Glycaemic Control In Diabetics Attending Primary Care Clinics In A Multi-Ethnic Caribbean Country

D Ramdath, N Ramdhanie, H Singh, P Prabhakar

Citation

D Ramdath, N Ramdhanie, H Singh, P Prabhakar. *Glycaemic Control In Diabetics Attending Primary Care Clinics In A Multi-Ethnic Caribbean Country*. The Internet Journal of Third World Medicine. 2003 Volume 2 Number 1.

Abstract

Objectives: To conduct an audit of glycaemic control in diabetics attending primary care clinics in Trinidad.

Methods: Random glucose and urine test strip results at 3 primary care clinics were compared with measurements of glucose and HbA1c at a reference laboratory.

Results: There were 207 volunteers: 73 males, 134 females; 57.6±10.9 yrs (mean±sd). Clinic glucose (95%CI=10.4 -12.3 mmol/L) correlated strongly with that of the reference laboratory (r=0.91, p<0.005). Frequency of hyperglycemia (>11.1 mmol/L) in the different clinics was similar;
46% of the diabetics were hyperglycemic and 19% had glucose >16.7 mmol/L. Plasma glucose and urine test strip results correlated positively (r=0.45, p<0.001) however, 30% of patients with a negative test strip had plasma glucose >11.1 mmol/L. The sensitivity and specificity of urine test strips at a plasma glucose of 11.1 mmol/L were: 71% and 62%, respectively. The predictive value was 63% and the diagnostic efficiency was 47%. Mean HbA1c was 8.9% (95%CI=8.2-9.6%); this correlated with glucose (r=0.66, p<0.005) and urine test strip (r=0.50, p<0.005).

Conclusions: Optimal glycaemic control of diabetic patients at these primary care facilities is not being achieved. Blood glucose measurement is superior to urine test strip; however, the validity of both these results may be improved by the implementation of routine quality assurance.

The work was conducted at the Biochemistry Unit, Department of Preclinical Sciences, Faculty of Medical Sciences, The University of the West Indies. St. Augustine. Trinidad & Tobago.

Funding: This study was supported by a grant from PAHO/WHO

INTRODUCTION

Type 2 diabetes is one of the leading causes of morbidity and mortality in many developing countries undergoing demographic transition[1,2] and includes many of the islands of the Caribbean[3]. In Trinidad and Tobago the prevalence of diabetes is the highest in the Caribbean and approximately 6 times higher than that in North America[4,5]. The health care burden inflicted by diabetes and its complication can pose a significant challenge to the fragile economies of developing countries[1,5].

It has been shown that complications of diabetes could be reduced when good glycemic control is achieved[6,7]. However, monitoring of glycemic control requires accurate, valid measurements of plasma glucose and glycated hemoglobin (HbA_{1c})[7,8,9]. Laboratory tests for monitoring glycemic control are relatively inexpensive, especially when compared to the costs associated with diabetic complications. It would therefore seem prudent to identify and promote reliable and cost-effective tools for the diagnosis and control of diabetes in the primary health care system of developing countries.

At primary care clinics in Trinidad and Tobago, and in many developing countries, health care workers constantly face the dilemma of having to choose between a random blood glucose measurement, if available, and urine test strip to aid in the diagnosis and management of patients with suspected or confirmed diabetes. In the absence of point of care testing facilities the turn-around time for plasma glucose is several days, as such there is increased reliance on urine test strips to provide an immediate proxy measure of glycaemic control.

There have been conflicting findings as to whether or not urine test strips should be used to screen for glucosuria[10,11,12,13]. More recently, self-monitoring blood glucose (SMBG) devices are being used with increasing frequency to guide management, but the accuracy of these instruments can be questionable[14,15]. This study was carried out to assess the accuracy and usage of routine measures of glycaemic control in diabetics attending clinics in the primary health care system in a developing country.

METHODS

RECRUITMENT OF PATIENTS

Patients attending three major diabetic clinics in Central Trinidad (COU; CUN; CHAG) were enrolled following informed consent. The study was approved by the Ethics Committee of the Faculty of Medical Sciences, University of the West Indies, St. Augustine Campus. A pre-tested questionnaire was used to obtain demographic information, clinical details, medication and complications.

