Diabetes mellitus on the Zambian Copperbelt

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Diabetes mellitus has become more common in Africa, in association with increasing urbanisation [1]. In 1975 the World Health Organisation (WHO) undertook a multinational study of diabetes [2], the object of which was to compare the prevalence of microvascular and macrovascular disease in different populations using a standardised questionnaire and examination technique, but Africa was not represented. This paper reports the characteristics of diabetes in the Copperbelt region of Zambia which formed part of a detailed assessment of diabetes and its complications using a standardised technique based on the WHO protocol.

Subjects and methods

Patients recruited were ethnic Africans who were being treated for diabetes in general medical clinics at nine hospitals belonging to Zambia Consolidated Copper Mines Ltd (ZCCM) and at two government hospitals, Kitwe Central and Ndola Central, all situated in the Copperbelt region of Zambia. Of the 372 men in the study, 30% were directly employed by the mines. Once employed, they would stay for many years, live in shanty towns and return to the rural areas on retirement. Most of the remainder worked in the various light industries that the presence of the mines attracted. Although African populations in general are much more mobile than Europeans, having found work they are unlikely to leave unless they are sacked or become sick. The development of diabetes, however, would make them stay in the Copperbelt since treatment would not be available outside larger centres. Registers of diabetic patients were not kept and there were no special diabetic clinics, but patients attended hospital rather than private practitioners in order to receive free medicine. All diabetic patients currently attending for treatment were personally seen and examined by one of the authors (M.R.). It was estimated that approximately 90% of all diabetic patients in the Copperbelt were examined; a few patients may have returned to the rural areas or failed to attend because they were asymptomatic. Most patients spoke English but, for those not able to understand, a Zambian nurse translated and interpreted the local dialect.

A questionnaire was completed for each patient, on which were recorded the name, sex, date, tribal origin, present age and age at diagnosis of diabetes. The exact age was not always known, especially by older women, and occasionally had to be estimated from the patient's physical appearance, after consultation with the attending Zambian nurse. The duration of the disease was calculated from the age at diagnosis, with information given by the patient and from hospital records. Details of current treatment were recorded. The type of diabetes was categorised into three groups. Patients receiving insulin who had had documented ketosis at some time were regarded as having insulin-dependent diabetes mellitus (IDDM). Patients on oral hypoglycaemic drugs or treatment with diet alone had non-insulin-dependent diabetes mellitus (NIDDM), while patients who were receiving insulin but who had had no documented ketosis were called insulin-treated (IT).

The height of each patient, without shoes, was recorded in metres, and the weight, without coat or shoes, in kilograms. The body mass index (BMI) was calculated according to the formula BMI = weight in kilograms divided by the square of the height in metres. Initial statistical analysis was done using the Student t test [3]. As duration of diabetes had not a normal distribution, log transformation was performed to normalise the distribution. Multiple logistic regression analysis of the major variables was carried out using the statistical package GLIM [4]. This involved adjustment for the correlation of the different independent variables to reveal associations with a dependent variable taking only two values—present or absent.

Results

Six hundred African diabetic patients were seen (372 men, 228 women); 543 were Zambians and the remainder were from Angola (10), Botswana (1), Malawi (7), South Africa (7), Tanzania (6), Zaire (4) and Zimbabwe (22).

Table 1. Minimum crude prevalence rate for each decade.

Age (years)	Number of diabetic patients	Population (thousands)	Prevalence (%)
0–19	37	732	0.005
20–29	54	205	0.03
30–39	86	125	0.07
40–49	185	82	0.23
50–59	158	37	0.43
60–69	65	14	0.46
70+	15	5	0.30

Table 2. Duration of different types of diabetes in men and women.

Duration (years)	IDDM	NIDDM	IT	Total
Men				
0–6	73 (20%)	93 (25%)	77 (21%)	243 (65%)
7–13	24 (6%)	29 (8%)	35 (9%)	88 (24%)
14+	9 (2%)	10 (3%)	22 (6%)	41 (11%)
Women				
0–6	44 (19%)	71 (31%)	45 (20%)	160 (70%)
7–13	16 (7%)	19 (8%)	17 (8%)	52 (23%)
14+	3 (1%)	6 (3%)	7 (3%)	16 (7%)

Prevalence

The minimum crude prevalence rate was 0.05% (population 1,200,000). Prevalence rose with age (Table 1). This was based on the patient's age at interview and figures from the 1980 population census [5].

Age at diagnosis and sex ratio

The mean age at diagnosis was 39.0 years, with a peak frequency in the fourth and fifth decades. Fifty-seven patients (9.5%) developed the disease before 20 years of age and eleven (1.8%) before the age of 10. The male to female ratio was 1.6 to 1 and men outnumbered women in each decade except the seventh.

