ORIGINAL ARTICLE

Distribution of Blood Glucose in a National Sample of Malaysian Adults

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Summary

We describe the distribution of capillary blood glucose (BG) by age, sex and ethnicity in Malaysian adults. A national sample of 20041 individuals aged 30 or older had usable data. They were selected by stratified 2-stage cluster sampling. BG was measured using reflectance photometer. Percentile tables and curves by age, sex and ethnicity are presented. The BG distribution was right skewed and showed the expected increase with age. Except in Indian, women had higher BG than men. There were also marked ethnic differences. Indian had the highest BG concentration, followed by Chinese, Malay and other indigenous ethnic group.

Key Words: Blood glucose, Diabetes mellitus, Population survey, Percentile, Distribution

Introduction

The distribution of blood glucose(BG) in a representative national sample of Malaysian adults has not previously been described. Such information are of epidemiological interest, and are also useful in public health practice. High levels of BG are associated with increase risk of cardiovascular morbidity[1,2] and in the diabetic range (capillary BG>=11.1) specific microvascular complications like diabetic retinopathy[3]. Information on distribution of BG is therefore useful for describing hyperglycaemia related health burden in a population as well as for planning prevention strategy.

We present here the distribution of blood glucose by age, sex and ethnicity using the data from the National Health and Morbidity survey (NHMS) completed in 1996.

Materials and Methods

Sampling design and sample

The NHMS was a multi purpose health survey designed to describe the health status, health related behaviour and health services utilisation for a representative sample of the population of Malaysia. An up to date and representative sampling frame for this population was provided by the frame used by the annual Labour Force survey conducted by the Department of Statistics[4]. The sampling frame was stratified by state and urban/rural residence. A stratified two stage cluster sampling design with self-weighting sample was used to draw a sample of 17995 private dwellings. However, only 13025(87%) of dwellings were contactable or responded. All residents of sampled dwellings were included yielding a sample size of 59903 individuals. For NHMS component on blood glucose, 23034 individuals aged 30 years or older were eligible. 20028 (87%) of them

Table I
Characteristics of Respondents Compared with Total Population of Malaysia Aged 30 or Older in 1996

	% Respondents (unweighted) n=20028 No. (%)	% Malaysia Population Age 30 or Older n=7.84 million %
Sex		
Male	9298 (46%)	50%
Female	10730 (54%)	50%
Age		
30 - 34	3953 (20%)	21%
35 - 39	3683 (18%)	19%
40 - 44	3146 (16%)	16%
45 - 49	2495 (12%)	12%
50 - 54	1839 (9%)	9%
55 - 59	1540 (8%)	7%
60 - 64	1301 (7%)	6%
65 - 69	887 (4%)	4%
>=70	1184 (6%)	6%
Ethnic groups		
Malay	9196 (46%)	43%
Chinese	5356 (27%)	31%
Indian	1367 (7%)	8%
Other indigenous	3096 (15%)	9%
Others	1040 (5%)	10%

agreed to have their measurements taken or had evaluable measurements. Table I and II show the composition of the sample.

Interview and capillary blood glucose measurement

During a home visit, the first hour was devoted to completing a questionnaire administered by an interviewer. The questionnaire included the following diabetes related items:

1. Are you known to have high blood sugar (colloquially, sweet urine disease)?
2. Have you ever been told by a doctor or other health personnel that you had high blood sugar?
3. Have you ever been on medication (oral dug or insulin injection) for treatment of high blood sugar?
4. Are you still taking the medication now?

At the end of the interview, respondent's blood glucose was measured by a trained nurse using reflectance photometer (Accutrend, Boehringer Mannheim). All subjects without medical history of diabetes (negative response to question 2 above) were approached for blood glucose measurement. Only a sub-sample of known diabetic had blood glucose measurement taken too. The procedure was explained and verbal permission obtained from the respondent prior to the examination. 75 gram of glucose monohydrate powder was mixed with a glass of plain water and ingested by respondent. Respondents then fast for 2 hours (only plain water allowed). After 2 hours, blood sample was obtained by finger prick and a small droplet of blood placed on a test strip. The strip was then inserted into the photometer for blood glucose (BG) measurement. Respondents were informed of their blood glucose values and referred to a nearest health facility for follow up if their BG exceeded 11.1mmol/L. All nurses attended centralised training on standardised protocol for BG measurement. During field survey, supervisors conduct weekly check on compliance with BG measurement protocol.

The reflectance photometer has lower and upper detection limits of 1.1 to 33.3mmol/L respectively. Beyond the limits, measurements are recorded as 'lo' and 'hi'. Its precision was deemed satisfactory for survey use. Reported within-run coefficient of variation was 2 - 4% and correlation with measurements on plasma using conventional laboratory method varied between 0.98 and 0.99[5].

Definitions

A known diabetic is defined as a subject with medical history of diabetes and is currently on anti-diabetic medication (answered positively to questions 2 and 4 above). The mean (SD) blood glucose of a sub-sample (n=61) of known diabetics was 11.2 (7.1), in comparison, the mean (SD) of rest of the sample (n=19171) without history of diabetes was 5.3 (2.4). This provides evidence for the validity of self-reported diabetes. The diagnostic criteria recommended by WHO[6] based on 2 hour post loading blood glucose value are used to classify subjects without medical history of diabetes as diabetic, impaired glucose tolerance (IGT) or normal. The WHO criteria for diabetes require 2 hour post loading capillary blood glucose (BG) be >=11.1, for IGT require BG be <11.1 and >=7.8, and for normal BG be <7.8.

