and height standards), this dose should be adjusted by administering 30 g/m^2 body surface.

(2) 100 g glucose (dextrose monohydrate), given in 400 ml water with suitable non-caloric flavouring where possible to avoid nausea. For children (and grossly underweight adults), this dose should be adjusted by giving 60 g/m^2 body surface with appropriate reduction in volume.

It was noted that the 50-g load is in wide use and found acceptable today in countries with very diverse standards of height and weight. This amount of glucose can be replaced by an equivalent carbohydrate load (45.4 g) of Liquid Glucose,[2] without altering the diagnostic levels of the text. The 100-g load is also widely used, but data on the effects of substituting Liquid Glucose for glucose are not yet available. Investigators using other loads and procedures must take the responsibility for establishing their own criteria of normality.

The Committee was unable to recommend double glucose-loading procedures for world-wide use at this time.

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[1] Some research workers prefer rapid intravenous glucose loads, using the appropriate methods of analysis of the slope for comparison with suitable control data. However, the Committee preferred oral tests at this time because, although they take longer, (*a*) they represent an easier and more natural form of glucose loading, and (*b*) they involve less risk and need less technical support.

[2] *British Pharmaceutical Codex, 1963*, London, Pharmaceutical Society of Great Britain, p. 338; *The Pharmacopaeia of the United States of America, 16th revision, 1960*, Easton, Penn., Mack Printing Co., p. 308.

It is suggested that the responsible health authorities in each country or region seek out their local diabetes specialists and accept their advice regarding the most appropriate and feasible test for the community in question.

Blood-sugar values as criteria for the diagnosis of diabetes mellitus

Because of the lack of appropriate control data in persons drawn at random from different sex- and age-groups of defined populations to serve as a reliable basis for any recommendations, the Committee encountered much difficulty when confronted with the task of preparing criteria for the confirmation of diabetes mellitus based on G.T.T. blood-sugar values. The Committee found it easier to establish two levels. The first represents values below which diabetes, on the particular occasion, would either be ruled out or be regarded as latent. The other values refer to blood-sugar levels above which diabetes could be regarded as definitely established. Cases falling between the two sets of values would be border-line cases: if near the values accepted for normal, the possibility that they were diabetic would be less great than in those close to the criteria for diagnosis on a laboratory basis. The physician would therefore have to look more closely for other evidence in, for example, family or obstetrical history, the findings on physical examination (e.g., cataract, vascular disease), or more thorough laboratory tests, to check the diagnosis. All these factors, and obesity, should be taken into account in assessing the need for, and type of, treatment.

Obviously, the discrepancy between these two values can be expected to diminish as data are collected on glucose tolerance in the population at large, and on the relationship between glucose tolerance and the course and development of the disabling diabetic complications. Nothing is more difficult, in this respect, than choosing specific levels to segregate diabetics from non-diabetics on the basis of blood-sugar values measured in the first hour after administering glucose. After considerable discussion, the Committee agreed it would be wiser to delay making recommendations about diagnostic levels established in this way. The two-hour levels set out below are more reliable but should not be regarded as irrevocable.

Normal (or latent) diabetic levels. Providing there are no causes for abnormal glucose absorption, such as gastro-intestinal and hepatic diseases, resection of bowel, or thyroid disease, it was agreed that two-hour levels of venous true blood-sugar of less than 110 mg/100 ml blood would indicate normal carbohydrate tolerance — i.e., normality — although latent or potential diabetes could not be excluded. The equivalent level of capillary true blood-sugar recommended is 120 mg/100 ml blood.

Diabetic levels. With the same provisions about absorption and other conditions as above, the Committee believed that diabetes would be accepted as established anywhere in the world if, in a person under 45 years of age, the two-hour venous true blood-sugar values reached or exceeded 130 mg/100 ml. The equivalent level of capillary true blood-sugar recommended is 140 mg/100 ml blood.

When a higher level is found in a person over 45 years of age, and especially over 65, the Committee considered that the other clinical data — family history, physical examination, etc. — should provide the main guides to the diagnosis and treatment needed, since population-study data becoming available make it clear that aging is associated with diminishing glucose tolerance (i.e., higher blood-sugar curve).

The border-line state. Many persons are in the border-line state between the values given in the accompanying table for normality and diabetes (i.e., 110-129 mg/100 ml for venous and 120-139 mg/100 ml for capillary blood). The Committee urged all physicians and health authorities to pay special attention to this group, who will yield a high proportion of diabetics and for whom preventive measures will be most rewarding. Furthermore, it is among this group that research is most likely to reveal important information. Re-examination and re-evaluation of these people at regular intervals is mandatory.

RECOMMENDED LEVELS OF TRUE BLOOD-SUGAR TWO HOURS AFTER GLUCOSE LOADING

Blood	Normal	Diabetic
Venous	Less than 110 mg per 100 ml blood	130 mg and over per 100 ml blood
Capillary	Less than 120 mg per 100 ml blood	140 mg and over per 100 ml blood

Accumulation of control data: an urgent priority

The Committee was conscious of the rapid developments in the fields of diabetic research occurring in all parts of the world, but wished to draw special and repeated attention to the lack of suitable epidemiological information about glucose tolerance in various populations of various races and cultures in different countries. It recommended that responsible authorities everywhere should recognize the opportunity afforded them to place this important matter on a firm basis by encouraging investigations in

their own countries. Furthermore, all studies of glucose tolerance in random samples of populations should be carried out in one of the standard manners described.[1]

2.3 Classes of diabetes mellitus

Once a diabetic has been thus identified it may be possible to classify him or her. It is obviously possible to define diabetic types according to the period of life when the disease begins and becomes manifest, e.g., the so-called growth-onset or adult-onset diabetes, or according to the need for, and response to, treatment, e.g., insulin-dependent diabetes. However, after much discussion, the Committee came to recognize that the available terms were not really suitable for world-wide use. For example, growth terminates at different ages in different countries: the present acceptable groupings or definitions do not cover all cases nor add up to the sum total of diabetics in any community. This was regarded as a serious disadvantage, and it was therefore decided to make the following strong recommendations, based on the age of recognized onset, which seemed the only reliable means of classification for universal use.

(1) Recognized onset between ages 0 and 14 years (*infantile or childhood diabetics*). These cases usually present severe initial symptoms and rapidly become insulin-dependent. The age-group is within the limits imposed by a good deal of paediatric research.

(2) Recognized onset between 15 and 24 years (*young diabetics*). These cases usually have an acute onset of symptoms and most may be expected to become insulin-dependent. However, in the tropics, cases in this age-group may resemble the adult cases (see below).

(3) Recognized onset between 25 and 64 years (*adult diabetics*). Growth-onset, insulin-dependent diabetes may occur up to the age of 22 or 23 years, but between 20 and 25 years such cases merge into the adult-onset cases that are much less insulin-dependent. The Committee recommended the designation of this third, adult, group, which is very similar to the current adult-onset group. Cases begin with variable symptoms and may or may not need insulin.

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[1] As far as possible such studies should be carried out using forms to record as much data on each individual as possible : name, age, sex, community or address, height, weight, body build, family history of diabetes, birth weight, previous illnesses, pregnancies with birth weights of any children or miscarriages, any drugs being taken, data about the carbohydrate load, the route of administration and the times and form (venous or capillary) of blood sampling, blood-sugar (or glucose) levels at these times and the method of estimating true blood-sugar or glucose : it was noted that simplified methods (e.g., impregnated papers) are becoming available (see Annex 3, page 42) that may prove sufficiently reliable for such studies. It would be appreciated if investigators would communicate to WHO any detailed results thus obtained.

(4) Recognized onset over 65 years of age (*elderly diabetics*). This class represents those persons whose diabetes develops after the 65th birthday. These cases frequently present with symptoms of the complications of diabetes and can often be controlled without resort to insulin injections.

The above age-groups have the advantage that they correspond to those recommended in the WHO Nomenclature Regulations,[1] which is convenient for tabulation and statistical comparison.

It should be noted that all classifications refer to the age *when the diabetes was recognized*, and *not* to the current age of the patient. The Committee recommends that, wherever possible, prevalence data should be expressed in terms of cases per 1000 population by class and age-group.

In addition to these classifications by age, the Committee recognized certain other types of diabetes, which were defined as follows:

Juvenile-type diabetes. This term should refer to cases in any age-group that require insulin and are prone to attacks of ketosis.