Duration of diabetes

The geometric mean duration of diabetes was 3.9 years overall (4.1 years in men, 3.7 years in women). Long duration disease (14 years or more) was uncommon, especially in women (Table 2). Most of the patients with long duration disease were men with IT diabetes.

Types of diabetes

Three hundred and seventy-two patients (62%) were on insulin (Table 3), 169 (28%) being IDDM and 203 (34%) IT patients. The mean dosage of insulin was 1.16 units/kg body weight in patients with IDDM (range 0.30–4.80) and 0.76 units/kg in IT patients (range 0.20–2.70). NIDDM was commoner in women; 213 (35.5%) patients were on oral hypoglycaemic drugs and 15 (2.5%) on dietary treatment alone. Men with IT diabetes had longer duration disease than men with IDDM ($t = 2.13$, df = 238, $p < 0.05$) but not longer than men with NIDDM, and there was no significant difference amongst the women. As expected, IDDM patients were younger than the others but they had a similar duration of diabetes.

Table 3. Descriptive statistics by type of diabetes: present age, age at diagnosis, duration of diabetes (years) and BMI.

	IDDM	NIDDM	IT	Overall
Men				
Numbers	106 (29%)	132 (35%)	134 (36%)	372 (62%)
Mean age at interview	34.3 SD 14.8	49.8 SD 8.3	49.7 SD 10.3	45.4 SD 13.2
Mean age at diagnosis	28.9 SD 14.2	44.6 SD 8.8	42.7 SD 9.9	39.4 SD 12.8
Median duration	3.0 (interquartile range 2–7)	4.0 (interquartile range 2–7)	5.0 (interquartile range 2–12)	
Mean log duration	1.28 SD 0.94	1.35 SD 0.87	1.55 SD 1.00	1.41 SD 0.96
BMI	21.1 SD 3.7	25.1 SD 4.0	23.0 SD 4.0	23.2 SD 4.3
Women				
Numbers	63 (28%)	96 (42%)	69 (30%)	228 (38%)
Mean age at interview	29.2 SD 12.6	49.7 SD 10.5	47.8 SD 9.6	43.5 SD 14.0
Mean age at diagnosis	24.2 SD 12.1	44.7 SD 10.2	42.1 SD 9.4	38.2 SD 13.6
Median duration	3.0 (interquartile range 2–7)	4.0 (interquartile range 2–7)	5.0 (interquartile range 2–8)	
Mean log duration	1.22 SD 0.93	1.31 SD 0.81	1.41 SD 0.92	1.31 SD 0.83
BMI	23.2 SD 5.0	26.5 SD 5.6	26.8 SD 5.2	25.7 SD 5.5
Total	169 (28%)	228 (38%)	203 (34%)	600

Body mass index

Women were significantly more obese than men (mean difference in BMI 2.5, 95% CI 1.7–3.3; $t = 6.25$, df = 598, $p < 0.001$) (Table 3). There was no significant difference in BMI between women with NIDDM and IT diabetes, but women with NIDDM were significantly fatter than women with IDDM (mean difference in BMI 3.3, 95% CI 1.6–5.0; $t = 3.79$, df = 157, $p < 0.001$). Men with NIDDM were significantly more obese than men with IDDM (mean difference in BMI 4.0, 95% CI 3.0–5.0; $t = 7.92$, df = 236, $p < 0.001$) and IT men (mean difference in BMI 2.1, 95% CI 1.1–3.1; $t = 4.29$, df = 264, $p < 0.001$) while IT men were significantly more obese than men with IDDM (mean difference in BMI 1.9, 95% CI 0.9–2.9; $t = 3.78$, df = 238, $p < 0.001$).

Complications

Diabetic complications, determined by the use of a standardised technique based on the WHO protocol [2], were common (Table 4), with the exception of large-vessel disease. Multiple logistic regression analysis of the major variables showed no significant difference between the sexes for the presence of retinopathy, neuropathy or large-vessel disease, but women were at higher risk of nephropathy than men and this risk was highest in women with NIDDM and IT diabetes. The risk of neuropathy and nephropathy decreased with increasing obesity.

Additional data

Seven patients had been diagnosed as having chronic pancreatitis (five had pancreatic calcification). This information was extracted from the case notes and is therefore likely to be an underestimate of the true prevalence of this condition. Sixteen patients had been under treatment for tuberculosis (15 pulmonary, 1 hip joint) while one patient developed diabetes following acute hepatitis and another had cirrhosis of the liver. Two patients were on treatment for leprosy but neither showed evidence of peripheral neuropathy on examination. Two patients had the acquired immune deficiency syndrome, one with aggressive Kaposi's sarcoma. Seven patients had presented with ketosis and hyperglycaemia but had gone into remission and were on tablets and/or diet alone at the time of the examination.