REFERENCE LABORATORY:

Aresearch laboratory at the University of the West Indies was designated as the Reference Laboratory. This laboratory was enrolled in an external quality assurance program for glucose and HbA_{1c}. In this program general chemistry surveys were conducted quarterly and twice yearly for HbA_{1c}. Routine quality control was achieved by the use of commercial material (Accutrol - Sigma. MO. USA). Plasma glucose was measured with the hexokinase end-point method[16] with blank-correction. HbA_{1c} was measured with an immunoassay using a specific mouse monoclonal antibody (DCA2000; Bayer Diagnostics. IN, USA)[17].

BLOOD COLLECTION:

Ten (10) mL of blood was collected from patients attending two health centers (COU; CUN). This was split into two aliquots, one was sent for routine glucose measurement and the other was transported on ice to the Reference Laboratory for glucose measurement; HbA_{1c} was measured in every third patient. At these clinics urine was collected and tested on site for gucosuria (Rapignost, Hoechst-Behring, Germany). At the CHAG clinic urine test strips were not used, instead glucose measurements were carried out on finger prick samples using a SMBG device. At this clinic, an additional 5mL blood samples were obtained for glucose and HbA_{1C} and transported on ice to the Reference Laboratory. At all centers blood samples for glucose were collected in sodium fluoride and quickly processed within 2 hr of collection. The plasma obtained was stored at -20°C for a maximum of two days pending glucose assay. Samples for HbA_{1c} were collected in EDTA and stored at 4°C for a maximum of two days before analysis. The coefficient of variation for glucose and HbA_{1C} was 3.2% and 1.3%, respectively.

DATA ANALYSIS:

The data was processed in SigmaStat (SPSS Inc, CA, USA). Hyperglycemia was defined as a random blood glucose concentration of greater than >11mmol/L [7]. Results from the SMBG device were multiplied by 1.11 to adjust to plasma values[18]. Paired t-test or Wilson Signed Rank test was used to compare plasma glucose results obtained at the clinics with those obtained at the Reference Laboratory. The proportion of patients with hyperglycemia at each clinic was compared using Chi-square analysis. One-way ANOVA was used to check for significant group differences in mean glucose levels among the three clinics. Pearson correlation was used to compare continuous variables. Spearman Rank correlation was used to compare urine test strip results against other variables. A value of $p<0.05$ was regarded as being significant.

RESULTS

A total of 207 diabetics were studied at the three primary health care centers. There were 73 males and 134 females with a mean (sd) age of 57.6 10.9 yrs. Apart from males being significantly older than females (M=59.7 1.5 vs F=56.4 0.8 yrs: mean SEM; $p<0.05$), there were no other gender differences (Table 1A).

Figure 1

Table 1a: Patients' Measurements By Gender

GENDER	AGE yrs	YEARS DIABETIC (yrs)	GLUCOSE mmol/L	URINE TEST STRIP	HbA_{1c} %
MALE	59.7 ±1.5 (73)	9.67 ± 1.06 (69)	206.5 ± 13.8 (72)	1.4 ± 0.2 (50)	8.86 ± 0.70 (12)
FEMALE	56.4 ± 0.8 (132)	10.55 ± 0.83 (117)	209.4 ± 8.4 (131)	1.3 ± 0.2 (89)	8.92 ± 0.38 (35)

Means and SEM are shown.
Number of measurements made are shown in parenthesis ( ).

Table 1B shows a summary of the patients' results by clinic. The mean plasma glucose concentration of patients attending the different clinics was not significantly different. Overall, plasma glucose measurements at the Reference Laboratory were not significantly different from results obtained at the

clinics (Table 1B) and showed a very good correlation (r=0.91, n=150, p<0.005). However, as expected capillary whole blood measurements using a SMBG device at one clinic were significantly different (Wilson Signed Rank Test; p<0.005) from those obtained from the Reference Laboratory, but there was a reasonable good correlation between the two measurements (r= 0.73; n=38; p<0.004). The mean (SEM) difference between SMBG and plasma measurements was 1.95 0.69 mmol/L or 16.6%. The difference disappeared when SMBG measurements were adjusted to plasma levels according to Rohlfing et al[18].