Brittle diabetes. It was recommended that this term should be used as little as possible when referring to juvenile-type cases that prove difficult to stabilize between hyperglycaemia and ketosis on the one hand and hypoglycaemia with symptoms on the other. Genuine brittle diabetics are very uncommon compared with the other types; furthermore, the brittle state does not necessarily persist. These cases represent the only diabetic class for which employment problems were envisaged by the Committee.

Insulin-resistant diabetes. This term should be reserved for cases requiring over 200 units of insulin per day.

Gestational diabetes refers to hyperglycaemia of diabetic levels (see above) occurring during pregnancy. This condition is responsible for embryopathia diabetica in the foetus.

Pancreatic diabetes. Cases where disordered carbohydrate tolerance can be attributed directly to destruction of the pancreas — e.g., through surgery or calcification and, perhaps, in haemochromatosis and haemosiderosis.

Endocrine diabetes. Cases where disordered carbohydrate tolerance can be attributed to endocrinological disease — e.g., Cushing's disease

[1] *Off. Rec. Wld Hlth Org.*, 1948, **13,** Annex 1, Articles 6, 7, 8, and 15; as amended by: Additional Regulations of 21 May 1956 (*Off. Rec. Wld Hlth Org.*, 1956, **71,** 426). (For an extract of the Regulations, see: *Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death*, 1955 Revision, Geneva, World Health Organization, Vol. 1, p. 393.)

(i.e., pituitary basophilic hypersecretion), Cushing's syndrome (i.e., adrenocortical hyperfunction), acromegaly and perhaps thyroid disease.

Iatrogenic diabetes. The Committee recognized that various forms of therapy may precipitate diabetes mellitus — e.g., steroids and certain diuretics — and that where this causal relationship could be established without doubt, the classification as an iatrogenic diabetic should be accepted.

These classifications may need revision from time to time, and they should not replace the classification based on age of onset suggested on page 13. However, adherence to the definitions set out above would be a great help in describing relevant clinical material in research or population reports.

3. PREVENTION OF DIABETES MELLITUS

3.1 Genetics

Most authors today believe that diabetes mellitus is an inherited disease. The findings in monozygotic twins are the strongest evidence in support of this view; in seven out of ten pairs diabetes will appear in both, although there may be a delay of ten or more years between the onsets. For instance, a married woman may become diabetic during a first pregnancy at, say, 21, while her unmarried twin may reach 35 years of age before developing symptoms of the disease.

On genetic grounds, therefore, it is generally agreed that diabetics should be counselled (*a*) not to marry another diabetic, or (*b*), if they marry another diabetic, not to have children, because conjugal diabetes may increase the number of diabetic offspring and perhaps determine the appearance of diabetes at earlier ages. The same advice should be given, but perhaps less categorically, to an overt diabetic contemplating marriage with a potential diabetic.

However, it would be unwise, particularly from the public health point of view, to assume that diabetes is always due to a single recessive gene — which might suggest that little can be done to prevent the condition. There is a strong body of opinion that polygenic inheritance or other complex causes may be involved.

Whatever theory is favoured, it would appear prudent to assume that a high proportion of the population has a greater or lesser tendency to diabetes in view of the high prevalence of the disease now recognized among the elderly in many countries. In persons who have this tendency, almost any factor taxing the insulin-producing β-cells of the pancreas may lead to the diabetic state. Today the most common factors are lack of physical exertion and obesity, whereas endocrine or other disorders

are rare. The situation appears to be aggravated for the elderly, in whom the glucose metabolic balance is disturbed by the general impairment of their ability to synthesize proteins, including perhaps the hormone insulin. In this connexion, from the preventive point of view it is also noteworthy that a child or grandchild may develop diabetes some years before members of the older generation — the so-called " anticipation of diabetes ". This phenomenon should lead the paediatrician, on finding a new case of infantile or childhood diabetes, to make close inquiries about older relatives and recommend their screening.

3.2 Congenital factors

Another possible excessive demand upon the β-cells of the islets of Langerhans occurs in the foetus when the mother (but not the father) is diabetic, because the abnormalities in her circulating blood can be transmitted through the placenta.

Before insulin became available, it was an exceptional event for a diabetic woman to have a liveborn child and to keep it alive. Even today, with modern therapy, the infant of a severely diabetic mother may be stillborn, oversize and overweight, with cardiomegaly, hepatomegaly and erythroblastosis. On post-mortem examination, the pancreas of such an infant is characterized by hyperplasia of the islets of Langerhans.

Among surviving children, diabetes is often observed early in life, and to reduce risk it is recommended that even mild diabetes should be controlled during pregnancy, especially as the physiological endocrine disturbances associated with this state themselves are a burden on the β-cell insulin production of the mother.

Another important possibility under active investigation is that maternal hyperglycaemia may lead to foetal congenital malformations, in particular of the central nervous system, and this must be taken as another strong reason for recommending that gestational diabetes should be sought out and controlled. Some data indicating the changes observed in glucose tolerance at various stages of pregnancy are reproduced in Annex 2.

The diabetic or potentially diabetic pregnant woman must be treated with the greatest care. Control of abnormal weight increases and obesity during the first two months of pregnancy is of great importance to protect foetal development. Fortunately, experience shows that vigilant treatment of diabetes with insulin during pregnancy prevents the great majority of foetal losses.

3.3 Nutrition

The relation between certain aspects of nutrition and diabetes mellitus has long been recognized. As this relationship is well documented and

relatively well understood, the public health aspects can be elucidated with some confidence.

Thus, the evidence that undernutrition protects adult populations against diabetes mellitus seems unassailable. Improvement in the diabetic state in times of food shortage was noted as long ago as the siege of Paris, and there was a dramatic fall in the morbidity and mortality from diabetes when food was scarce during the Second World War. There is also strong evidence that in highly industrialized communities obesity leads to diabetes: in the USA the annual death rate from diabetes for men aged over 45 who were 50 lb overweight was 136 per 100 000, compared with only 6 per 100 000 for those underweight. For both men and women the death rate from diabetes for persons more than 26% overweight was ten times greater than the rate for those of normal weight. On the other hand, in less developed countries, such as the Cook Islands, obesity is less closely associated with diabetes, indicating the importance of physical exercise in re-establishing the metabolic balance.

It is possible, on the results of recent work, to offer some explanation for these effects. Obesity, old age and under-exercise are all associated with important alterations in the disposal of glucose between the various tissues of the body. The diversion of glucose towards peripheral adipose tissues has been demonstrated to have adverse effects on the body-glucose/insulin economy. An insulin antagonist might mediate in these alterations by interfering with the action of insulin on muscles in man, as it does in the rat diaphragm *in vitro*, but it should be noted that this suggestion has not been confirmed everywhere.

Since over-eating unmasks the diabetic tendency, it is obviously important to determine what factors in the diet may be of significance. The fact that the fat content of the diet is reduced during periods of famine and rationing has led it to be indicted as the cause of diabetes in times of plenty. A high fat diet leads to mildly diabetic glucose tolerance curves, and reduction of dietary fat reduces insulin requirements in diabetics. But while these points seem to corroborate the theory, there are obviously many other factors involved. In times of war, fuel rationing leads to increased need for muscular exercise, which certainly increases insulin clearance into and subsequent glucose uptake by muscle, and is all-important in preventing diabetes. In times of peace, however, other items such as refined sugar appear in the diet and may be implicated in the genesis of vascular disease, and diabetes and its complications.

3.4 Diet and prevention of diabetic complications

Widespread interest in the diet of diabetics is aroused owing to the part food may play in the development or suppression of the complications of the disease. While it is uncertain whether the so-called vascular

complications may not underlie the disease itself in some cases (see below), there is general agreement that uncontrolled diabetes with continuing hyperglycaemia predisposes those suffering from the disease to diabetic *cataract*, a common cause of disability and blindness among the aged. Suggestive evidence has been produced that, in addition to carbohydrate intolerance, high fat diets and perhaps sodium imbalance may be important in the development of diabetic *nephropathy*, while diabetic *neuritis* may be aggravated by hyperglycaemia and improved when the diabetes is controlled.

