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Community screening for diabetes in the National Capital District, Papua New Guinea: is betelnut chewing a risk factor for diabetes?

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SUMMARY

This cross-sectional study was conducted intermittently in the National Capital District of Papua New Guinea from 1995 to 1999. Fasting capillary blood glucose (FCBG) was used as the screening test for diabetes. Blood glucose level was measured using the standard pocket-size reflectometer. A total of 769 individuals were screened. There were 385 males and 384 females ranging in age from 12 to 76 years. High FCBG (hFCBG) (≥7.0 mmol/l) was found in 13% of those examined and was associated with older age (p=0.001), high body mass index (p=0.027), coastal region of origin (p=0.012) and betelnut chewing (p<0.001). The prevalence of hFCBG in those of highland origin was 9% compared to 16% among the coastal people. Among the Seventh Day Adventists, the prevalence of hFCBG was 10%. The overall prevalence of hFCBG was the same in males and females but in those aged 35 years or more the prevalence was higher in females. Multivariate analysis (logistic regression) showed that hFCBG was significantly associated with betelnut chewing (p=0.005) and age (p=0.028); the body mass index (p=0.061) and region of origin (p=0.056) associations approached statistical significance. Sex and smoking were not statistically significant factors. In conclusion, diabetes is common in the 'healthy' population of Port Moresby and rates in highlanders living there were surprisingly high. In this study, betelnut chewing was independently associated with diabetes, and may therefore be a risk factor for diabetes mellitus.

Introduction

Urbanization is the direct result of development or may be a form of development in itself. Diabetes mellitus is one of the diseases that is the result of changes brought about by urbanization (1). Many Papua New Guineans have adopted a more western-type lifestyle characterized by high intake of fatty and refined food. With sedentary jobs and inactivity, many are becoming prone to noncommunicable diseases such as diabetes.

In the past 15 years, diabetes mellitus has become a disease of major public health concern and is now included in the lifestyle diseases program in the Papua New Guinea National Health Plan. The goals set by the Ministry of Health are: "to contain the disease in the low- and medium-incidence areas and to limit the rising incidence and complications in the high-incidence areas" (2).

Historically, it is important to note that diabetes mellitus was never mentioned in the early medical reports such as the Report of the New Guinea Nutrition Survey in 1947 (3). In 1961 Campbell described 10 cases of diabetes in Port Moresby (4). In 1962 Hingston and Price conducted a survey around Port Moresby and two traditional rural villages. No diabetes was found in the traditional rural villages and 2 cases were found in the 4 suburbs (a prevalence of 0.2%) (5). A similar study by Price and Tulloch in 1966 showed that the prevalence had increased to 1.4% in the suburbs with the longest contact with western lifestyles (6).

In 1977 a survey was conducted in Port Moresby (Koki) and at Kalo, a rural village 70-80 km from Port Moresby. The prevalence of diabetes was 15.8% in the relatively affluent Wanigelan suburb of Koki, while the rural village of Kalo had a prevalence of 1.0% (7). In 1991 a follow-up study found that the prevalence in Koki had risen to 27.5% in men

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and 33.0% in women while in the rural villages of Wanigela, of the same ethnic group as Koki, and Kalo the prevalences were 11.7% and 1.5% respectively (8). In studies conducted in the highlands in 1983 and 1985, no cases of diabetes were found but periurban subjects showed the high insulin response which may be a precursor of glucose intolerance (9,10).

There is not, however, very much recent information on diabetes prevalence throughout Papua New Guinea (PNG), nor on the various possible risk factors. One of these is betelnut chewing, which is common in PNG, and there is preliminary information that suggests it may contribute to the raising of blood sugar levels (11,12).

Methodology

This cross-sectional study was intermittently conducted in the National Capital District (NCD) between October 1995 and September 1999. No screening was conducted in 1998. The aims of the study were to determine the prevalence of diabetes in the 'healthy' population in the NCD and to identify possible risk factors.

Study population

The screening tests were conducted in the local community and church halls in various locations in the NCD. The subjects were healthy groups of people who were notified and informed 2-3 days before the screening test. Subjects who were 12 years old and above were invited to participate in the study. The Wanigela people from Koki village, predominantly Seventh Day Adventists, were excluded from the study because of the known high prevalence of diabetes in this community.

The subjects were required to fast overnight before screening. They were weighed with light clothing only and without shoes. Weight was recorded to the nearest kilogram and height measured to the nearest centimetre. Information collected included age, province of origin, religious denomination, and smoking and betelnut chewing habits.