Figure 2

Table 1b: Summary Of Patient Characteristics And Measurements

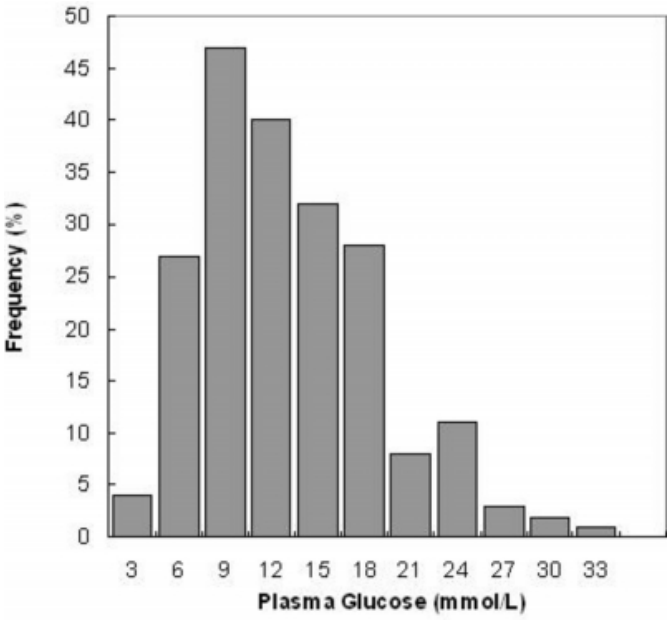
	AGE (yrs)	M:F	YEARS DIABETIC (yrs)	REFERENCE LAB GLUCOSE (mmol/L)	CLINIC GLUCOSE (mmol/L)	TESTSTRIP	HbA_{1c} (%)
ALL	57.6 ± 0.8 (205)	73/134	10.22 ± 0.65 (186)	208.4 ± 7.3 (203)	204.9 ± 8.5 (153)*	1.31 ± 0.12 (139)	8.9. ± 0.07 (47)
COU	59.4 ± 1.4 (60)	17/43	12.00 ± 1.40 (59)	196.9 ± 14.1 (59)	193.6 ± 165 (40)	0.97 ± 0.15[a] (60)	8.9. ± 0.4 (17)
CUN	57.8 ± 1.2 (79)	33/46	9.22 ± 0.85 (78)	220.1 ± 12.2 (79)	226.8 ± 12.2[a] (79)	1.57 ± 0.17[b] (79)	9.8. ± 0.8[a] (18)
CHAG	55.7 ± 1.3 (66)	23/45	9.69 ± 1.18 (49)	204.5 ± 11.6 (65)	167.2 ± 15.1[a, b] (34)	.....	7.6. ± 0.4[b] (12)

Means and SEM are shown. Number of measurements made are shown in parenthesis ( );
..... = not done;
#: whole blood glucose from SBGM device; multiply by 1.11 to convert to plasma values [ref 18];
a vs b = significantly different; p<0.05
*= clinic blood glucose results unavailable in some cases

The frequency of patients with different concentrations of plasma glucose is shown in Figure 1. Overall, approximately 46% (n=93) of the patients could be regarded as being hyperglycemic and 19% had a random glucose concentration that was greater than 16.7 mmol/L. The proportion of patients with hyperglycemia in the various clinics was not significantly different (2= 2.827, df=2, NS).

Figure 3

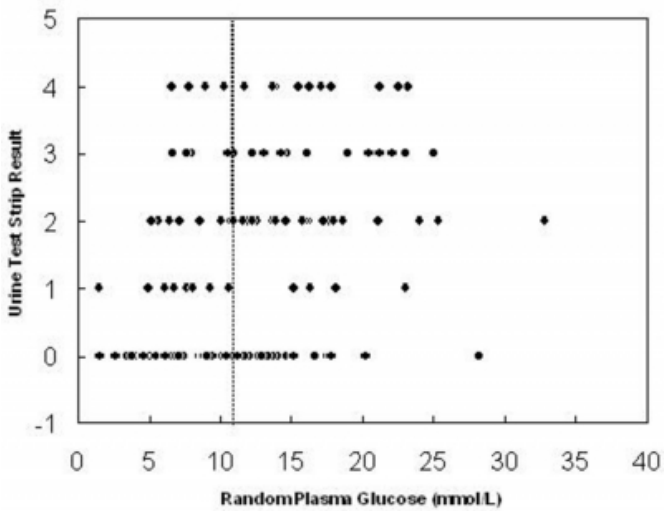
Figure 1: Frequency of random plasma glucose among diabetic clinic attendees.