The exact relationship of diet to the peripheral, coronary and other *vascular complications* of diabetes is, however, not so clear-cut. In the first place it is necessary to distinguish at least three and possibly four entities for consideration here. First, there are changes in the capillary basement membrane; these have been observed in electron microscopy studies in the kidney and elsewhere. Secondly, there may also be an alteration in the capillary reactivity. Thirdly, diabetes mellitus is associated with the deposition of para-aminosalicylic-acid-positive, colloidal-iron-negative glycoproteins in the lumen of smaller arteries. The exact relationship of any particular dietary item to any of these factors has not yet been identified, but there is general agreement that ignorance is no excuse for recommending diabetics to neglect their dietary regime. Fourthly, there is widespread belief that *atherosclerosis* of the main vessels is more prevalent in the diabetic than in the non-diabetic population. In comparison with males, young female diabetics do not seem to be spared, as are female non-diabetics, from coronary and other vascular diseases. Furthermore, the clinical impression is supported by investigations on the deposition of lipid in the walls of blood vessels *in vitro*. Once pathological changes have occurred in the walls of the blood vessels, the way is open for the progress of events that can result in thrombosis. There is some evidence that the hyperlipaemia believed to be associated with atherosclerosis in diabetes and intravascular thrombosis is diminished by substituting vegetable fat for animal fat in the diet, and the latter appears to be correlated with ischaemic heart disease, particularly in younger persons. The efficacy of some vegetable fats appears to reside in their being unsaturated, which may increase the intestinal loss of endogenous cholesterol by the formation of insoluble bile salts. Saturated fats may also be important in the pathology of atherosclerosis or in the formation of intravascular thrombi, and various authorities believe in substituting unsaturated for saturated fats in the diet of diabetics. The Committee, while very interested in developments in this field, did not think that the case had been sufficiently well substantiated to form the basis of any recommendations at this time.

4. CONTROL OF DIABETES MELLITUS AS A PUBLIC HEALTH PROBLEM

4.1 Screening methods and procedures for early case detection

Appreciating the magnitude of the health problem created by the progressive increase in the prevalence of diabetes in all parts of the world, and realizing that overt manifestations of the disease may be a late feature, the Committee was of the opinion that the participation of the public health authorities and other agencies in early case detection is essential. This is the first challenge that diabetes presents.

Case detection, or screening of a population, consists in sorting out from the apparently fit population by the appropriate techniques those persons who probably have the disease. The diagnosis must then be established by further, more detailed, examination and investigation. Screening for diabetes, using a variety of techniques, has been carried out in many countries in the past fifteen years and considerable experience has been accumulated (see Annex 1). The Committee felt that some standardization of the methods and procedures would allow better comparison of results and would better orientate further epidemiological studies of this type. The Committee did, however, appreciate that the practicability of its recommendations must be considered in relation to the cultural, economic and manpower situation of the country in which such a programme is contemplated. It is also essential, it was unanimously agreed, that the programme should not be limited to case detection. Clinical assessment of those with a positive test must be made. Research projects may also be included in the general plan of the survey. Prior to all screening programmes, a decision on the management and follow-up of all definite and border-line cases of diabetes must be made. In formulating the programme the participation of medical students, nurses and members of allied professions should be considered in view of the educational opportunity presented.

Screening projects vary in nature from efforts to test the entire population of a community in a short period of time to continuous projects testing small groups each day. Mass programmes have attempted to test large segments of the population following an energetic community organization and public information programme aimed at inducing the greatest number of persons possible to appear for screening. The methods range from the operation of community diabetes detection centres to the use of mobile laboratories and field teams.

Another approach to diabetes detection has been the recurring project, such as the Diabetes Week, or Month, as recently recommended by the International Diabetes Federation to all national associations.

The Committee noted the important roles played by successfully treated diabetics of the medical and allied professions in these organizations.

A third approach is the continuous screening project, in which public information media are used to stimulate the population so that a steady flow of persons comes to be tested, and in which screening and follow-up go on simultaneously. Staffing, laboratory facilities, and other needs can be regularized in this type of project, and the whole undertaking can be more easily integrated into the total community health programme.

Selection of a population for screening

In deciding on who is to be screened, several factors must be taken into account, such as the availability of funds and resources, the readiness of various groups to accept diabetes screening and, probably the most important overriding consideration, the "yield" that might be expected from the population selected. "Yield" is the total number of new, verified cases (previously unknown) of diabetes discovered among the population screened. This factor is the most realistic measure of the success of a screening project. The yield, in turn, is influenced by three factors — namely, the prevalence of diabetes in a population, the reliability of the testing method used, and the validity of the test. Reliability is understood to refer to the extent to which the results of the test may be reproduced by a technician of average training. Validity reflects the frequency of confirmation of the test by accepted diagnostic procedures.

There are three main population groups to consider for selection: (*a*) the general population, (*b*) identified groups, such as industrial groups, civic organizations and clinic patients; and (*c*) groups with a high prevalence of diabetes.

In general population screening everyone in the community is invited for testing, with the usual exception of persons under 25 years of age — an extremely low-yield group. In this approach diabetes detection may readily be combined with other chronic disease detection procedures. The yield of new cases in this type of screening will depend on public response and on the local prevalence of diabetes.

The next approach — that of screening social or industrial groups — has several advantages. Providing the group with information about the test is inexpensive and a high level of response can be expected. By selecting groups of appropriate size, the volume of screening can be regulated and expanded as desired. Follow-up is often simplified because of the circumstances surrounding the group relationship. Such projects generally include industrial employees, members of community organizations, health and welfare recipients, adult clinic patients or patients of private physicians.

High-prevalence groups are perhaps the hardest to reach, but are among the most desirable groups for screening — e.g., the potential dia-

betic, as previously defined. Obesity is reported to precede diabetes in 85 % of the cases in some countries and is considered to be second only to predisposition as the most activating factor in the development of the disease. Mass screening surveys demonstrate the pronounced prevalence of diabetes among persons who are overweight. Similarly, diabetes has been found to be more prevalent among women who have given birth to a baby weighing 4.5 kg or more than among women with babies under that weight.

Testing techniques

It is essential that in the planning of the survey the sensitivity and specificity of the tests used should be considered. *Sensitivity* is defined as the ability of the test used at the level of suspicion chosen to classify as positive all those who have the disease for which they are being screened. *Specificity* is defined as the ability of the test used at the level of suspicion chosen to classify as negative all those who do not have the disease for which they are being screened. It must be understood that since diabetes is a complex and variable metabolic disease it is not possible to devise a screening test, and/or to use a level of suspicion, that would be both 100 % specific and 100 % sensitive.

In most countries urine screening using a true glucose method has been the usual choice, all people with glycosuria being referred for more precise testing by glucose tolerance. This has often been chosen in the belief that urine-glucose testing is less expensive than blood-sugar testing. However, when the relative lack of sensitivity and specificity of urine-sugar testing and the problem of the subsequent follow-up of many false positives by blood-sugar methods are considered, it is questionable whether the actual total costs of a programme based on urine-sugar testing are, in fact, less. More recently, therefore, blood-sugar testing alone has been used. This is a trend to be encouraged since it has been well documented that blood testing is to be preferred over urine testing as an indication of abnormal carbohydrate metabolism. Nevertheless, if local custom and belief makes blood taking difficult, urine tests should be used. Urine collected for testing two hours after loading with sugar or a high carbohydrate meal is the best basis.

Experience so far has proved that results of blood tests are most reliable and valid for screening if taken two hours after a meal high in carbohydrate or after oral glucose loading. It would obviously be advantageous to use a shorter time in screening procedures, but at present the lack of adequate information about the specificity and sensitivity of one-hour tests, particularly with respect to the proviso about control data regarding follow-up (see page 11), precludes the making of any firm recommendations. Absence of information, however, should never be accepted as an excuse to procrastinate about screening programmes.

Blood samples may be either capillary or venous. The use of a venous blood sample has certain advantages, such as repetition of the laboratory measurement in the event of error and the availability of the blood for screening for other diseases. The blood-sugar estimates should be of true glucose only (following, for example, the Somogyi-Nelson, Wilkerson-Heftman or Hoffman method, among many others) and should be quantitative, which allows not only the identification of the definite and border-line diabetics, but also gives an indication of the priorities for further investigation and treatment. Evaluation of diagnostic sugar levels has been considered in section 2. For a description of mass screening testing techniques see Annex 3.

Costing of surveys

It is inevitable that the cost will vary from country to country and from project to project; it should be measured against the number of patients discovered and in relation to the prevention of future ill-health made possible by the early discovery of the diabetic state.