Table II
Sample Size by Age, Sex and Ethnicity in the Survey

	Malay	Chinese	Indian	Other indigenous
Men, age in years				
30 - 34	760	370	123	315
35 - 39	748	376	144	269
40 - 44	664	372	113	227
45 - 49	560	361	76	139
50 - 54	401	280	45	146
55 - 59	370	224	36	88
60 - 64	272	180	36	101
65 - 69	205	131	26	52
>=70	245	148	33	98
Women, age in years				
30 - 34	954	485	155	418
35 - 39	918	486	161	335
40 - 44	834	485	113	202
45 - 49	594	389	92	194
50 - 54	441	293	44	122
55 - 59	372	244	55	108
60 - 64	314	199	53	106
65 - 69	218	139	29	67
>=70	299	194	33	109

Statistical methods

Probability weighted estimation was used to obtain all estimates as appropriate for the sampling design[7,8]. The sampling weights were adjusted for household non-response using adjustment cells formed by state and urban/rural residence. Post stratification[9] was used to adjust the weighted sample totals to known population totals for age, gender and ethnicity based on 1996 census population projection.

For estimating percentiles and means, blood glucose measurements must be available from all subjects. Since the vast majority of known diabetics had no BG measurements taken, and in principle their true blood glucose values prior to diagnosis and unmodified by treatment are unknowable. We therefore imputed their BG values based on a censored regression imputation model[10]. The imputation was guided by the imputation principles described by Little[11]. BG values for subjects with medical history of diabetes were right-censored at 11.1mmol/L The imputation model included medical history of diabetes status, body mass index, age, gender and ethnicity. These variables are all known to be predictive of BG outcome in a population[12,13]. The imputations were then drawn by predictive mean matching[11]. Each subject without BG value (non-respondent) was matched with each respondent on his or her predicted BG values. We then imputed the BG value of the respondent with the closest predicted value. In effect, imputed values were drawn from the BG distribution of undiagnosed diabetics in the sample. The advantages of this method over others are that it preserves the distribution of BG and provides some protection against model misspecification[11].

Overall, ethnic and sex specific means and percentages were standardised by the direct method to the age distribution of the 1996 adult Malaysian population S-Plus[14] and STATA[15] software packages were used for analysis.

Results

Percentiles distribution

The percentiles of BG by age, gender and ethnicity are shown in Tables III to X. In all ethnic-gender groups, BG rose with increasing age, and likewise its standard deviation. In contrast, the magnitude of the skew to the right tended to decrease with age. The rise in BG was equally steep for men and women.

Mean blood glucose

Table XI and XII show the mean blood glucose (BG) values by gender, ethnicity and age. Women had higher mean BG than men except for Indian. Indian men and women had higher mean BG than both sexes of the other 3 ethnic groups. The tendency of Indian men and women to have systematically higher BG than all other sex-ethnic groups is further illustrated in figures 5 to 10. In all groups, mean BG rose with increasing age but the rise was particularly steep in Indian. Chinese men and women's mean BG begun to rise steeply after the fifth decade of life and converged to that of Indian. Other indigenous men and women had the lowest mean BG.

Percentage distribution of blood glucose

Table XIII and XIV show the percentage distribution of BG according to WHO classification[6]. Overall, about 7% of the adult population had BG in the diabetic

Table III
Empirical Percentiles of Blood Glucose for Malay Males, by Age

Age Group	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	>=70
n	760	748	664	560	401	370	272	205	245
Percentiles									
2.50th	2.2	2.1	2.4	2.4	2.5	2.3	2.5	2.3	2.0
5.00th	2.6	2.7	2.7	2.6	2.7	2.7	3.0	2.8	2.2
10.00th	3.0	3.1	3.2	2.9	3.0	3.0	3.3	3.3	3.0
15.00th	3.3	3.3	3.5	3.2	3.2	3.2	3.6	3.6	3.3
20.00th	3.5	3.6	3.7	3.5	3.6	3.6	4.0	3.8	3.6
25.00th	3.7	3.8	3.9	3.8	3.8	3.8	4.2	4.1	3.7
30.00th	4.0	4.1	4.1	4.0	4.0	4.1	4.3	4.4	3.9
35.00th	4.1	4.2	4.2	4.2	4.2	4.2	4.6	4.6	4.3
40.00th	4.3	4.3	4.4	4.3	4.4	4.4	4.6	4.9	4.6
45.00th	4.5	4.5	4.6	4.5	4.5	4.5	4.8	5.1	4.7
50.00th	4.6	4.6	4.7	4.7	4.7	4.7	5.1	5.3	5.0
55.00th	4.8	4.8	4.8	4.9	4.9	5.0	5.2	5.5	5.2
60.00th	5.0	4.9	5.1	5.1	5.1	5.1	5.5	5.6	5.4
65.00th	5.2	5.2	5.2	5.2	5.3	5.4	5.8	5.7	5.9
70.00th	5.3	5.3	5.4	5.6	5.6	5.7	6.1	6.1	6.3
75.00th	5.5	5.6	5.7	5.9	5.9	6.0	6.6	6.3	6.6
80.00th	5.8	5.9	6.0	6.3	6.1	6.5	7.5	7.6	6.9
85.00th	6.0	6.3	6.5	7.2	6.6	7.1	9.1	8.9	7.5
90.00th	6.5	6.7	7.3	8.8	8.7	10.7	12.2	13.6	11.0
95.00th	7.6	8.5	12.0	14.8	14.4	14.1	17.3	19.1	17.2
97.50th	11.1	13.1	16.4	19.8	19.7	17.1	20.0	21.8	21.6
mean	4.99	5.12	5.4	5.69	5.73	5.73	6.46	6.69	6.24
sd*	2.65	2.77	3.12	3.78	4.0	3.6	4.3	4.77	4.65
skew**	4.68	4.19	3.32	2.79	3.2	2.59	2.36	2.23	2.71