There was a significant positive correlation between plasma glucose and urine test strip results (r=0.45; p<0.001). However, 30% of patients with a negative urine test strip result had plasma glucose above 11.1mmol/L (Figure 2). Similarly, 38% of patients with a positive test for glucosuria, had plasma glucose below 11.1 mmol/L. The overall sensitivity and specificity of urine test strips at a plasma glucose of 11.1 mmol/L were 71% and 62%, respectively. The predictive value of urine test strips in this group of diabetic patients was 63% and the diagnostic efficiency was 47%.

Figure 4

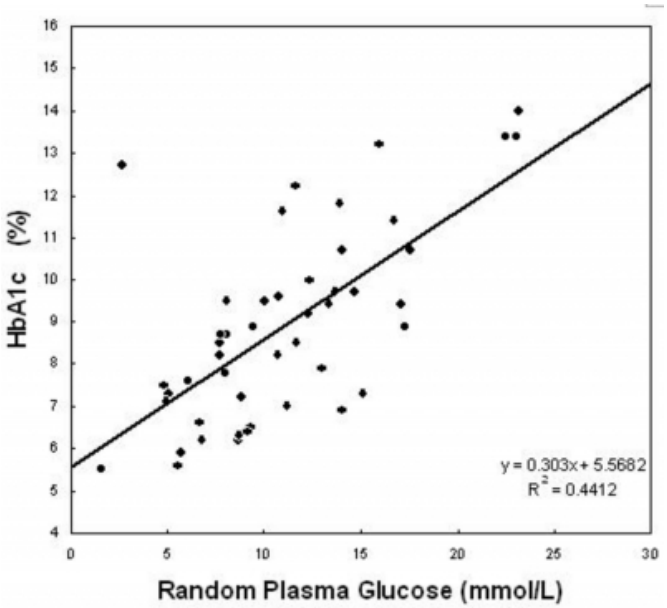
Figure 2: Relationship between urine test strip results and reference plasma glucose concentrations (mmol/L) made at the Reference Laboratory. The broken vertical line indicates a glucose concentration of 11.1mmol/L. Values to the right of this line are indicative of hyperglycaemia.



The mean HbA_{1c} was 8.9% (95%CI=8.2-9.6%), and as shown in Figure 3, there was a good correlation between HbA_{1c} and random plasma glucose concentrations (r=0.66, n=47, p<0.005). HbA_{1c} also correlated positively with urine test strip (r=0.50, n=35, p<0.005). The mean HbA_{1c} of patients attending CHAG clinic was significantly lower than that of their counterparts at CUN clinic (Table 1B).

Figure 5

Figure 3: Relationship between Haemoglobin A1c (%) and reference plasma glucose (mmol/L) made at the Reference Laboratory. The regression line and equation are shown



DISCUSSION

Measurements of glycaemic control were evaluated in diabetic patients attending three clinics within the primary health care system in Trinidad. The American Diabetic Association has recommended that such exercises be carried out in order to assess the validity of patient results[19]. This study showed that clinic measurements of glucose were generally comparable to those at a Reference laboratory. More than 45% of these diabetic patients had random glucose of >11.1 mmol/L. Further, 19% had random glucose of >16.7 mmol/L thereby increasing the possibility of impending ketoacidosis[19]. There were almost twice as many females; this probably reflects the national trend in which more women than men are affected by diabetes[3,4], or the possibility that more women than men attend primary health clinics.

The correlation between plasma glucose concentration and urine test strip results was good, however, the latter failed to identify 30% of patients with plasma glucose levels above 11.1mmol/L. Further, 38% of patients with plasma glucose below 11.1 mmol/L had a positive test for glucosuria. It is reasonable to expect that these results could have influenced decisions in patient care. The test strips were supplied regularly and were stored according to the manufacturer's instructions, hence test results were unlikely to have been influenced by reagent stability. A major confounder in the interpretation of urine test strip results is differences in renal function[10,11]. To this must be added operator error, particularly as a result of variation in ambient lighting[20]. It is not easy to overcome these problems without the use of further diagnostic facilities; this would incur additional costs. Nevertheless, it has been shown that analytical performance of urine test strips could be improved with re-training of staff, and moreover, with the implementation of a quality assessment scheme for urine tests using reagent strips[21,22]. Urine glucose testing has been found to be acceptable by some workers[21,22,23], but unacceptable by others[11,13] for the monitoring of glycaemic control in both population studies and in diabetics. Some studies have advocated the use of a post-prandial glucosuria test for assessing glycaemic control[23]. However, this may be of limited use in diabetic clinics within the primary health care of developing countries where the waiting time to see a doctor is long. Patients are unlikely to conform to dietary regimens that would optimize the utility of the postprandial glucosuria test. Given the overall poor analytical performance of urine test results it is difficult to recommend

that this test be routinely used in the primary health care system. However, it would seem prudent to address the factors that affect the analytical performance of urine test results and implement an external quality assessment programme[19].