Follow-up

The discovery of definite or border-line cases of diabetes is only the first stage of the programme. Arrangements must be made for the regular follow-up of all border-line cases until the final diagnosis is made. Similarly, the need for proper treatment of the definite cases must have been foreseen and organized. The human aspects of detecting unrecognized disease must be borne in mind at all times, and not only by the screening personnel and by physicians. Administrators are advised to pay special attention to this point when choosing posters and drafting leaflets or circular letters, such as those informing people for the first time that they are diabetic and need medical attention. Finally, the greatest care must be taken by all concerned to appreciate the position of practising physicians; screening procedures must never be allowed to be taken as any criticism or indication of failure on their part, and screening personnel, in the enthusiasm for their mission, must never forget that it is the practising physician who is responsible for the long-term care of a case, which may be uncovered by a few minutes' work.

4.2 The principles of treatment of diabetic patients

Although it was not the task of the Committee to discuss treatment of the diabetic patient in any detail, it was considered useful to summarize the main principles of treatment, as follows:

(1) The physician's first responsibility must be to reassure the diabetic patient by explaining that he can live a normal life, comparable to that of healthy persons.

(2) The physician should make himself responsible for the insight of the diabetic patient into his disease by continuing education; he may have to delegate detailed instruction to others (e.g., diet to dieticians, sterilizing syringes to nurses, etc.), but this does not absolve him from his over-all educational responsibility. The diabetic patient on insulin or oral hypoglycaemic drugs should be instructed to recognize hypoglycaemia or deterioration in his condition. Properly instructed, the patient can play an important role in his treatment — for example, by testing his urine for sugar and/or acetone, regularly recording his results and making accurate information available to be taken into consideration, together with his or her physician's biochemical (blood or urine) determinations at clinic visits, in planning treatment.

(3) The physician's therapy must aim to establish or restore the diabetic's capacity for work and normal social life, and, in diabetic children, to secure normal growth and weight gain.

(4) Obesity should be corrected and physical exercise encouraged.

(5) Treatment should certainly cause the disappearance of the clinical symptoms and signs of diabetes (polyuria, thirst, hunger, fatigue, etc.), and it should also aim to restore the normal biochemical and metabolic balances.

(6) It should prevent and cure infections (skin and urinary infections, tuberculosis, etc.).

(7) It should prevent or delay the onset of the vascular, ocular, renal, neurological, and other complications of diabetes.

In infantile and childhood diabetes, insulin is the main therapeutic weapon. At present, only in exceptional cases should oral antidiabetic drugs be used; in such cases the dietary regime should aim to ensure normal growth and weight gain. It is recognized that, in well-controlled cases, there should be no restriction in physical exertion and prophylactic inoculations. Stress must be laid on the need to educate the patients concerned and to reassure them that they are not abnormal children. Both objectives may be materially assisted by establishing holiday camps for diabetic children, where instruction can be organized and where contact with other sufferers gives great reassurance. In dealing with young adult diabetics, the physician may need to follow the foregoing recommendations, or those referable to adult and elderly cases (see below), according to the case and the needs for insulin.

For adult and elderly patients, who are the most likely types to be found in screening surveys and population studies, dietary regimes are the real basis of treatment. Dietary control is the essential feature of therapy and it alone may be adequate in many such cases, particularly

the elderly, obese patients. It should be supplemented wherever possible with physical exercise.

The main trend of current opinion (which is, however, by no means unanimous) about the importance of various dietary factors in treatment is that the aim of dietary intake should be to achieve at least perfect *clinical* control (symptoms), and preferably perfect *chemical* control in terms of blood constituents (glucose, triglycerides, cholesterol and non-esterified fatty acids). Such control is completely practicable in mild cases, but the strongest protagonists of strict control in chemical as well as clinical terms have found that they could achieve it in only about 3 % of the more severe insulin-dependent cases. The importance of dietary restrictions commensurate with the insulin dosage rather than free diet for adults seems confirmed by the fact that of 90 insulin-dependent diabetics on an unrestricted (free) diet, who were controlled as appropriate by changes in insulin dosage, 50 had to change to strict dietary control within five years — either because of hypoglycaemia, or obesity, or because of excessive insulin dose (more than 80 units per day).

To achieve dietary control, the Committee recommended the compilation of national dietary manuals in vernacular languages, such as are planned by WHO. These should give a clear description of general dietary principles, of appropriate weights and measures, and the calorific value of foodstuffs — particularly local foodstuffs — broken down into protein, carbohydrate and fats if possible. Such manuals are of inestimable value in diabetic clinics, where regulation of diet presents many difficulties and must be based on the pattern of diet of the local community.

The next stage in severity will demand the administration of oral antidiabetic drugs to control the blood-sugar level, but it must be emphasized that in such cases diet and exercise remain essential. Even when the diabetes is sufficiently severe to require replacement therapy with insulin injections, the same points about diet and exercise apply. Today as previously, insulin is essential in saving the life of patients with acute metabolic decompensation (acidotic coma, infections, etc.).

The Committee believed that the indications for oral antidiabetic drugs to control hyperglycaemia (sulphonylureas, biguanides, etc.) are almost completely limited to a relatively small proportion of the total adult and elderly diabetic population. This type of therapy should be avoided wherever natural means (diet and exercise) will suffice.

In potential or latent diabetes, the precise value of oral antidiabetic drugs has not yet been demonstrated, and indiscriminate use of such drugs in these circumstances may be dangerous. It was therefore recommended that patients or potential diabetics, and particularly obese persons, should not be allowed to obtain oral antidiabetic drugs without a proper prescription. It is a grave therapeutic error to believe that such drugs make dietary restriction or control unnecessary.

The Committee also noted certain other points of therapeutic importance. Despite the diversity of insulin preparations available today, in some countries an increasing number of patients are becoming resistant to certain standard insulin preparations. Pending the manufacture of synthetic insulin for such cases, physicians everywhere would welcome the provision of pure insulin preparations from various known (and stated) animal sources.

Apart from cases with keto-acidosis, most diabetic patients can be stabilized and followed up in ambulatory circumstances. Furthermore, these circumstances are much nearer to the normal life of the diabetic, and it is often preferable to work out control of the patients under such conditions rather than in hospital, which is at times unhelpful because of the artificiality of the life, diet and physical exertion, and which is, of course, always relatively costly.

It should be re-emphasized that the education of the diabetic is a continuing problem. He needs to understand all aspects of his disease and its treatment if the best control is to be secured. Various lay organizations are available to help in many countries and the doctor and his diabetic patient are strongly advised to take the advantages these can offer — either as social security services or as diabetes associations.

4.3 Organization of services

The life-long natural history of diabetes mellitus and its debilitating effects demands a wide variety of public health measures to control the disease, varying from detection at the earliest asymptomatic stages to assisting in the control and long-term management of cases that may be suffering the complications of other chronic complaints. Because the population at risk includes persons with different severities and at so many different stages of the disease, it is appropriate to consider the services that should be made available, but from the outset it should be stressed that their success is largely dependent on the level of education achieved.

Provision of adequate medical care

Responsible health authorities are recommended first to consider the adequacy of medical care offered to diabetics in general. A great deal can always be done to help known cases by a programme of patient education and by offering facilities for diet and hygiene counselling, which the Committee felt was generally overlooked. Great assistance in these matters can be forthcoming from lay diabetes associations, the nursing profession, nutritionists and dieticians.

Case-finding

Responsible health authorities are recommended to consider the question of finding in their community those diabetics whose symptoms have not yet led them to seek medical attention, or who have relapsed, or who have diabetes at the asymptomatic but nevertheless potentially serious (in terms of complications) stage.

Experience shows that if case finding is accepted as a public health responsibility the first decision must be to select the medical procedure to be used. Urine-sugar testing with follow-up blood-sugar tests has been widely employed in the past. But since a blood-sugar test will certainly be needed for all glycosurics and not all diabetics always show glycosuria, the Committee recognized the superiority of blood-sugar testing for the early detection of diabetes. (For a discussion of testing techniques see page 21). Obviously the particular method chosen will depend on the organization and facilities available.

Once the test method has been settled, the other supporting facilities required must be envisaged — registration forms, space for testing and records, etc. — as set out below.

(1) The registration of persons being screened can adequately be done by lay volunteers, after brief instructions. It is important that volunteers should be given a clear definition of what questions they are to answer, what information they are to give and what questions they should refer to the trained health worker.