**sd means standard deviation, **skew means skewness*

Table IV
Empirical Percentiles of Blood Glucose for Malay Females, by Age

Age Group	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	>=70
n	954	918	834	594	441	372	314	218	299
Percentiles									
2.50th	2.3	2.6	2.6	2.8	2.6	2.6	2.3	2.8	2.4
5.00th	2.8	3.0	3.0	3.1	3.0	3.1	3.0	3.1	3.0
10.00th	3.2	3.5	3.5	3.3	3.5	3.7	3.5	3.5	3.5
15.00th	3.5	3.7	3.7	3.6	3.8	3.9	3.8	4.0	3.9
20.00th	3.7	3.9	4.0	3.8	4.0	4.2	4.2	4.2	4.2
25.00th	3.9	4.1	4.1	4.2	4.1	4.3	4.5	4.5	4.5
30.00th	4.1	4.3	4.3	4.3	4.3	4.6	4.7	4.7	4.6
35.00th	4.2	4.5	4.5	4.6	4.5	4.9	4.9	4.8	4.8
40.00th	4.4	4.6	4.6	4.7	4.7	5.1	5.1	5.0	5.1
45.00th	4.6	4.8	4.8	4.9	5.0	5.3	5.3	5.3	5.4
50.00th	4.7	5.0	5.0	5.1	5.2	5.4	5.5	5.5	5.5
55.00th	4.9	5.1	5.1	5.2	5.4	5.6	5.7	5.6	5.7
60.00th	5.0	5.3	5.2	5.5	5.6	5.9	5.9	5.8	6.0
65.00th	5.2	5.5	5.5	5.7	5.8	6.1	6.2	6.2	6.1
70.00th	5.4	5.7	5.7	5.9	6.1	6.3	6.7	6.3	6.4
75.00th	5.6	5.9	5.9	6.2	6.4	6.6	7.0	6.8	6.6
80.00th	5.8	6.3	6.1	6.7	7.0	7.2	7.7	7.3	7.0
85.00th	6.1	6.6	6.8	7.4	7.8	8.3	11.2	8.2	7.9
90.00th	6.6	7.1	7.7	8.8	11.5	12.3	12.7	12.1	9.7
95.00th	7.5	8.8	11.2	13.0	14.8	17.6	16.7	16.4	14.8
97.50th	10.0	12.8	16.6	18.4	17.0	21.1	19.8	19.8	19.1
mean	4.99	5.39	5.59	5.95	6.19	6.71	6.9	6.56	6.36
sd*	2.18	2.51	3.01	3.47	3.78	4.51	4.57	3.96	3.73
skew**	4.41	3.78	3.33	2.85	2.82	2.7	2.49	2.38	2.73

**sd means standard deviation, **skew means skewness*

Table V
Empirical Percentiles of Blood Glucose for Chinese Males, by Age

Age Group	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	>=70
n	370	376	372	361	280	224	180	131	148
Percentiles									
2.50th	2.1	2.5	2.5	2.2	2.4	2.7	2.4	2.6	3.1
5.00th	2.6	2.8	2.9	2.6	2.7	3.0	2.9	2.8	3.2
10.00th	3.2	3.1	3.3	3.3	3.2	3.7	3.5	3.3	3.6
15.00th	3.5	3.5	3.7	3.7	3.6	3.9	3.8	3.6	3.8
20.00th	3.7	3.7	4.0	4.0	3.9	4.3	4.1	4.0	4.2
25.00th	3.8	4.0	4.2	4.3	4.2	4.6	4.2	4.3	4.5
30.00th	4.1	4.2	4.3	4.5	4.3	4.7	4.5	4.6	4.8
35.00th	4.2	4.4	4.5	4.7	4.6	5.0	4.8	4.8	5.0
40.00th	4.3	4.6	4.7	5.0	4.9	5.2	5.1	5.1	5.2
45.00th	4.5	4.7	4.8	5.1	5.1	5.5	5.3	5.3	5.4
50.00th	4.7	4.9	5.0	5.2	5.2	5.5	5.5	5.4	5.7
55.00th	4.8	5.1	5.2	5.5	5.4	5.7	5.9	5.7	5.9
60.00th	5.0	5.3	5.3	5.7	5.6	6.0	6.2	6.1	6.2
65.00th	5.2	5.4	5.6	6.0	5.8	6.2	6.6	6.6	6.6
70.00th	5.4	5.6	5.8	6.2	6.2	6.7	7.0	7.0	7.1
75.00th	5.6	5.8	6.3	6.5	6.4	7.1	7.7	7.2	7.8
80.00th	5.9	6.0	6.6	6.7	6.8	7.8	9.2	8.0	10.2
85.00th	6.3	6.5	7.1	7.5	7.4	9.1	12.5	9.1	12.5
90.00th	6.7	6.9	7.9	10.2	9.1	11.8	16.1	13.6	15.6
95.00th	7.8	8.3	10.6	13.6	12.8	13.0	23.6	18.0	19.0
97.50th	12.0	11.5	14.6	15.9	15.6	16.4	28.8	19.9	27.0
mean	4.98	5.25	5.66	6.06	5.87	6.54	7.64	7.0	7.65
sd*	2.06	2.56	3.05	3.35	3.13	3.54	5.98	4.9	5.4
skew**	2.82	4.06	3.5	2.4	2.67	2.4	2.3	2.46	2.07