Capillary blood tests

Capillary blood glucose is widely accepted and used by patients and health professionals in the management of diabetes (13,14). Fasting capillary blood glucose (FCBG) as a screening test for diabetes and impaired glucose tolerance has been used by others (15-18). In this study FCBG was used as the screening test for diabetes.

The Ames Glucometer 3 (Bayer Diagnostics) was used to test the capillary blood for glucose level. After an overnight fast (without consumption of any food or beverage other than water for at least 10 hours before testing), the capillary blood was obtained by a finger prick. A drop of blood was applied on to the glucofilm strip and the result read at the end of 60 seconds.

Diabetes was defined as FCBG ≥7.0 mmol/l and impaired fasting glycaemia as 6.1-6.9 mmol/l (19).

All individuals with FCBG ≥7.0 mmol/l were retested in 2 hours using the same glucometer and at the same time a second glucometer was used to cross-check the results of the first. High FCBG (hFCBG) in both glucometers was accepted as indicating a possible case of diabetes and these individuals were referred to the hospital laboratory for fasting blood glucose and then to the Diabetes Clinic at Port Moresby General Hospital (PMGH).

Results

The results of the analysis of 769 records are presented here. There were 385 males and 384 females. Their ages ranged from 12 to 76 years. 66% of the subjects were under the age of 40 and only 2.7% were 60 years of age or older (Table 1).

On a regional basis, more of the participants originated from the Southern Region (37%) and Highlands (34%), than the Islands Region (21%) and Momase Region (8%) (Table 1).

There were 62 (8%) smokers and 102 (13%) betelnut chewers in the study. The large majority (78%) of participants were Seventh Day Adventist church followers, while the remaining 22% consisted of other Christian denominational groups (Table 1).

TABLE 1

DISTRIBUTION OF SUBJECTS BY SEX, AGE GROUP, REGION OF ORIGIN, BETELNUT CHEWING, SMOKING AND RELIGION

Characteristics of subjects	Number (N=769)	Percent
Sex		
Males	385	50.1
Females	384	49.9
Age group (years)		
12-19	46	6.0
20-39	462	60.1
40-59	240	31.2
≥60	21	2.7
Region of origin		
Southern	281	36.5
Highlands	265	34.5
Islands	160	20.8
Momase	63	8.2
Betelnut chewer*		
Yes	102	13.4
No	661	86.6
Smoker**		
Yes	62	8.1
No	703	91.9
Religion		
Anglican	3	0.4
Baptist	4	0.5
Lutheran	14	1.8
Pentecostal	25	3.3
United Church	41	5.3
Catholic	52	6.8
SDA	602	78.3
Other	28	3.6

* 6 missing values
** 4 missing values
SDA = Seventh Day Adventist

Fasting capillary blood glucose

Based on the criterion stated above, 13% of the 769 subjects in this study had hFCBG (≥7.0 mmol/l – the level which can be considered as diabetes mellitus).

The mean FCBG was 5.4 mmol/l. 97 subjects had diabetes, with a prevalence of 16% in those from the coastal areas and 9% in those of highland origin (Table 2).

The prevalence of hFCBG increased with age in both males and females (Figure 1). The prevalence was 20% for the subjects aged 40 years and older and 11% for those under 40 years (odds ratio 2.18, 95% CI 1.38 - 3.45, p=0.001) (Table 2). At the age of 35 years and above the rate of hFCBG in both males and females was above 15% (Figure 1).

The prevalence of hFCBG was the same in both males and females overall, but was more common in males than females for subjects under 35 years and more common in females than males for those over 35 years.

When the coastal and highlands subjects were grouped by age, the prevalences of hFCBG were higher in the coastal subjects in almost all age groups. However, among the 45-54 year olds, prevalence in the highlanders was 33% compared with 22% among the coastal people (Figure 2). For both coastal and highlands subjects, the prevalence of hFCBG increased with age.

Betelnut chewers and FCBG

Among the 92 betelnut chewers, 30% had a high FCBG whereas the prevalence of hFCBG

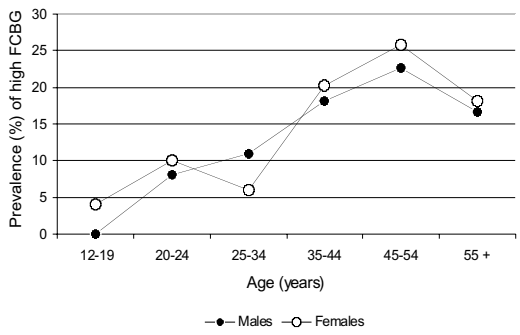

Figure 1. Prevalence (%) of high fasting capillary blood glucose (FCBG ≥7.0 mmol/l) by sex and age.