In light of the well-known limitations of urine glucose tests, SMBG has been recommended as the preferred method for day-to-day monitoring of blood glucose[19]. It was expected that SMBG measurements (ie. capillary whole blood) would significantly differ from the results obtained by the Reference Laboratory, since the latter measured venous plasma glucose concentrations. In the present study the accuracy of the SMBG device was unknown since there was no quality control program in place. It has been shown that SMBG devices are susceptible to large analytical variation[14,15,24] and that their accuracy should be monitored on a regular basis. However, there is no local quality control programme for users of SMBG devices. Several studies have shown if these devices are to be used for point of care testing it is imperative that regular re-training be carried out, and that a quality control programme be implemented. Together these interventions have been shown to produce valid results and allow patients to work towards achieving near normal blood glucose levels[14,19].

It may be argued that in the absence of proficiency testing advantages of the SMBG are likely to be negated. However, in the clinic where a SMBG device was used to monitor blood glucose levels, the mean HbA_{1c} was significantly lower than that of the other clinics, which did not have a SMBG device at the time of this study. This suggests that knowledge of the patient's approximate blood glucose concentration at the time of treatment is more useful than a urine test result in achieving glycaemic control. Hence, the use of SMBG devices for point of care testing can have a significant impact on glycaemic control, which could reduce the secondary complications of diabetes. The latter in turn would reduce the cost of treating the diabetic patient. Although the SMBG devices are generally more costly than urine test strips proper usage can improve its cost-effectiveness. Additional resources will be incurred with the concurrent implementation of a quality assurance programme, but this investment is likely to be cost effective compared to the potential costs for tertiary health care for diabetes-related complications[25,26]. With improved accuracy of portable glucose analysers via a quality control programme it may be possible to achieve satisfactory glycaemic control in diabetic patients attending primary health care facilities.

The relationship between HbA_{1c} and plasma glucose found in this study is similar to that reported by Rohlfing et al[18], who used the DCCT data set to show a correlation of 0.67 between HbA_{1c} and post-breakfast plasma glucose. Based on the HbA_{1c} levels found in a sub-sample of patients in the present study (95%CI=8.2-9.6%) it is possible to estimate[18] that the mean plasma glucose (MPG) of the patients studied ranged from 11.7 to 14.6 mmol/L. This is undesirable and highlights the prevalent pattern of poor glycaemic control in patients attending primary health care facilities[27].

It is not clear whether similar problems exist in other developing countries; however, attention is needed in order to achieve improved glycaemic control of diabetic patients who seek medical attention in at the primary care facilities. Failure to meet this goal could result in a continued high prevalence of diabetes-associated morbidity and mortality in many developing countries. Under the present circumstances it is difficult to recommend the continued use of urine test strips for monitoring glycaemic control. A quality assurance programme must accompany the use of SMBG device for point of care testing.

ACKNOWLEDGMENTS

This study was supported by PAHO/WHO. We thank the clinic staff and the patients for their kind cooperation, and C Bridgemohan and N Sankar for technical assistance

CORRESPONDENCE TO

Dr. Dan Ramdath
Biochemistry Unit, Department of Preclinical Sciences
Faculty of Medical Sciences
The University of the West Indies
EWMSC, Champs Fleurs, Trinidad & Tobago
Tel/Fax: 868 662 1873
E-mail: dramdath@tstt.net.tt

References

1. World Health Organisation Technical Report Series. Diet, nutrition and the prevention of chronic diseases. 2003;916:1-v111, 1-149.
2. Reddy KS, Yusuf S. Emerging epidemic of cardiovascular disease in developing countries. Circulation 1998;97:596-601.
3. Holder Y, Lewis MJ. Epidemiological overview of morbidity and mortality. In: Health Conditions in the Caribbean. Washington DC: PAHO Scientific Publications #561; 1997:22-61.
4. Report on the Trinidad & Tobago Health Survey 1994-95. Ministry of Health. Trinidad & Tobago. 1996.
5. Gulliford MC (1996) Epidemiological transition in