(2) Forms for the registration of persons being screened should provide for the recording of the person's name; how he may be reached by mail and telephone; the name and address of the personal physician; and the age, sex, height, weight, and other data that will be useful for evaluating yields. Other items may be added to this, such as whether or not the person has a relative who is diabetic, his race, and, for women who have given birth to children, whether any of the children weighed 4.5 kg or more at birth.

Planning

Once it has been decided to institute a diabetes detection and/or control programme, a central planning body must be organized whose function is to establish general policy, select screening methods, set standards and criteria, co-ordinate operations and integrate both detection and control with other health agencies. The Committee foresaw the tendency for multiple screening programmes of which diabetes should be an important part.

This planning body should have representation from the local medical and allied professions (societies or associations), the local lay diabetes

association, public health and civic authorities, and any appropriate local voluntary organizations. This group must provide the leadership for the programme.

Facilities needed for case-finding

To achieve a successful case-finding programme, the central planning body should examine and consider the following list of facilities with a view to providing them :

(1) Personnel, equipment and suitable over-all facilities (building, mobile laboratory, etc.) to obtain blood samples at scheduled and well-publicized times and places.

(2) Personnel, equipment and supplies to perform basic screening tests. As above, the Committee recommended blood-sugar tests — in which case the decision will be needed on whether to use capillary blood from a finger prick or to do venepunctures (which are an advantage in multiple screening programmes). It must be emphasized that, under medical supervision, persons with little training can, after practice, master the techniques of drawing blood by either method. The same is true for laboratory procedures — urine testing or blood-sugar measurement. Thus a shortage of physicians, nurses or medical technologists need not be a deterrent to initiating a case-finding programme — the persons trained may be valuable in follow-up, while physicians and members of other health professions are best utilized in a supervisory capacity, reassuring the persons being screened, interpreting test results, etc.

(3) The system and organization to record full data on each person screened.

(4) The system to notify each person screened of the results of the test.

(5) The system to refer each newly suspected (or relapsed) diabetic or border-line case to his personal physician or to a clinic or screening organization for any re-test and other diagnostic procedure. (Where it can be arranged, facilities for re-testing can be incorporated into the screening operation.)

(6) The system of follow-up by suitable letter, telephone call, or home visits to ensure that such persons are followed up until a final diagnosis is made. It must also be confirmed that the individuals concerned are receiving a physician's care.

(7) The system of liaison between the screening programme and the medical community.

(8) A plan to provide newly diagnosed diabetics with continuing services, such as (*a*) patient education, (*b*) financial assistance or guidance

for the indigent in obtaining continuing medical care, and (*c*) long-term follow-up to ensure that patients remain under medical supervision. (Previously known diabetics should, of course, have these same services made available to them.)

(9) The programme of health education for the public directed at individuals through the usual media to provide the public with such essential information as:

(*a*) basic characteristics of diabetes mellitus;

(*b*) The nature of the threat to personal health should diabetes remain undetected and untreated;

(*c*) the type of person — i.e., the obese, the elderly, relatives of diabetics, mothers of heavy babies, etc. — most likely to develop diabetes;

(*d*) how diabetes is detected, stressing the simplicity and painlessness of the tests;

(*e*) how diabetes is controlled, emphasizing that few new adult cases are likely to need insulin injections;

(*f*) how, where, and when persons may obtain a screening test for diabetes;

(*g*) the fact that screening is only the first step, and that further tests and treatment by a physician may be necessary.

The co-operation of the medical profession on the planning group is only the first phase of the professional education that will be needed. Programme planners should not assume that the level of knowledge about, and interest in, diabetes is uniform within the medical community.

Physicians

One of the functions of the liaison established between the case-finding programme planning group and the physicians in the community is to transmit to physicians the most accurate and authoritative criteria for re-testing and diagnosis. Suitable periodic postgraduate refresher courses in the management of diabetes should be made available through the authorities responsible for providing continuing medical education. The diabetes association and the regional or local medical school should participate in such professional education.

The educational programme for the physician should cover the following aspects:

(1) The public health problem of diabetes — its toll in numbers, death, blindness, and other complications.

(2) The necessity for, and the local criteria to be applied in, the re-examination and testing of cases found and regular follow-up.

(3) How diabetes can be detected early.

(4) Who should be tested (particularly blood relatives of diabetics, the obese, elderly people, mothers of babies weighing 4.5 kg or more at birth, and pregnant women with glycosuria).

(5) The screening techniques to be used.

(6) Retests to be done before referral and recommendations for medical interpretation of the results of such retests.

(7) A description of and suggestions for interpreting the results of currently accepted diagnostic tests.

(8) A list of appropriate references to current medical literature.

Nurses, nutritionists, dieticians and other groups

Physicians, of course, are not the only professional workers who need to be educated about diabetes. Nurses of all categories — public health, outpatient clinic, hospital, private, school, industrial and others — will necessarily become involved in a successful diabetes control programme. The same is true of nutritionists, dieticians, medical social workers, health educators and laboratory technicians. Representatives of all these disciplines should be included in the planning body and involved in the programmes, to ensure that suitable educational programmes to meet the needs of all disciplines should be undertaken early.

The value of the nurse's assistance to the physician — in making appointments, giving treatment, following-up cases by telephone, letter or home visit, etc. — needs no emphasis here. But it must be stressed that the knowledgeable nurse can also assist the patient in interpreting instructions.

Nutritionists and dieticians help the diabetic with his dietary problems, bearing in mind his physical needs, living conditions, nutritional needs, food habits, daily routine, emotional needs, cultural background and economic status. Dieticians will teach the patient the necessity for the diet and for weight control, the nature of foods, their calorific values and carbohydrate content, and how to plan and prepare enjoyable meals within his means and restrictions. The Committee stressed the necessity for regular follow-up and counselling (which is often neglected) by the dietician and the physician.

Educating the patient

The Committee emphasized the importance of educational programmes for patients. These should cover:

(1) What diabetes is and its effect on the body.

(2) Dietary instruction.
(3) Insulin and its use.
(4) The oral drugs and their use.
(5) Urine tests.
(6) Diabetic emergencies (insulin reaction and diabetic coma).
(7) Personal hygiene, especially foot care.
(8) Danger of obesity and need for physical exercise.

The physician should take time to reassure the newly discovered case and the family. He must take over-all responsibility for initiating and maintaining the education of his patients. Of course, few can spend the many hours necessary adequately to instruct the newly diagnosed patient on every point — e.g., syringe sterilization or dietary details — and some of this responsibility must be delegated to other professional workers (as mentioned above) and lay organizations, such as national diabetes associations. Thus the education team is composed of a physician, a nurse and a nutritionist or dietician.

Instruction may be given individually, to a group, or to the patient and his family. Group instruction has many advantages, both for the patient and for the instructor, since in such group classes patients can share their experiences and gain support from those who have similar problems.

The Committee stressed the need for refresher courses for the diabetic patient. It further emphasized that these should be repeated and reinforced. The Committee believed that hospitalization is not essential for this education: it can be carried out at the physician's consulting rooms, or at the office of the outpatient diabetes clinic attached to a local hospital.

Need for priorities

Regardless of the system for providing medical care or the relative affluence of the society in which cases are sought, the numbers of new cases are such that some system of priorities invariably needs to be established. Just as it is impossible to detect every diabetic in every community, not every known diabetic can receive the optimum of medical care and health supervision. Ultimately, the continuing care of both new cases and those long recognized depends on the adequacy of resources available, the efficiency of follow-up and the co-operation of the patient.

Subsequent care of newly detected diabetics

It can be seen that case-finding, follow-up, and the education of the patient, the professions and the public can be carried out by either public or voluntary health agencies. In some countries, where subsequent medical care is provided under government auspices, administrators will

need to consider the impact of newly found diabetic cases on the organization of the medical care programme. In other countries care after diagnosis is usually provided by the patient's physician, assistance being rendered by public health authorities only if the patient is referred by his physician.

It was noted that if the responsibility for the medical care of indigent patients falls on an agency other than the health authorities, that other agency should be included in the planning of the total programme. One does the indigent person no service by finding him to be diabetic unless resources to assist him have been made available.