TABLE 2

ANALYSIS OF ASSOCIATIONS BETWEEN HIGH FASTING CAPILLARY BLOOD GLUCOSE AND AGE GROUP, REGION OF ORIGIN, RELIGION AND BETELNUT CHEWING

Characteristics	Fasting capillary blood glucose		Number*
	High (≥7.0 mmol/l)	Normal (<6.1 mmol/l)	
Age			
≥40 years	48 (20.4%)	187 (79.6%)	235
12-39 years	49 (10.5%)	417 (89.5%)	466
χ^2=12.87, odds ratio 2.18, 95% CI 1.38 - 3.45, p=0.001			
Region of origin			
Coastal	74 (16.2%)	382 (83.8%)	456
Highlands	23 (9.4%)	222 (90.6%)	245
χ^2=6.25, odds ratio 1.87, 95% CI 1.10 - 3.19, p=0.012			
Religion			
SDA	57 (10.3%)	496 (89.7%)	553
Others	40 (27.0%)	108 (73.0%)	148
χ^2=27.17, odds ratio 0.31, 95% CI 0.19 - 0.50, p<0.001			
Betelnut chewing			
Yes	28 (30.4%)	64 (69.6%)	92
No	69 (11.3%)	540 (88.7%)	609
χ^2=24.43, odds ratio 3.42, 95% CI 1.99 - 5.87, p<0.001			

* 68 participants had a fasting capillary blood glucose level of 6.1-6.9 mmol/l (impaired fasting glycaemia) and were excluded from the above analysis

SDA = Seventh Day Adventist

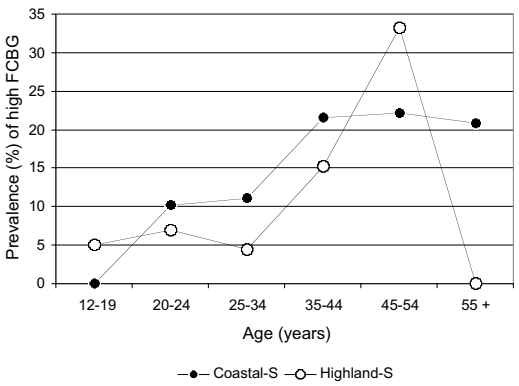

Figure 2. Prevalence (%) of high fasting capillary blood glucose (FCBG ≥7.0 mmol/l) by region of origin and age.

among the non-chewers was 11% (odds ratio 3.42, 95% CI 1.99 - 5.87, p<0.001) (Table 2). In this study (with no Seventh Day Adventist Koki Wanigelas included) being a Seventh Day Adventist reduced the chance of diabetes (Table 2).

Province of origin

Of the participants originating from a coastal area 16% had diabetes compared to 9% in highlanders (Table 2). There was a significant association between coastal origin and diabetes mellitus, odds ratio 1.87, 95% CI 1.10 - 3.19, p=0.012 (Table 2).

Body mass index

The body mass index (BMI) provides information on the nutritional status of the subjects. On the western standard definition of a normal BMI of 20-25 kg/m^2, more than a half (58%) were overweight, 38% had normal BMI and 4% were underweight, with BMI <20 kg/m^2 (Table 3).

There was a significant association between BMI and hFCBG (odds ratio 1.71, 95% CI 1.03 - 2.84, p=0.027). Among those who were overweight, 16% had hFCBG (Table 3).

The mean BMI of both males and females increased with age to 45 years. There was, however, a decrease in BMI at the age of 45 years and above in both males and females (Figure 3). Nevertheless, the mean BMI for all groups aged 25 years and above was greater than 25 kg/m^2.

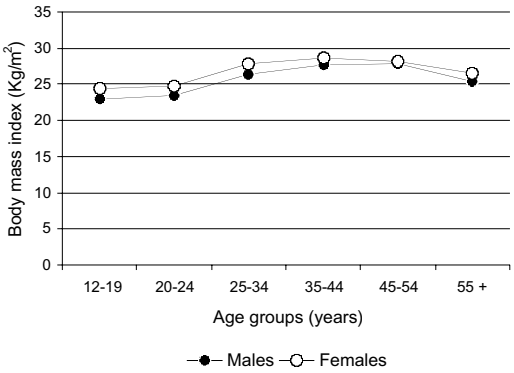

Figure 3. Mean body mass index by sex and age.