**sd means standard deviation, **skew means skewness*

range, 5% in the impaired glucose tolerance range and 88% in the normal range. Indian had the highest prevalence of diabetes, followed by Chinese, Malay, and other indigenous ethnic group the lowest.

Discussion

We advise caution in interpreting the results. The stability of the centile estimates is assured only if based on large sample sizes. This was clearly the case for Malay, Chinese and other indigenous ethnic group's estimates. However sample sizes for Indian in the older age groups (age 65 - 70+) were small. One should also be cautious in interpreting cross sectional data longitudinally. The observed age trend in BG is likely to be genuine as has been shown in longitudinal study[16]. However, the tendency of the rise in BG with age to flatten or even reverses beyond age 50 - 60 may not be due to ageing effect alone. One alternative explanation is selective survival. People with lower BG tend to survive with increasing age thus shifting the BG distribution of survivors downwards. Cross sectional data as presented here cannot differentiate the individual contribution of ageing and selective survival.

Characteristics of the BG distribution of the Malaysian population, as shown here, largely resemble those observed in other substantial population surveys[12,17-19]. The right skewed distribution, the rise in BG with age, the marked ethnic differences are all well described characteristics of population BG distribution. The suggestion of bi-modality in the BG distribution of our population warrants further investigation.

The BG distribution of Malaysian adults described here is not merely of epidemiological interest. It is useful in its own right. In public health practice, the planning of any prevention strategy must take into account the burden of illness due to any risk factor in the community. Population BG distribution can help in estimating the burden of illness due to hyperglycaemia related morbidity in the population. In the planning of diabetes screening programme, information on BG distribution in the population is required for resource planning. The available resources must match the number of individuals in the population targeted for intervention, the number in turn depends on the population BG distribution.

To our knowledge, this is the first detailed description of BG distribution in a representative national sample of Malaysian adults. The distribution can serve as a baseline for comparison with future repeat survey to determine the effectiveness of intervention programme in shifting the population BG distribution in a favourable direction. The population BG distribution described here can also serve as a yardstick for assessing the representativeness of sample in small scale survey. The BG distribution of a representative sample should closely match that described here.

In conclusion, we found the distribution of BG of Malaysian adults was largely similar to that in other populations. Detailed description of BG distribution in our population is useful for public health practice.

Acknowledgement

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Table VI
Empirical Percentiles of Blood Glucose for Chinese Females, by Age

Age Group	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	>=70
n	485	486	485	389	293	244	199	139	194
Percentiles									
2.50th	2.2	2.4	2.5	3.0	2.5	2.6	2.8	2.8	2.6
5.00th	3.1	3.0	3.1	3.4	3.0	2.8	3.5	3.1	3.3
10.00th	3.5	3.5	3.7	3.8	3.7	3.5	3.8	3.7	3.7
15.00th	3.8	3.7	3.9	4.1	4.0	3.9	4.2	4.1	4.2
20.00th	4.0	4.0	4.2	4.3	4.2	4.1	4.5	4.6	4.4
25.00th	4.1	4.1	4.3	4.5	4.4	4.5	4.8	5.0	4.7
30.00th	4.3	4.3	4.6	4.6	4.7	4.7	5.1	5.2	5.1
35.00th	4.5	4.4	4.8	4.8	5.0	5.1	5.3	5.5	5.3
40.00th	4.6	4.6	5.0	4.9	5.1	5.1	5.5	5.7	5.6
45.00th	4.8	4.7	5.1	5.1	5.2	5.5	5.7	5.9	5.8
50.00th	5.1	4.8	5.3	5.3	5.3	5.7	6.0	6.3	6.0
55.00th	5.2	5.0	5.5	5.5	5.6	5.9	6.3	6.5	6.2
60.00th	5.4	5.2	5.6	5.6	5.8	6.0	6.8	6.8	6.5
65.00th	5.5	5.3	5.8	5.8	6.1	6.3	7.3	7.0	6.8
70.00th	5.6	5.6	6.0	6.2	6.3	6.7	8.7	7.5	7.2
75.00th	5.8	5.8	6.3	6.5	6.7	7.0	11.1	8.4	7.9
80.00th	6.0	6.1	6.6	6.8	7.3	7.6	12.3	11.1	9.0
85.00th	6.3	6.5	6.9	7.3	8.5	9.2	13.6	12.4	12.0
90.00th	6.7	7.2	7.5	8.6	11.7	11.5	15.6	14.1	14.7
95.00th	8.0	8.0	9.4	12.1	15.2	13.2	16.7	16.8	16.5
97.50th	8.5	9.8	12.4	17.0	19.1	15.6	20.5	18.2	17.8
mean	5.14	5.17	5.7	6.06	6.48	6.54	8.0	7.59	7.28
sd*	1.71	1.83	2.52	3.14	3.76	3.56	4.78	4.31	4.06
skew**	2.42	2.24	3.15	3.02	2.37	2.32	1.39	1.51	1.6