Discussion

Previous prevalence studies in Central Africa have demonstrated rates of 0.1% in a township near Harare, Zimbabwe [10], and 0.06% in Lilongwe, Malawi [11]. The prevalence of diabetes in the developed world rises with age [12]; this has also been shown in the present study. The fall in prevalence for patients aged over 70 years may reflect a high death rate in older diabetic patients as well as the tendency of Zambians to return to rural areas on retirement and the low

Table 4. Prevalence of complications with significantly associated variables.

Complication	Prevalence	Variable
Large-vessel disease	8% [6]	Age[a] (+) Total cholesterol[b] (+) Systolic blood pressure[c] (+)
Neuropathy	31% [7]	BMI[a] (−) Age[b] (+) Duration of diabetes[b] (+)
Retinopathy	34% [8]	Duration of diabetes[a] (+) Age[b] (+)
Nephropathy	Women: 27% [9] Men: 22%	*Women* BMI[a] (−) NIDDM, IT diabetes[b] (+) Total cholesterol[b] (+) *Men* Age[c] (+) BMI[c] (−) Systolic blood pressure[c] (+)

(+) denotes variable associated with increased risk of complication.
(−) denotes variable associated with decreased risk of complication.
[a] $p < 0.001$. [b] $p < 0.01$. [c] $p < 0.05$.

numbers at risk. Diabetes is more prevalent in urban regions of Africa [1] than in rural regions, while a relationship between the length of urban exposure (about 20 years) and development of diabetes has been shown in Zulus in Durban [13]. The number of diabetic patients seen may reflect the relative affluence in the region 25 years ago when the copper industry was at its peak, but unfortunately time did not permit a more detailed study on the relationship between diabetes and residence in Copperbelt towns. As in most countries of the developing world, there has been increasing urbanisation in Zambia. The proportion of urban to the total population has risen from 20.5% in 1963 to 43% in 1980 [5] and is currently around 55%. It is likely therefore that the prevalence of diabetes in Zambia will increase in the future. The peak age at onset of diabetes in the fourth and fifth decades has also been found in other studies from Africa [14–16].

Childhood diabetes has been reported to be rare in Africans [17,18], but in this study 57 (9.5%) patients developed the disease before 20 years of age and 11 (1.8%) patients before the age of 10, the youngest being 2 years old. In some countries, such as Nigeria, there is a higher proportion of patients with disease onset before 20 years, but 50–75% of these have tropical diabetes and a calcified pancreas [14]. The findings in the present study are comparable to those from Ethiopia where Lester [19] reported that 7.4% of 1,088 patients had developed diabetes at or before 15 years of age and none had pancreatic calcification; only one Zambian patient was found with tropical diabetes [20].

Diabetes in Africa is most common in men [14,15,17], while in developed countries diabetes is more prevalent in women, possibly owing to increasing obesity with middle age [21]. However, the sex ratio in the population must be taken into account. The ratio in the general Zambian population is 962 men to 1,000 women whilst in the Copperbelt it is 1,060 men to 1,000 women [5] owing to selective migration in search of work. This factor probably operates throughout urban Africa and may contribute to the male predominance in this and other studies.

Duration of diabetes has been short in most African studies, reflecting a high mortality rate and increased prevalence and diagnosis with recent urbanisation. The small number (10%) with long duration disease in this study contrasts with the WHO study [2] where the average was approximately 27% and only Oklahoma had a lower proportion of patients with long duration disease.

In Europe and America the ideal range of BMI is considered to be 20–25 for men and 19–24 for women [22]. No figures have been suggested for an African population but Coles [23] showed that, height for height, Ugandans were 10 kg lighter than Europeans or Americans. In the present study, 39% of women and 16% of men were obese by European standards (BMI > 27), while 12% of women and 3% of men were very obese (BMI > 33). There was no apparent change in BMI with age. Men were less obese than in most countries of the WHO study [2], being similar to those from India, Japan and Hong Kong who had the lowest BMIs. Women were more obese than diabetic women in Japan or Hong Kong, similar to those in Brussels, but less obese than women in India or London.