Multivariate analysis

Multivariate analysis (logistic regression) was done to determine the relative contributions of betelnut chewing, age, sex, smoking, region of origin and BMI to hFCBG. There was a significant association between

TABLE 3

ANALYSIS OF ASSOCIATION BETWEEN BODY MASS INDEX (BMI) AND BLOOD GLUCOSE LEVEL

Body mass index	Fasting capillary blood glucose ≥7.0 mmol/l	Fasting capillary blood glucose Normal (<6.1 mmol/l)	Total
High (BMI ≥25.1 kg/m^2)	66 (16.2%)	341 (83.8%)	407
Normal (BMI 20-25 kg/m^2)	27 (10.2%)	238 (89.8%)	265
Total	93 (13.8%)*	579 (86.2%)	672**

*4 subjects who had fasting capillary blood glucose ≥7.0 mmol/l but BMI <20 kg/m^2 were excluded
**29 subjects (including the 4 subjects above) whose BMI was <20 kg/m^2 and 68 subjects who had fasting capillary blood glucose 6.1-6.9 mmol/l were excluded from this table
χ^2 = 4.89, odds ratio 1.71, 95% CI 1.03 - 2.84, p=0.027

TABLE 4

MULTIVARIATE ANALYSIS OF ASSOCIATION BETWEEN HIGH FASTING CAPILLARY BLOOD GLUCOSE (≥7.0 MMOL/L) AND AGE, BETELNUT CHEWING, BODY MASS INDEX, REGION OF ORIGIN, SEX AND SMOKING

Variables	B	Degree of freedom	p value
Age	0.554	1	0.028
Betelnut chewing	1.032	1	0.005
Body mass index	0.507	1	0.061
Region of origin	-1.582	1	0.056
Sex	-0.070	1	0.777
Smoking	0.392	1	0.359

hFCBG and betelnut chewing (p=0.005) and age (p=0.028) (Table 4). The associations of BMI and region of origin with hFCBG approached statistical significance (p=0.061 and 0.056 respectively).

Discussion

In PNG diabetes is increasing in prevalence with urbanization (9). In a country where there is not only a shortage of doctors but also of the necessary equipment and essential supplies, community screening for diabetes is very important because it is an opportunity for detection, prevention and treatment.

Community screening for diabetes and other levels of glucose intolerance using fasting capillary blood is accepted by many experts (14). Fisch and others (18) used reflectometers such as Reflolux extensively in epidemiological studies of hyperglycaemia in Africa. In Saudi Arabia, other workers have used capillary blood and reported that 49% of those with a random blood glucose of 7.8 to 11.1 mmol/l at screening were confirmed by oral glucose tolerance test to have diabetes (15).

This study not only showed, as expected, the high prevalence of high blood sugar level among coastal people (16%) but also a prevalence of 9% among the highlanders living in Port Moresby. This is an important observation because previous studies conducted in the highlands in 1983 and 1985 reported no cases of diabetes (9,10). However, in Port Moresby it is likely that highlanders and coastal people are eating the same refined and high-fat diet, with obesity common in both groups. It is also of concern that, based on western BMI criteria, 58% of the subjects were overweight, and of these, 20% were obese. Previously BMI has been shown to be higher in urbanized men and women than in their rural counterparts in PNG (20). Also obesity has long been implicated as a factor in diabetes mellitus (6). In this study high BMI was associated with hFCBG.

Betel palms (*Areca catechu*) grow readily in the coastal areas of Papua New Guinea. Betelnut is chewed with mustard (a tropical pepper vine) and lime (calcium hydroxide). Betelnut chewing is socially acceptable in PNG. Both adults and schoolchildren as young as 10 years chew betelnut. Betelnut is a 'social icon' which is given as a gift to visitors, in appreciation of kind deeds or as a sign of agreement between individuals or clans, and is shared in social gatherings**.**

It is noteworthy that betelnut chewing was associated with hFCBG. With the growing popularity of herbal medicine in PNG, many people are advocating the chewing of betelnut as a treatment for diabetes. This study showed the opposite in that betelnut chewers have high FCBG. There is evidence that betelnut induces glucose intolerance. Boucher et al. showed that glucose intolerance occurred in adult CD1 mice and their F1 and F2 offspring when they were fed betelnut (11). A study by Mannan et al. in humans showed that consumption of betelnut was strongly related to increased weight and waist size and that betelnut was a risk factor for increased glycaemia (12). These studies suggest that betelnut consumption may be diabetogenic.

The higher prevalence of diabetes in females over 35 years than in males in this age group is similar to the data from Western Samoa (1).

It is a serious issue that while Papua New Guinea is burdened with a high prevalence of infectious diseases, diabetes is emerging as a public health problem in the urban centres. This appears to be happening not just in the coastal peoples but also in highlanders moving to the city.