**sd means standard deviation, **skew means skewness*

Table VII
Empirical Percentiles of Blood Glucose for Indian Males, by Age

Age Group	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	>=70
n	123	144	113	76	45	36	36	26	33
Percentiles									
2.50th	2.4	2.1	2.1	2.1	3.9	1.8	2.9	2.9	2.6
5.00th	2.9	3.2	2.4	2.8	3.9	2.2	4.0	3.3	2.7
10.00th	3.4	3.6	3.4	3.1	4.7	3.2	4.2	3.7	2.8
15.00th	3.8	4.0	3.9	3.7	4.8	3.7	4.4	3.7	3.2
20.00th	4.0	4.1	4.3	4.1	4.9	4.0	4.6	4.4	3.4
25.00th	4.2	4.3	4.6	4.5	5.2	4.0	4.8	4.4	3.6
30.00th	4.4	4.6	4.8	4.9	5.2	5.1	5.0	5.1	3.7
35.00th	4.6	4.7	5.1	5.1	5.3	5.6	5.3	5.2	4.6
40.00th	4.7	4.8	5.3	5.2	5.6	6.1	5.6	5.5	4.7
45.00th	4.9	5.0	5.3	5.4	5.8	6.5	5.8	5.5	5.2
50.00th	5.0	5.1	5.6	5.8	6.5	6.6	6.5	5.8	6.1
55.00th	5.1	5.2	5.8	6.0	7.0	6.7	6.9	6.1	6.2
60.00th	5.2	5.3	6.0	6.5	9.5	7.1	8.9	6.1	6.3
65.00th	5.5	5.6	6.2	7.0	10.3	8.2	11.5	7.2	6.8
70.00th	5.6	5.8	6.6	8.1	11.5	9.1	11.5	11.5	7.4
75.00th	5.8	6.2	7.2	11.0	12.2	13.0	12.9	11.6	8.0
80.00th	6.2	6.7	7.7	12.6	13.9	13.1	14.1	12.0	8.4
85.00th	6.6	7.9	8.3	14.2	15.3	14.1	14.8	13.3	11.9
90.00th	7.7	8.5	13.6	18.0	17.0	16.1	17.0	14.4	15.6
95.00th	13.1	12.8	19.6	21.1	18.8	21.2	22.3	15.8	19.3
97.50th	13.3	13.7	21.7	23.7	29.0	22.5	30.0	17.6	20.5
mean	5.48	5.83	7.04	8.01	9.41	8.48	9.2	7.8	7.22
sd*	2.45	2.89	4.96	5.49	6.12	5.56	6.3	4.49	5.15
skew**	2.48	2.63	2.41	1.41	1.59	1.12	1.7	0.93	1.49

**sd means standard deviation, **skew means skewness*

Table VIII
Empirical Percentiles of Blood Glucose for Indian Females, by Age

Age Group	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	>=70
n	155	161	113	92	44	55	53	29	33
Percentiles									
2.50th	2.3	3.0	2.8	2.8	3.2	3.0	1.8	2.7	2.2
5.00th	2.6	3.1	3.1	3.3	3.3	3.3	1.8	3.6	3.2
10.00th	3.3	3.3	3.3	3.7	3.8	3.8	3.3	4.3	3.7
15.00th	3.7	3.8	3.5	3.8	4.3	4.3	3.8	4.5	4.3
20.00th	3.8	4.1	4.2	4.0	4.5	4.5	4.2	4.5	4.3
25.00th	4.0	4.2	4.4	4.3	4.8	4.7	4.5	4.6	4.7
30.00th	4.2	4.4	4.6	4.5	5.2	5.0	4.8	4.7	5.2
35.00th	4.5	4.6	4.8	4.7	5.4	5.2	4.8	4.9	5.2
40.00th	4.6	4.7	5.0	4.9	5.6	5.3	5.0	5.0	5.3
45.00th	4.7	4.9	5.2	5.0	5.7	5.5	5.1	5.7	5.5
50.00th	5.1	5.0	5.4	5.2	5.8	5.7	5.2	6.2	5.6
55.00th	5.1	5.2	5.5	5.6	6.0	7.2	5.3	6.7	5.7
60.00th	5.3	5.3	5.7	5.7	6.2	7.6	5.7	6.9	6.2
65.00th	5.4	5.5	5.7	5.8	6.2	8.1	6.6	7.6	7.7
70.00th	5.6	5.8	5.9	6.3	6.7	9.3	7.3	11.1	9.0
75.00th	6.0	6.1	6.2	6.6	7.4	10.7	7.7	11.1	10.2
80.00th	6.2	6.3	6.4	7.3	7.8	11.5	9.2	13.0	11.1
85.00th	7.0	7.0	7.8	9.0	11.6	12.4	12.4	14.7	11.7
90.00th	7.5	7.7	10.1	12.2	13.1	14.8	12.7	15.0	13.2
95.00th	15.0	9.1	15.1	17.7	16.8	17.0	15.8	16.8	16.8
97.50th	19.1	15.2	18.3	20.1	17.7	19.0	20.6	20.3	16.8
mean	5.72	5.55	6.25	6.67	6.93	7.87	6.94	8.22	7.41
sd*	3.65	2.55	3.75	4.22	3.55	4.43	4.52	4.92	4.05
skew**	3.29	3.03	2.65	1.97	1.7	1.08	1.8	1.21	1.01