There have been conflicting reports on the proportion of Africans with diabetes requiring insulin. Oli from Nigeria [24] stated that most African patients were non-insulin-dependent. However, Gelfand and Forbes [17] in Zimbabwe thought African patients responded poorly to oral hypoglycaemic drugs. Other studies give figures of 40% of patients requiring insulin in Ethiopia [25], 47% in Tanzania [15] and 45% in Nigeria [14]. Wicks and Jones in Zimbabwe [26] found 76% of their patients to be insulin-dependent and suggested that this might be related to the diet of maize meal which, being slowly digested and absorbed, was a poor stimulus for insulin release. Wapnick *et al.* [27] demonstrated that the fasting blood glucose, oral glucose tolerance curve and changes in serum insulin levels were significantly lower in healthy Africans than in Europeans. The diet in Zambia is similar to that in Zimbabwe and, together with the low prevalence of obesity, may explain why so many patients in Central Africa require insulin. The proportion receiving insulin in this study was higher than in any other country in the WHO study [2]. Indeed, the proportion should probably have been even higher as substantial numbers of patients with NIDDM were inadequately controlled [28]; 132 (58%) patients had a fasting blood glucose above 10.0 mmol/litre. The IT patients were a heterogeneous group; a few of them may have been truly insulin-dependent, but past records were sometimes missing or incomplete, so there was no documentary proof of ketosis. Others may have avoided insulin treatment with tighter dietary control or improved compliance, but most of these patients required insulin to control the symptoms of hyperglycaemia. There were no patients with J-type or ketosis-resistant youth-onset diabetes; all patients with onset of diabetes before 20 years of age were typical ketosis-prone insulin-dependent patients. There was also none who could be classified as having maturity-onset diabetes of youth; two young patients were on oral hypoglycaemic drugs but both had high fasting blood glucose levels.

Retinopathy was as common [8] as in other countries of the multinational study [2], despite the relatively short duration of diabetes. However, retinopathic blindness was rare, affecting only one patient who had had diabetes for 28 years; in contrast, cataract (13%) caused blindness in 25 patients [8]. Multiple logistic regression analysis of the major variables confirmed that duration of diabetes was the most important factor associated with the presence of retinopathy; this was found in all centres of the WHO study [2], and in both sexes with the exception of men in Hong Kong and Havana. Of interest was the decreasing risk of nephropathy and neuropathy with increasing BMI; this association was found with microvascular disease in a few centres of the WHO study [2], but does not appear to have been previously described with neuropathy. There was a low prevalence of large-vessel disease [6] which was comparable to Japan and Hong Kong which had the lowest prevalence in the WHO study [2].

The toll of diabetes in this area of Central Africa is considerable, with 45% of patients having microvascular disease, comparable to other countries [2], despite the relatively short duration of diabetes; only 196 (33%) patients were free of vascular disease, cataract and neuropathy.

The WHO study [2] showed wide variations in the prevalence of vascular disease in diabetic populations of different countries; the data presented here from an African population provide further evidence of the diverse nature of diabetes and its complications.

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It's only money

Fees for their professional services have always been a tricky subject for Fellows of the College. Dr Alec Cooke pointed out that the tradition of barristers and Fellows not suing for fees could have derived from Roman law when the *honorarium* as compensation for higher intellectual services was considered to be entirely different from the *merces* paid for physical labour. This was underlined in 1791 when a Doncaster physician, not an FRCP, tried to sue for a fee. The Chief Justice said '... it has been understood in this country that the fees of a physician are honorary and not demandable by right.' This did not stop 18th century physicians making a lot of money, particularly attending patients in Bath. It did lead to nice gestures of disdain for money, like John Fothergill saying 'I had rather return the fee of a gentleman with whose rank I am not perfectly acquainted than run the risk of taking it from a man who ought perhaps to be the object of my bounty.'

When the Medical Act of 1858 regulated so many professional affairs, its Section 31 permitted registered practitioners to sue for fees. But the Section contained a clause, put in at the request of the London College, that empowered any College of Physicians to make a by-law prohibiting its Fellows from suing for their fees. The Edinburgh and Dublin Colleges did not avail themselves of this clause but the London College did pass a by-law that prevented its Fellows from suing.

The College's Charter Committee in 1860 went a little further. Its report stated that, as a rule, a physician 'is remunerated by fees paid at the time of his visits ... any person whose custom it should be to send in bills of charges for his attendances would be considered not to be a physician.' This conjures up visions of how the approximately 220 Fellows of the time were to collect their income. Did one rely on the butler to carry a bag of guineas on a silver salver out to one's carriage? Were the guineas left discreetly in the bathroom to be collected when the physician washed after the consultation? There could be no reminder sent after the visit; it was now or never for the cash. Perhaps the Fellows were being asked to accept a monastic vow of poverty to purify the doctor–patient relationship. This seems unlikely because when the younger Fellows of that time died in the fullness of professional achievement some at least were not impoverished. Sir William Jenner, PRCP 1881–8, left £375,000 and his successor, Sir Andrew Clark, left £204,000. You did not have to be President to do that; witness the £350,000 left by Dr James Blundell and the £344,000 left by Sir William Gull. In today's terms these were enormous fortunes. Perhaps the financial advice they received was as good, or better, than the medical advice they gave without resorting to a bill.

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