Conclusion

This study showed that betelnut chewing is strongly associated with diabetes. This is a significant observation and together with the published literature suggests that those with, or at risk of, diabetes should not chew betelnut. However, further studies on the association are indicated in order to confirm these findings. Among the Seventh Day Adventist followers, the prevalence of diabetes was 10%, which is still higher than in many other communities in the South Pacific.

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REFERENCES

1 **Collins VR, Dowse GK, Toelupe PM, Imo TT, Aloaina FL, Spark RA, Zimmet PZ.** Increasing prevalence of NIDDM in the Pacific island population of Western Samoa over a 13-year period. *Diabetes Care* 1994;17:288-296.

2 **Papua New Guinea Department of Health.** Papua New Guinea National Health Plan 1991-1995. Port Moresby: Department of Health, 1990.

3 **Hipsley EH, Clements FW.** Report of the New Guinea Nutrition Survey Expedition 1947. Sydney: Government Printer, 1950:308p.

4 **Campbell CH.** Diabetes mellitus in the Territory of Papua and New Guinea. *Med J Aust* 1963;2:607-610.

5 **Hingston RG, Price AVG.** Diabetic surveys in Papua. *PNG Med J* 1964;7:33-35.

6 **Price AVG, Tulloch JA.** Diabetes mellitus in Papua New Guinea. *Med J Aust* 1966;2:645-648.

7 **Martin FIR, Wyatt GB, Griew AR, Mathews JD, Campbell DG.** Diabetic surveys in Papua New Guinea - results and implications. *PNG Med J* 1981;24:188-194.

8 **Dowse GK, Spark RA, Mavo B, Hodge AM, Erasmus RT, Gwalimu M, Knight LT, Koki G, Zimmet PZ.** Extraordinary prevalence of non-insulin-dependent diabetes mellitus and bimodal plasma glucose distribution in the Wanigela people of Papua New Guinea. *Med J Aust* 1994;160:767-774.

9 **King H.** Glucose tolerance in Papua New Guinea: past and future studies. *PNG Med J* 1985;28:283-289.

10 **King H, Finch C, Collins A, Koki G, King LF, Heywood P, Zimmet PZ.** Glucose tolerance in Papua New Guinea: ethnic differences, association with environmental and behavioural factors and the possible emergence of glucose intolerance in a highland community. *Med J Aust* 1989;151:204-210.

11 **Boucher BJ, Ewen SWB, Stowers JM.** Betel nut (*Areca catechu*) consumption and the induction of glucose intolerance in adult CD1 mice and their F1 and F2 offspring. *Diabetologia* 1994;37:49-55.

12 **Mannan N, Boucher BJ, Evans SJ.** Increased waist size and weight in relation to consumption of *Areca catechu* (betel-nut); a risk factor for increased glycaemia in Asians in east London. *Br J Nutr* 2000;83:267-275.

13 **Daneman D, Siminerio L, Transue D, Betschart J, Drash A, Becker D.** The role of self-monitoring of blood glucose in the routine management of children with insulin-dependent diabetes mellitus. *Diabetes Care* 1985;8:1-4.

14 **Knowler WC.** Screening for NIDDM. Opportunities for detection, treatment, and prevention. *Diabetes Care* 1994;17:445-450.

15 **Kabadi UM, O'Connell KM, Johnson J, Kabadi M.** The effect of recurrent practice at home on the acceptability of capillary blood glucose readings. Accuracy of self blood glucose testing. *Diabetes Care* 1994;17:1110-1123.

16 **Bortheiry AL, Malerbi DA, Franco LJ.** The ROC curve in the evaluation of fasting capillary blood glucose as a screening test for diabetes and IGT. *Diabetes Care* 1994;17:1269-1272.

17 **Abu-Zeid HAH, al-Kassab ASK.** Prevalence and health-care features of hyperglycemia in semiurban-rural communities in southern Saudi Arabia. *Diabetes Care* 1992;15:484-489.

18 **Fisch A, Pichard E, Prazuck T, Leblanc H, Cisse H.** Suitability of reflectometry in epidemiology of diabetes mellitus in Africans. *Lancet* 1990;335:661-662.

19 **Baba S, Zimmet P.** Non-insulin-dependent Diabetes Mellitus (NIDDM): Practical Targets and Treatment, First edition. Asian-Pacific NIDDM Policy Group, 1995.

20 **Hodge AM, Dowse GK, Koki G, Mavo B, Alpers MP, Zimmet PZ.** Modernity and obesity in coastal and highland Papua New Guinea. *Int J Obes Relat Metab Disord* 1995;19:154-161.