** sd means standard deviation, **skew means skewness*

Table IX
Empirical Percentiles of Blood Glucose for Other Indigenous Males, by Age

Age Group	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	>=70
n	315	269	227	139	146	88	101	52	98
Percentiles									
2.50th	2.2	2.2	2.1	1.8	1.9	2.3	1.7	3.0	2.5
5.00th	2.5	2.6	2.4	2.3	2.6	2.3	2.1	3.0	2.6
10.00th	2.8	3.0	2.8	2.7	3.1	2.8	2.6	3.6	3.1
15.00th	3.1	3.3	3.1	3.2	3.5	3.1	3.1	3.8	3.6
20.00th	3.3	3.6	3.4	3.3	3.6	3.2	3.3	4.0	4.0
25.00th	3.5	3.8	3.6	3.6	3.8	3.5	3.6	4.1	4.1
30.00th	3.7	4.0	3.9	3.8	4.1	3.8	3.7	4.2	4.2
35.00th	3.9	4.1	4.0	4.1	4.3	4.0	4.0	4.3	4.4
40.00th	4.1	4.2	4.3	4.3	4.4	4.1	4.1	4.6	4.6
45.00th	4.3	4.4	4.4	4.5	4.6	4.3	4.2	4.6	4.7
50.00th	4.5	4.6	4.6	4.6	4.7	4.5	4.5	4.8	4.8
55.00th	4.6	4.8	4.8	4.8	4.9	4.6	5.0	5.0	4.9
60.00th	4.7	5.0	5.0	4.8	5.1	4.7	5.3	5.3	5.5
65.00th	4.9	5.1	5.2	5.2	5.3	5.0	5.6	6.0	5.6
70.00th	5.0	5.2	5.3	5.6	5.6	5.1	5.7	6.1	5.8
75.00th	5.2	5.5	5.5	5.7	5.8	5.6	6.1	6.2	6.1
80.00th	5.4	5.8	5.8	6.0	6.0	5.9	6.3	6.5	6.5
85.00th	5.8	6.2	6.1	6.6	6.3	6.1	6.7	7.0	7.0
90.00th	6.1	6.8	6.5	7.8	7.1	6.6	7.7	7.6	7.3
95.00th	6.9	7.6	7.7	15.3	8.0	8.1	10.0	8.5	13.2
97.50th	8.1	8.6	11.3	21.2	19.8	13.4	13.3	13.9	13.2
mean	4.58	4.92	5.01	5.41	5.24	4.79	5.04	5.56	5.54
sd*	1.84	2.42	3.02	3.68	2.96	2.15	2.43	2.66	2.81
skew**	3.27	5.89	4.59	3.05	3.55	2.5	1.75	3.08	2.38

**sd means standard deviation, **skew means skewness*

Table X
Empirical Percentiles of Blood Glucose for Other Indigenous Females, by Age

Age Group	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	>=70
n	418	335	202	194	122	108	106	67	109
Percentiles									
2.50th	2.5	2.2	2.5	2.0	2.6	2.4	2.8	3.3	2.3
5.00th	2.9	2.7	2.8	2.4	3.1	2.7	3.0	3.5	2.7
10.00th	3.2	3.1	3.1	3.2	3.5	3.0	3.5	3.8	3.5
15.00th	3.5	3.3	3.5	3.6	3.7	3.4	3.8	3.9	3.6
20.00th	3.7	3.6	4.0	3.8	3.9	3.7	4.0	4.1	3.6
25.00th	3.8	3.8	4.1	4.1	4.1	3.9	4.2	4.3	4.1
30.00th	4.0	4.1	4.3	4.3	4.3	4.1	4.5	4.4	4.3
35.00th	4.2	4.2	4.5	4.4	4.5	4.2	4.6	4.5	4.6
40.00th	4.3	4.3	4.6	4.7	4.6	4.6	4.7	4.8	4.9
45.00th	4.6	4.6	4.8	4.8	4.8	4.7	5.0	4.9	5.0
50.00th	4.7	4.7	5.0	5.0	5.0	4.9	5.3	5.1	5.1
55.00th	4.8	5.0	5.1	5.2	5.1	5.0	5.5	5.3	5.3
60.00th	5.0	5.1	5.2	5.3	5.3	5.2	5.7	5.5	5.5
65.00th	5.1	5.3	5.3	5.5	5.5	5.5	6.0	6.0	5.7
70.00th	5.2	5.6	5.5	5.6	5.8	5.8	6.1	6.2	5.9
75.00th	5.4	5.7	5.7	6.0	5.9	6.0	6.6	6.6	6.5
80.00th	5.6	6.0	6.2	6.2	6.2	6.2	7.0	6.7	7.1
85.00th	6.0	6.3	6.6	6.5	6.5	6.4	7.8	7.5	7.8
90.00th	6.3	6.7	7.5	7.3	7.2	7.2	11.2	7.7	9.6
95.00th	7.1	7.3	10.6	10.2	12.3	12.3	17.7	12.2	14.1
97.50th	7.8	10.9	12.0	13.0	13.1	16.6	18.3	15.6	17.0
mean	4.77	5.11	5.37	5.49	5.51	5.69	6.29	5.88	6.0
sd*	1.35	2.66	2.51	3.29	2.69	4.07	3.93	2.87	3.43
skew**	1.06	4.52	3.32	4.67	2.97	4.08	2.41	2.98	2.29