Subsequent care of border-line cases

Whatever the arrangements for medical care for the diagnosed patient, border-line cases are a group (defined on page 12) for which the public health authorities should always be prepared to accept responsibility. A programme of health education must be directed at these people to induce them to avoid or correct obesity, to recognize infection early and seek treatment, to seek early pre-natal care when pregnant, and to have regular and frequent physical examinations and diagnostic laboratory tests. When screening tests are offered continuously, the public health authorities should attempt to bring border-line cases in for retesting at yearly intervals. Likewise, when screening is only offered annually, a special effort should be made to inform this group of the schedule and secure their regular participation.

Finally, there are a number of services for diabetics that may be given by voluntary agencies, independent of government funds — e.g., summer camps for diabetic children, which are of great value not only to the children but to their parents and other adults involved, or screening programmes undertaken by industrial concerns. The Committee recommended that these services should always be given the encouragement they deserve.

5. EMPLOYMENT AND PLACEMENT OF DIABETICS

The Committee viewed with dismay the restrictions in many countries hindering the employment of diabetics. All too often these restrictions are purely negative and are based on prejudice or ill-informed opinion about the effect of diabetes on a person's working ability or capacity. This injustice is perpetuated and even increased by the tendency to regard all diabetics as a group of patients with identical characteristics. This is bound up with the mistake of failing to distinguish between mild cases and cases under proper medical control on the one hand and unco-

operative, uncontrolled cases on the other. The Committee urged strongly that a much more liberal attitude of mind be adopted, which should aim at eliminating the discrimination against diabetics that has arisen simply on diagnostic grounds. Emphasis should be placed on the individual's aptitudes, experience, education, attainments and physical condition, and not on his being diabetic. In short, a diabetic should have the same chances as any other person of obtaining and performing work for which he is medically and vocationally suitable.

With very few exceptions, diabetics are capable of accomplishing any type of work. The determining factors medically are the mildness or severity of the diabetes, the degree and regularity of the medical control, and the physical demands and working conditions of various jobs. Persons with the mildest forms of the disease, who require no insulin and are controlled by diet alone, may be employed on any work. Those afflicted with more severe forms, who require insulin, but who are well-controlled and well-regulated, can safely be employed provided that the necessary precautions are taken to avoid the hazards to themselves and their fellow-workers that might be brought about by insulin shock, induced by failure to obtain meals on time or by an increased workload.

The limitations on the physical activities of diabetics may vary widely, depending on the degree of severity of the disease, the effectiveness of the control, and the presence of other complications. Physical abilities should be matched with the demands of suitable jobs so as to ensure that the diabetic is employed to the best advantage and that his strength is not overtaxed.

If the general sense of the above recommendations is accepted, only severe diabetics who remain uncontrolled despite insulin and well-regulated diet should experience difficulty in getting employment under normal industrial conditions. They should be placed in working conditions that avoid unexpected changes in physical exertion, sudden and marked changes of temperature and exposure to circumstances that might predispose to skin infections and impaired circulation to the feet. If diabetics are employed on shift work, they should, as far as possible, be kept on the same shift, since a change to a different shift can cause difficulty in relation to the insulin injections, especially when patients are assigned to overnight work. Attention may also have to be paid to visual requirements. In the most severe cases the provision of sheltered employment under special conditions may have to be arranged.

5.1 General recommendations — young diabetics

Although in theory most types of employment are suitable for properly treated young diabetics, subject to the general reservations made above, in practice a large number of jobs in many countries are closed to

them. This applies to careers in the public services and, as a consequence, in large private undertakings. The risk of degenerative complications possibly appearing in ten or twenty years' time and the possibility of a premature end to working life are the arguments usually advanced to justify this kind of attitude.

It would seem paradoxical for a society that is tending more and more to assume responsibility for the fate of individuals to deprive itself of the services of persons fully capable of carrying out a wide range of jobs, especially in sectors where shortages of qualified personnel are being felt — such as, for example, in the teaching of the nursing professions. And even if careers have to be cut short by early retirement and a reduced pension paid to some diabetics sooner than foreseen, this is likely to cost no more in real terms than any invalidity pension that it would otherwise be necessary to pay, without taking into account the contribution of many years of useful work.

The inequity of the prevailing attitude in some countries can be judged by contrasting the situation of an adult who becomes diabetic after he has acquired a position as an official — e.g., in government service — and is not discharged, even if he looks after himself very badly, with that of the young diabetic who, even when perfectly controlled, is faced with insurmountable obstacles in obtaining such a post. It therefore seems necessary to urge the authorities to reconsider the implications of national regulations defining the employment open to young diabetics or, more widely, the physical requirements for entry into government service. In such a reassessment account should be taken of improvements that have been brought about in the treatment of diabetes, the transformations that have been effected in the social legislation of some countries, and, of course, the real interests of society. The Committee believed that the value of the example set by certain governments in this respect cannot be over-emphasized.

5.2 General recommendations — adult cases

Diabetics should not be excluded from employment because of unfounded prejudice, because of fears that the possible prognosis may envisage a shorter working life than normal (e.g., much sick absence and early retirement), or because they do not satisfy certain physical requirements, which are unrelated to the actual physical demands of the training or work in question. The test should be whether the persons concerned are physically and mentally capable of carrying out the tasks involved. In certain cases vocational training facilities and employment openings available to the general public, especially in the public service and other similar secure and stable occupations, should be made equally available to diabetics.

The Committee noted with regret that in some countries diabetics were sometimes discriminated against by the effect of group insurance schemes that excluded them from coverage, sometimes making it difficult or even impossible for the employer to engage them without the risk of possible financial loss to himself or the payment of an exorbitant premium. In some other countries the requirements for acceptance in social security schemes or under labour law provisions may also have inhibiting effects on the employment prospects of diabetics. The Committee recommended that everything should be done to remove any restrictions on entry to employment brought about unwittingly by the operation of legislation enacted for quite other reasons, and that diabetics in employment should be covered by the same provisions for social security, insurance, etc., as all other workers in the same occupations.

The proper placement of diabetics is important not only to ensure that they are employed to the best advantage to themselves and their employers, but also in relation to the maintenance of their health and safety and the avoidance of hazards. This will involve the use of selective placement techniques, (*a*) in placing certain diabetics seeking work in fresh jobs, or (*b*) in considering the transfer within the same company to a more suitable job of those who have acquired diabetes. Closely connected with the operation of selective placement techniques and medical control, there is a need for the employed diabetic to understand the nature of his disease, the principles of treatment and the principles governing his placement or transfer. There is no stigma in having diabetes and the diabetic should never feel that he must hide his disability, since it is to his advantage and the mutual advantage of his employer and his fellow-workers that all concerned should know of his condition. This will facilitate immediate attention and treatment should a diabetic emergency arise, such as an insulin reaction or coma. With respect to injuries, the importance of prompt treatment in order to avoid the risk of added infection should be stressed. The diabetic must also be taught that, properly cared for, he presents no problem to his employer. The employer must be taught this too. The importance of maintaining good medical care and close co-operation between the diabetic's physician, his employer and his employer's medical department, if one exists, should be insisted on. The need for adequate and regular medical examinations should be stressed. To be given employment and responsibilities in accordance with their abilities helps diabetics to overcome their anxieties; thus their treatment is assisted and their work attendance and efficiency are increased.

5.3 Driving permits

In some countries diabetics are refused permits to drive private motor vehicles or heavy motor vehicles for public or commercial transport on

the grounds of their diagnosis alone, or are subjected to unnecessary, restricting conditions in qualifying for such a permit. The point of view the Committee would like to see accepted would be more in harmony with that underlying the above recommendations with respect to employing the diabetic in general. Difficulties are very rare and are only likely to arise with severe diabetics who remain uncontrolled despite insulin and well-regulated diet. The Committee therefore recommended that, except in these difficult circumstances, diabetic applicants, supported where necessary by a certificate from their physician, should be granted motor-vehicle driving permits.

5.4 Life assurance

Many adult and elderly diabetics are being detected in screening programmes and are thus in a position to benefit from modern medical care as well as future research. These cases are, almost without exception, of the mild, adult type, readily brought under control by diet and occasionally oral medication. Few require insulin. The Committee noted that, although identification as diabetics increases the life expectancy of such persons, after discovery, they are expected to pay a much higher life assurance premium according to present practices. Before being screened these same persons would have been regarded as non-diabetic, since few will necessarily have had glycosuria present when examined for their policy.

These practices were considered by the Committee to be not only an unjustifiable burden for the mild diabetic; unless amended, they will also discourage persons from participating in screening programmes.