Trinidad and Tobago, West Indies 1953-1992. International Journal of Epidemiology 1996;25:357-365.
6. The Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. New Engl J Med 1993; 329:977-86.
7. The Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. Diabetes Care 2003; 26:S5-S24.
8. McCance DR, Hanson RL, Charles M_A, Jacobsson TH, Pettitt DJ, Bennett PH et al. Comparison of tests for glycated haemoglobin and fasting and two hour plasma glucose concentrations as diagnostic methods for diabetes. Br Med J 1994;308:1323-8.
9. Wiener K. The diagnosis of diabetes mellitus, including gestational diabetes. Ann Clin Biochem 1992;29:481-93.
10. Kilpatrick ES. Problems in the assessment of glycaemic control in diabetes mellitus. Diabetic Medicine 1997;14:819-31.
11. Friderichsen B, Maunsbach M. Glycosuric tests should not be employed in population screenings for NIDDM. J Public Health Medicine 1997;19:5-60.
12. Davies M, Day J. Screening for non-insulin-dependent diabetes mellitus (NIDDM): how often should it be performed? Journal of Medical Screening 1994;1:78-81.
13. Hanson RL, Nelson RG, McCance DR, Beart JA, Charles MA, Pettitt DJ, Knowler WC. Comparison of screening tests for non-insulin-dependent diabetes mellitus. Archives of Internal Medicine 1993;153:2133-40.
14. Rumley AG. Improving the quality of near-patient blood glucose measurement. Ann Clin Biochem 1997;34:281-86.
15. Jonhson RN, Baker JR. Accuracy of devices used for self-monitoring of blood glucose. Ann Clin Biochem 1998;35:68-74.
16. Sigma Diagnostics. Glucose (HK). Proceedure No. 16-UV. Sigma Chemical Company. MO. USA. 1995.
17. John WG, Edwards R, Price CP. Laboratory evaluation of the DCA 2000 clinic HbA1c immunoassay analyser. Ann Clin Biochem 1994;31:367-70.
18. Rohlfing CL, Wieldmeyer H-M, Little RR, England JD, Tennill A, Goldstein DE. Defining the relationship between plasma glucose and HbA1c. Diabetes Care 2002; 25:275-278.
19. American Diabetes Association. Tests of glycemia in diabetes. Diabetes Care 2003; 26:S106-S108.
20. Rumley A. Urine dipstick testing: comparison of results obtained by visual reading and with the Bayer CLINITEK50. Ann Clin Biochem 2000;37:220-221.
21. White G. Twelve months' experience of a quality assessment scheme for urine test using reagent strips. Ann Clin Biochem 1995;32:589-590.
22. Tighe P. Laboratory-based quality assurance programme for near-patient urine dipstick testing, 1990-1997; development, management and results. British Journal of Biomedical Science 1999;56:6-15.
23. Davies MJ, Williams DR, Metcalfe J, Day JL. Community screening for non-insulin-dependent diabetes mellitus: self-testing for post-prandial glycosuria. Quaterly Journal of Medicine 1993;86:677-84.
24. Addae J, Mahabir D, Byam N, Ajimotokan A, Best B. Evaluation of a home kit blood glucose monitoring device. West Indian Med J. 1998;47(4):153-6.
25. Currie CJ, Peters JR. The demand and financial cost of hospital care for diabetes mellitus and its related complications. Diabetic Medicine 1998;15:449-51.
26. Gulliford MC, Ariyanayagam-Baksh SM, Bickram L, Picou D & Mahabir D. Counting the Cost of Diabetic Hospital Admissions from a Multi-ethnic Population in Trinidad. Diabetic Medicine 1995;12:1077-1085.
27. Appariccio N, Clerk N, Henry G, Seale J, Sealy R, Ward S, Mungrue K. How well controlled are our Type 2 diabetics in 2002: an observational study in North and Central Trinidad. West Indian Medical Journal 2003; 52(supp.3):72.

Author Information

D. Dan Ramdath, PhD
Department of Preclinical Sciences, Faculty of Medical Sciences, The University of the West Indies

Natasha Ramdhanie, MSc
Department of Preclinical Sciences, Faculty of Medical Sciences, The University of the West Indies

Harry Singh, MBBS, MPH
Ministry of Health

Parimi Prabhakar, MBBS
Caribbean Epidemiology Centre