**sd means standard deviation, **skew means skewness*

Table XI
Crude and Age-adjusted Mean Capillary Blood Glucose

		Mean (SE)	Age-adjusted mean (SE)
All		5.8 (0.03)	5.8 (0.03)
	men	5.7 (0.05)	5.7 (0.04)
	women	5.9 (0.04)	5.8 (0.04)
Malay		5.6 (0.05)	5.6 (0.04)
	men	5.5 (0.06)	5.5 (0.06)
	women	5.8 (0.06)	5.8 (0.05)
Chinese		6.0 (0.06)	5.9 (0.05)
	men	5.9 (0.08)	5.9 (0.07)
	women	6.1 (0.06)	6.0 (0.06)
Indian		6.7 (0.13)	6.7 (0.12)
	men	7.0 (0.20)	7.1 (0.20)
	women	6.4 (0.14)	6.4 (0.15)
Other indigenous		5.2 (0.07)	5.2 (0.06)
	men	5.0 (0.09)	5.0 (0.09)
	Women	5.3 (0.08)	5.3 (0.07)

Table XII
Age Specific Mean Capillary Blood Glucose

		Age Group	Mean (SE)
Malay	men	30 - 39	5.0 (0.09)
		40 - 49	5.5 (0.12)
		50 - 59	5.7 (0.15)
		60 - 69	6.6 (0.23)
		>=70	6.2 (0.33)
	women	30 - 39	5.2 (0.06)
		40 - 49	5.7 (0.1)
		50 - 59	6.4 (0.16)
		60 - 69	6.8 (0.21)
		>=70	6.4 (0.23)
Chinese	men	30 - 39	5.1 (0.08)
		40 - 49	5.8 (0.13)
		50 - 59	6.2 (0.16)
		60 - 69	7.4 (0.39)
		>=70	7.7 (0.52)
	women	30 - 39	5.2 (0.07)
		40 - 49	5.9 (0.11)
		50 - 59	6.5 (0.18)
		60 - 69	7.8 (0.27)
		>=70	7.3 (0.28)
Indian	men	30 - 39	5.7 (0.18)
		40 - 49	7.5 (0.38)
		50 - 59	9.0 (0.72)
		60 - 69	8.6 (0.78)
		>=70	7.2 (0.91)
Indian	women	30 - 39	5.6 (0.18)
		40 - 49	6.4 (0.27)
		50 - 59	7.4 (0.43)
		60 - 69	7.5 (0.6)
		>=70	7.4 (0.74)
Other indigenous	men	30 - 39	4.7 (0.1)
		40 - 49	5.2 (0.23)
		50 - 59	5.0 (0.19)
		60 - 69	5.3 (0.21)
		>=70	5.5 (0.33)
	women	30 - 39	4.9 (0.07)
		40 - 49	5.4 (0.15)
		50 - 59	5.6 (0.22)
		60 - 69	6.1 (0.29)
		>=70	6.0 (0.41)

Table XIII
Crude and Age-adjusted Percentage Distribution of Blood Glucose According to WHO* Classification

		% Normal (SE)	Age adjusted % Normal (SE)	% IGT** (SE)	Age adjusted % IGT (SE)	% Diabetic (SE)	Age adjusted % Diabetic (SE)
All		88.4 (0.3)	88.4 (0.3)	4.7 (0.2)	4.7 (0.2)	6.9 (0.2)	6.9 (0.2)
	men	89.0 (0.4)	88.9 (0.4)	4.3 (0.2)	4.3 (0.2)	6.7 (0.3)	6.8 (0.3)
	women	87.9 (0.4)	88 (0.4)	5.1 (0.3)	5.1 (0.3)	7.0 (0.3)	6.9 (0.3)
Malay		89.6 (0.4)	89.7 (0.3)	4.0 (0.2)	4.0 (0.2)	6.4 (0.3)	6.4 (0.3)
	men	90.2 (0.5)	90.2 (0.5)	3.5 (0.3)	3.5 (0.3)	6.2 (0.4)	6.3 (0.4)
	women	89.1 (0.5)	89.1 (0.5)	4.4 (0.3)	4.4 (0.3)	6.5 (0.4)	6.5 (0.4)
Chinese		86.3 (0.6)	87.1 (0.5)	6.0 (0.4)	5.8 (0.4)	7.7 (0.4)	7.1 (0.4)
	men	87.0 (0.8)	87.5 (0.7)	5.7 (0.5)	5.5 (0.5)	7.3 (0.6)	7.0 (0.5)
	women	85.6 (0.7)	86.7 (0.7)	6.3 (0.5)	6.1 (0.5)	8.0 (0.6)	7.2 (0.5)
Indian		79.8 (1.2)	79.3 (1.1)	6.3 (0.7)	6.3 (0.7)	13.9 (1.0)	14.3 (1.0)
	men	76.7 (1.8)	76.2 (1.7)	6.8 (1.0)	6.9 (1.0)	16.4 (1.5)	16.9 (1.5)
	women	82.8 (1.4)	82.3 (1.5)	5.7 (0.9)	5.8 (0.9)	11.5 (1.2)	11.9 (1.2)
Other		93.4 (0.5)	93.3 (0.5)	3.2 (0.3)	3.2 (0.3)	3.4 (0.4)	3.5 (0.4)
indigenous	men	94.2 (0.7)	94.1 (0.7)	2.9 (0.5)	2.9 (0.5)	2.9 (0.5)	3.0 (0.6)
	Women	92.6 (0.7)	92.5 (0.7)	3.4 (0.5)	3.5 (0.4	3.9 (0.5)	3.9 (0.5)