The Committee believed that present rates for diabetics are usually based on actuarial experience of the juvenile form of the disease, and that appropriate re-evaluation of the life expectancy of persons with the milder adult and elderly form described above will indicate that little, if any, upgrading of the premium rate is justifiable compared to what might be considered reasonable in the case of, say, heavy cigarette-smokers.

6. RESEARCH

The Committee thought it advisable to limit its recommendations to fields where comparative studies in different countries might yield information of public health value, of etiological importance, or of significance in the natural history of diabetes.

The following types of study should be encouraged:

(1) Collection of data on the prevalence of diabetes in communities of different culture and diet. This might include rural and urban com-

munities within one country. In each instance it is important that the population to be studied should be defined and a suitable age-sex stratified random sample studied. When necessary, WHO could be requested to provide the consultant advice of an epidemiologist in planning the study. The pattern of response to the recommended standard glucose load among healthy subjects (male and female) in various age-brackets would thus be recorded to establish adequate control data. Records should include a description of the diet of the community and clinical information on each subject — e.g., age, sex, height, weight, skinfold thickness, obstetrical history and daily activity (see page 13, footnote). In this way factors of etiological importance may come to light, and in particular the parts played by diet, obesity and exercise may be determined. It is to be hoped that many of these studies will be planned longitudinally to increase knowledge about the natural history of the disease in different countries.

(2) The foregoing studies could incorporate investigations of other substances — e.g., plasma insulin, non-esterified fatty acids and triglyceride amino-acids, etc.

(3) The correlation of the dietary pattern of various communities with the post-mortem size and insulin content of the pancreas.

(4) A study of pregnancy in relation to diabetes in various countries, special attention being paid to comparisons of (*a*) course and outcome, (*b*) birth weights, (*c*) pregnancy wastage, (*d*) congenital malformations, (*e*) carbohydrate tolerance and (*f*) occurrence of urinary infections. The Committee suggested that a central register of congenital malformations associated with diabetes in pregnancy might be useful and that WHO should study the possibility of compiling such a register.

(5) A comparative study in various countries of the complications (including ketosis) of diabetics (asymptomatic and clinical) and the relationship of diabetes to other disease — e.g., atherosclerotic disease and tuberculosis — following the pattern of investigations recommended by other WHO Expert Committees. In particular, this study should include, where possible, an investigation of pancreatic diabetics for comparison with other types.

(6) A study of potential and latent diabetics in various countries using a variety of research techniques and recording basic clinical details at regular intervals — age, sex, weight, height, skinfold thickness, glucose tolerance, pregnancy, infection, retinal examination, daily activity, etc. The research techniques might include gingival or ear lobe biopsy to permit the assessment of vascular changes in relation to carbohydrate tolerance or other biochemical characteristics.

(7) A study in various countries and communities of the prevalence of insulin antagonists, possible genetic markers, and insulin antibodies.

(8) Any local herbal, mineral or other medicines reputed to be of value in the treatment of diabetes should be thoroughly investigated.

The Committee was anxious to convey to health authorities the hope that they would encourage research into diabetes generally; particular interest was expressed in the value of comparative epidemiological and operational research, which WHO is in a unique position to encourage and assist. The foregoing list, which is presented for guidance, should not be regarded as complete or exhaustive.

7. RECOMMENDATIONS

The Committee made the following recommendations for appropriate international and national action.

(1) *Basic epidemiological information.* National health authorities are urged to collect basic epidemiological data in their own countries. This will serve two purposes: first, it will provide immediate information on cases of early and mild diabetes and asymptomatic and latent diabetes, in which preventive measures will be most rewarding; second, it will yield further information about the natural history of the disease to facilitate the discovery of etiological factors that may also be of importance in organizing preventive or control measures. It must be emphasized that the procedures involved are now inexpensive and that this is logically the first step in diabetes control from the public health point of view.

(2) *Health education of the public.* National health authorities and other interested agencies are recommended to organize programmes of health education for the adult aimed primarily at reducing obesity and any other factors that are presumptively diabetogenic. For school-children nutritional instructions are essential.

(3) *Promotion of organized action for the detection, prevention and control of diabetes mellitus.* National and local health administrations are recommended to promote and organize, in collaboration with medical societies, diabetes associations and other interested agencies, appropriate detection, follow-up and education programmes.

(4) *Employment of diabetics.* Every effort should be made to inform, by publicity and educational measures, employers, both official and private, that almost all diabetics are just as capable of working as non-diabetics. The aim must be to abolish the unjust discriminatory measures against diabetics that are still frequently practised.

(5) *Research.* The Committee urged all interested bodies, international as well as national, official as well as voluntary, to promote and

support the research activities recommended in this report. In particular, the Committee hoped that WHO would give all the support it could in diabetes research.

(6) *Review and follow-up.* It must be apparent from the research suggestions included in this report that there is still a serious lack of knowledge about many important aspects of diabetes, particularly its complications. It is recommended, therefore, that this disease should be kept under regular review by WHO, especially with regard to the collection and collation of results mentioned under paragraph (1) above, on which hinge the detection, diagnosis and public health control of diabetes mellitus.

Annex 1

SUMMARY OF RESULTS OF DIABETES DETECTION SURVEYS IN VARIOUS COUNTRIES 1946-1964

Date	Place	Category of sample [1]	Size of sample (persons)	Percentage of newly detected diabetics [2]	Prevalence of diabetes (%)
		1947-1949			
1947-48	Ottawa county, Michigan, USA	B	550	0.29	0.4
1946	Boston, Mass., USA	E	69 088	0.36	0.52
1947	Oxford, Mass., USA	C	3 516	0.85	1.99
		1950-1954			
1951	Newmarket, Ontario, Canada	C	4 419	0.47	1.22
		1955-1959			
1958	Hospitals in Manila, Philippines	H & H	3 012	0.96	—
1958	Saratoga, Warren and Washington counties, N.Y., USA	S	3 851	0.13	0.26
1956	Korle Bu Hospital, Accra, Ghana	H	4 000	0.40	—
1958	Lawrence Tavern, St Andrew parish, Jamaica	D	958	0.42	0.73
1956	Salford, Lancs., UK	E	2 156	0.74	—
1956	Bergen, Norway	A	5 964	1.18	—
1957, 1959-60	Christiana, Newport, Black River, Falmouth, and Lawrence Tavern, Jamaica	D	4 524	1.26	—
1958-60	Polk County Hospital, Iowa USA	G	7 164	1.30	—
1958	Shell Trinidad Ltd., St Patrick county, Trinidad and Tobago	W	2 325	0.99	1.37
1958-59	Oahu, Hawaii, USA	W	38 103	1.29	2.15
1957-58	Ibstock, Leics., UK	C	4 104	1.63	2.39
		1960-1964			
1963	Tongaat Sugar Co., Tongaat, Natal, South Africa	W	2 290	—	—
1963	Germiston, Transvaal, South Africa	E	5 064	0	—
1963	Lilongwe, Central Province, Nyasaland (now Malawi)	H	4 725	0.02	—
1961	Southern Rhodesia	D	1 007	0	—
1963	Longford, Lanesborough, Drumlish, and Ballymahon, Ireland	R	4 800	0.12	—
1962	Rotherham, Yorks., UK	R	17 508	0.15	—
1960	Seboche Hospital, Butha Buthe district, Basutoland	J	3 000	0.23	—

Date	Place	Category of sample [1]	Size of sample (persons)	Percentage of newly detected diabetics [2]	Prevalence of diabetes (%)
1964	Uganda	I	7 164	—	0.24
1962	Paris, France	W	9 155	0.22	0.55
1962	Canton of Aargau, Switzerland	R	12 061	0.90	—
1962	Canton of Solothurn, Switzerland	R	4 968	0.32	—
1962	Non-European Hospital, Johannesburg, South Africa	I	3 121	0.58	—
1961	Eisenhüttenstadt, East Germany	C	12 547	0.64	—
1960	Taiping General Hospital, Perak, Malaya	H	2 772	0.66	—
1962	Birmingham, UK	C	18 411	0.70	—
1962	Bedford, UK	D	25 701	1.03	—
1960	Newcastle upon Tyne, UK	C	1 991	0.50	0.95
1962	Forfar, Scotland, UK	C	9 183	0.37	0.96
1960-62	Prince Georges county, Maryland, USA	S	6 769	0.80	0.99
1961	Halstead, Essex, UK	C	5 843	0.60	1.25
1963	Sisal, Yucatan, Mexico	D	776	1.16	1.29
1960-61	Washington, D.C., and Dallas, Texas, USA	W	15 745	1.33	1.52
1963	Castle Hedingham and Sible Hedingham, Essex, UK	D	1 570	0.64	1.53
1960-61	East Bank, British Guiana	D	5 126	1.38	2.02
1963	Bombay, India	R	18 243	0.23	2.64
1962	San Luis Potosí, Mexico (low economy level)	D	1 060	2.17	3.30
1962-63	Magdeburg, East Germany	D	21 577	1.73	3.55
1962	San Luis Potosí, Mexico (high economy level)	D	1 000	1.10	4.8
1960	Springfield, Natal, South Africa	D	200	—	5.5
1962	Bedford, UK	B	570	7.2	—
1963	Birmingham, UK	B	247	7.8	—
1960	Mabuiag Island, Torres Strait, Australia	C	224	13.4	—

[1] The key to the type of population studied is as follows :

A Sample of total population; based on glucose tolerance test (G.T.T.).