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***IGT means impaired glucose tolerance*

Table XIV
Age Specific Percentage Distribution of Blood Glucose According to WHO* Classification

		Age group	% Normal (SE)	% IGT** (SE)	% Diabetic (SE)
Malay	men	30 - 39	94.6 (0.7)	2.6 (0.5)	2.8 (0.6)
		40 - 49	89.6 (1.0)	3.4 (0.6)	7.0 (0.8)
		50 - 59	87.3 (1.2)	4.3 (0.8)	8.4 (1.1)
		60 - 69	81.3 (1.9)	6.2 (1.2)	12.4 (1.6)
		>=70	86.0 (2.4)	4.1 (1.3)	9.9 (2.1)
Malay	women	30 - 39	94.5 (0.6)	2.8 (0.4)	2.7 (0.4)
		40 - 49	88.3 (0.9)	5.7 (0.7)	6.0 (0.7)
		50 - 59	83.9 (1.3)	4.7 (0.8)	11.3 (1.2)
		60 - 69	81.0 (1.9)	5.4 (1.1)	13.6 (1.7)
		>=70	84.4 (2.4)	6.8 (1.7)	8.8 (1.8)
Chinese	men	30 - 39	93.8 (0.9)	3.4 (0.7)	2.8 (0.7)
		40 - 49	87.4 (1.4)	6.0 (1.0)	6.6 (1.0)
		50 - 59	83.5 (2.0)	7.7 (1.3)	8.8 (1.4)
		60 - 69	76.2 (2.8)	8.5 (1.7)	15.3 (2.3)
		>=70	74.9 (4.2)	6.0 (2.2)	19.1 (3.8)
Chinese	women	30 - 39	93.8 (0.9)	5.0 (0.9)	1.2 (0.4)
		40 - 49	89.1 (1.2)	5.7 (0.9)	5.1 (0.9)
		50 - 59	81.4 (1.9)	6.6 (1.2)	12.0 (1.7)
		60 - 69	67.6 (3.0)	8.8 (1.8)	23.6 (2.4)
		>=70	72.8 (3.2)	10.1 (2.4)	17.1 (2.8)
Indian	men	30 - 39	87.3 (1.9)	6.8 (1.4)	5.9 (1.5)
		40 - 49	75.8 (3.1)	6.0 (1.8)	18.2 (2.9)
		50 - 59	59.1 (5.8)	10.3 (3.7)	30.6 (5.3)
		60 - 69	62.2 (6.8)	4.1 (2.5)	33.7 (6.7)
		>=70	74.2 (7.4)	6.6 (3.9)	19.2 (7.0)
Indian	women	30 - 39	91.2 (1.7)	4.1 (1.3)	4.7 (1.3)
		40 - 49	83.1 (2.6)	6.2 (1.7)	10.7 (2.2)
		50 - 59	70.0 (4.9)	10.2 (3.2)	19.8 (4.1)
		60 - 69	73.3 (5.9)	2.7 (1.6)	24.0 (5.3)
		>=70	66.7 (8.2)	9.5 (4.8)	23.8 (7.5)
Other indigenous	men	30 - 39	96.4 (0.8)	2.4 (0.7)	1.2 (0.5)
		40 - 49	92.9 (1.7)	2.7 (1.0)	4.4 (1.4)
		50 - 59	93.3 (1.7)	3.8 (1.3)	2.9 (1.2)
		60 - 69	91.0 (2.3)	5.2 (1.7)	3.8 (1.6)
		>=70	91.6 (3.5)	0.8 (0.8)	7.6 (3.4)
Other indigenous	women	30 - 39	96.8 (0.6)	2.0 (0.5)	1.2 (0.4)
		40 - 49	90.9 (1.4)	5.2 (1.1)	3.9 (1.0)
		50 - 59	91.6 (1.8)	2.1 (0.9)	6.3 (1.6)
		60 - 69	86.7 (2.8)	4.6 (1.6)	8.7 (2.2)
		>=70	83.3 (3.8)	8.2 (2.5)	8.5 (3.1)

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***IGT means impaired glucose tolerance*

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