B As A but adults only.

C As A but based on glycosuria, in most cases confirmed by blood sugar test.

D As C but adults only.

E As C but for special age- or sex-groups.

G Sample of adult attendances at hospital out-patient departments; based on G.T.T.

H Sample of all attendances at hospital out-patient departments; based on glycosuria.

I As H but adults only.

J As H but for special age- or sex-groups.

K Sample of all hospital in-patients; based on glycosuria.

R Sample of population at large, in response to public announcements; based on glycosuria or blood sugar.

S As R but adults only.

T As S but special age- or sex-groups.

W Working groups.

[2] Where possible the diagnosis of diabetes has been based on the diagnostic criteria adopted by the WHO Expert Committee on Diabetes Mellitus; otherwise, the author's criteria have been accepted.

Annex 2

BLOOD-SUGAR READINGS OF 1000 GLUCOSE TESTS FOR PREGNANT WOMEN BY TRIMESTER OF PREGNANCY, BOSTON, MASS., USA, 1954-55*

Somogyi-Nelson blood-sugar (mg/100 ml)	First trimester	Second trimester	Third trimester	All trimesters
20-29	—	—	1	1
30-39	1	2	—	3
40-49	2	7	6	15
50-59	3	18	24	45
60-69	9	44	35	88
70-79	10	67	88	165
80-89	9	56	89	154
90-99	4	67	95	166
100-109	5	34	64	103
110-119	5	25	78	108
120-129	2	16	38	56
130-139	—	4	32	36
140-149	—	3	18	21
150-159	—	3	7	10
160-169	—	—	7	7
170-179	—	6	3	9
180-189	—	1	5	6
190-199	—	—	3	3
200-209	—	—	—	—
210-119	—	—	1	1
220-229	—	1	—	1
230-239	—	—	1	1
240-249	—	—	—	—
250-259	—	—	—	—
260-269	—	—	—	—
Total	50	354	595	999
Mean	82	90	100	95
Standard deviation	21	26	28	28
Mean plus twice standard deviation	124	142	156	151
Above diagnostic level recommended by this Committee :				
No.	0	18	77	95
%	0	5	13	9.5

* The hitherto unpublished data contained in this table were made available by courtesy of Dr Hugh L. C. Wilkerson. The data are based on analyses of blood from pregnant women at the Boston City Hospital and Boston Lying-in Hospital, Boston, Mass., USA. The measurements were made two hours after the administration of glucose.

Annex 3

TESTING TECHNIQUES

1. Blood-Sugar Analysis

Although large numbers of blood samples may be tested on a semi-automatic scale by the suitable organization of routine procedures for true blood-sugar analysis, these are likely to be inadequate if mass screening is done in short periods of time. Faster methods have been developed, particularly in the USA, under the names Clinitron, Klinikit, AutoAnalyzer and, recently, Dextrostix.

1.1 Clinitron [1]

The Clinitron is an automatic machine for making blood-sugar determinations using the Wilkerson-Heftmann method.[2] This device automatically delivers reagent tablets into test tubes containing the sample in a measured amount of diluent, passes the tubes over a heating element, into a cooling bath, and finally into a storage rack where the results can be read. This method yields only qualitative results, indicating only that the glucose level is either above or below a pre-determined screening level.

1.2 Klinikit [3]

This piece of apparatus performs the same test as the Clinitron, using the Wilkerson-Heftmann method, but is not automatic. The test tubes containing the specimen must be manually placed into the machine, where they are heated above a heating element. The tubes are removed by hand and placed into a cooling bath, where a colour reaction indicates a qualitative measurement.

1.3 AutoAnalyzer [4]

This device automatically processes each test specimen through a series of operations that result in a completely quantitative " true glucose " measurement. The samples to be analysed are automatically pipetted

[1] Obtainable from Mathewson Machine Works, Inc., Quincy, Mass., USA.
[2] Wilkerson, H.L.C. & Heftmann, E. (1948) *J. Lab. clin. Med.*, **33**, 236-238.
[3] Obtainable from Kat-Nelle Products, Austin, Tex., USA.
[4] Obtainable from Technicon Instruments Corp., Chauncey, N.Y., USA.

from the sample container, pumped along and mixed with the diluent, passed into a dialyser, where the diffusable glucose is separated, and fed into a reagent stream. The stream then passes into a colorimeter and the result is permanently recorded on a moving graph. The method of chemical analysis employed with this mechanism is an adaptation of the Hoffman method.

1.4 Dextrostix[1]

The method recommended by the makers requires simply the application of a drop of blood to the active end of the prepared paper strip for 60 seconds, after which it is washed off in a jet of cold water; the colour is then compared with a colour chart printed on the bottle label. The active end of the test strip is impregnated with a glucose-oxidase/peroxidase chromogen mixture, and coated with a semipermeable membrane, which prevents staining by red blood-cells.

1.5 Notes for guidance

The technical skill and facilities needed for these methods vary. Dextrostix is the simplest to handle, but accurate timing and rapid colour comparisons are essential. Klinikit is relatively simple, but the Clinitron and AutoAnalyzer require a more highly trained operator, maintenance and repair requiring training beyond that needed for routine operation.

The Clinitron processes either venous or capillary blood at a maximum rate of 120 tests per hour. Results are indicative of a blood-sugar level (true glucose) that is either below or above one of three screening levels — e.g., 130 mg/100 ml, 160 mg/100 ml, or 180 mg/100 ml — though other levels are possible by suitable adjustment of blood quantities. The Klinikit (or the Glover-Edwards Test Kit) performs the same test as the Clinitron, but is entirely hand operated, whereas the Clinitron is semi-automatic.

The AutoAnalyzer is a device that automates each step of the test from pipetting to recording results and has the great advantage of giving a quantitative result. Since this method extracts glucose by dialysis rather than by chemical reduction, extremely accurate measurements are possible. Either capillary or venous blood may be processed with this machine, since both a macro- and a micro-method have been developed. From 40 to 60 samples may be run in an hour. To decrease the danger of blood clots, which may rupture the dialyser membrane, plasma is often used with the AutoAnalyzer. When it is, plasma values should be converted to whole-blood values before results are reported to the physician.

[1] Obtainable from Ames Co., Elkhart, Ind., USA.

The following table shows whole-blood-sugar levels commonly used in screening programmes, with their approximately equivalent plasma-sugar values:

Whole blood (mg/100 ml)	*Plasma (mg/100 ml)*
160	190
150	180
140	170
130	155
120	145
115	140

2. Urine Tests

Screening by urine tests, while having the grave disadvantage that glycosuria depends partly on the renal threshold and partly on the carbohydrate load,[1] is, however, relatively simple and has been widely used as an initial procedure. A screening procedure based on glycosuria may miss many diabetics needing attention, and a subsequent glucose test is mandatory. These are two reasons for generally favouring blood-sugar screening procedures, although in some countries or circumstances urine tests may be preferable.

The methods for urine testing should be specific for glucose, to prevent the need for a subsequent sorting-out of patients with lactosuria, galactosuria, xylosuria or other urinary-reducing substances. This means that glucose-specific tests such as Testape [2] or Clinistix [3] should be used.

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[1] The greater the load the higher is the incidence of glycosuria, so that with 50 g, up to a third of the population may have positive tests.

[2] Obtainable from Eli Lilley & Co., Indianapolis, Ind., USA.

[3] Obtainable from Ames Company, Inc., Elkhart, Ind., USA.