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Prevalence and risk factors for diabetes in Ho Chi Minh City, Vietnam

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Abstract

Aims To determine the prevalence of diabetes and associated risk factors in Ho Chi Minh City, Vietnam.

Methods A total of 2932 participants aged 15 and above in Ho Chi Minh City were screened for diabetes in a cross-sectional study. The study was conducted from March–May 2001. Demographic, occupation, anthropometry and blood pressure were recorded. Blood glucose was calculated on fasting capillary and venous blood. The classification of diabetes and impaired fasting glucose (IFG) was carried out according to WHO and American Diabetes Association criteria.

Results The crude prevalence of diabetes and IFG were 6.6 and 3.2%, respectively. After age, sex-adjustment to the Vietnam population census, the prevalence was 3.8 and 2.5%, respectively; approximately 40% of cases were found to be newly diagnosed diabetes. The crude prevalence of diabetes in the urban area was approximately 2.8 times higher than that recorded in the 1993 study (6.9 vs. 2.5%, respectively). In this study, there was a positive association between diabetes and sex, age, overweight, waist hip ratio (WHR), and having a history of delivering large for gestational age child; there was a negative association between diabetes and physical activity and occupation.

Conclusions This study found that the age, sex-adjusted prevalence of diabetes and IFG in Ho Chi Minh City were 3.8 and 2.5%, respectively, a rapid increase in the recent decade. Our study also indicates that ageing, a high WHR level, overweight and a sedentary lifestyle may be important determinants of the increased prevalence of diabetes during this transition period in Vietnam.

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Keywords diabetes, Ho Chi Minh City, impaired fasting glucose, prevalence, risk factors

Abbreviations ADA, American Diabetes Association; BMI, body mass index; DBP, diastolic blood pressure; FCBG, fasting capillary blood glucose; FPG, fasting plasma glucose; IFG, impaired fasting glucose; LGA, large for gestational age; NS, not significant; SBP, systolic blood pressure; WHR, waist-hip ratio.

Introduction

Type 2 diabetes mellitus is one of the major non-communicable diseases in the world. The incidence and prevalence of diabetes are increasing, especially in developing and newly industrialized countries. In 1995, it was calculated that there were already 135 million people with diabetes around the world

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and that this number will rise to 300 million by the year 2025 [1]. Of these cases, more than 228 million will be in developing countries. This increase probably relates to the changes in dietary habits and lifestyle that accompany industrialization and urbanization.

During the last decade, the Vietnamese socio-economy has undergone rapid changes, strongly affecting the lifestyle and dietary habits of the people; dietary patterns and meal structure are two examples of habits that have changed. These changes have been accompanied by health consequences in which non-communicable chronic diseases incidence has increased [2,3].

Information on diabetes and its risk factors in Vietnam are limited. According to previous surveys, which were conducted in three big cities in Vietnam, the prevalence of diabetes in Hanoi (1991) [4], Ho Chi Minh City (1993) [5] and Hue (1994) [6] were 1.2, 2.52 and 0.96%, respectively. In these surveys, the rates of newly diagnosed diabetes were 87.5, 50.8 and 77.1%, respectively. In addition, the complications associated with diabetes were widespread. Of the people with either undiagnosed or newly diagnosed Type 2 diabetes, 20% had retinopathy [7], 8% had nephropathy [8] and 9% had neuropathy [9], and 10% [9] had cardiovascular and peripheral vascular diseases. Moreover, 74.5% of silent atheromatous lesions in carotid arteries and 26.9% of lesion in lower limb arteries were found among diabetic patients without clinical symptoms [10].

The purpose of this study was to evaluate the current prevalence of diabetes in Ho Chi Minh City and to investigate risk factors for the disease in this population.

Patients and methods

Subjects

Located in southern Vietnam, Ho Chi Minh City is the biggest city in Vietnam with a population of over 5 million. It is the industrial and commercial centre of Vietnam. There are 303 wards and communes, which are divided into 238 wards in urban areas and 65 communes in rural areas [11]. This survey included 3000 participants living in Ho Chi Minh City.

The multistage sampling method was used in this study. First, using the probability proportion-to-size method, we selected 60 of the 303 wards and communes (urban and rural areas). In each of the selected wards and communes, a listing of all families and family codes were constructed. From this list, the first family was selected by randomly picking a family code. All the adults in this selected family that were invited to participate were without deformity, free of acute illnesses, and had resided in the selected areas for at least 6 months prior to the survey. From this first family, using the 'random walking' method, we approached another family and added subjects to obtain 50 adults for each selected ward and commune [12].

To maximize participation, the local health staffs explained the purpose of the survey and obtained written, informed consent from the subjects. In addition, the local health staff went to the participants' houses to remind them of the time and date of the survey.

The survey was conducted in the local health office of the selected ward and commune over 2-months (between March and May 2001).

The protocol of this survey was approved by the Research and Ethical Review Board of the Nutrition Center of Ho Chi Minh City.

Assessments of socio-economic status and physical activity

A diabetic screening questionnaire was completed by each participant prior to the measurement of blood glucose. The questionnaire included an assessment of the subject's medical history, family history of diabetes, socio-economic status, occupation and physical activities.

Education level was classified into three groups: high level as high school, college and university; medium level as junior high school; low level as illiterate, literate, and primary school. Occupation was classified into four categories: unskilled workers, including students and unskilled workers with the same activity level; office workers; home-makers; and retired workers, including unemployed subjects. Physical activities were assessed and classified on the basis of questions that related to leisure activities, frequency and duration of physical activities, exercises habits and occupational activities. The physical activity level was classified into four groups: sedentary, light, moderate and heavy [13,14].

Anthropometry, clinical and biochemical measurements

Height, weight, waist and hip circumferences were measured when the participants were in the standing position wearing light clothing and no shoes. BMI was calculated as the ratio of weight (kg) to height squared (m). Waist circumference was measured at the minimum circumference between the umbilicus and iliac crest; hip circumference was measured at the widest circumference around the buttocks. Blood pressure was measured twice in a sitting position after participants rested for at least 5 min. The mean of the two values was used in the analysis. Hypertension was classified using WHO criteria [15]. Participants currently taking anti-hypertensive medications were classified as hypertensive.

Prior to blood glucose measurement, participants were questioned as to any past diagnosis of diabetes. In order to maximize sensitivity and specificity, minimize the number of missed cases and reduce the number of false positives, two screening tests were applied in the study [16]. First, all subjects had a finger-prick fasting capillary blood glucose (FCBG) level determined by a trained nurse using an Omnitest Sensor (B-Braun Medical Ltd-Germany). The Omnitest Sensor is a biosensor based on an electron-mediated glucose oxidase reaction. The results appeared within 30 s. The range of the glucose measurements was 2.2–25 mmol/l. If the capillary blood glucose was > 5.5 mmol/l, the subjects were asked to return for a fasting plasma glucose (FPG) test on a different day. The FPG was measured by the glucose oxidase method (GOD-PAP method, Human-Germany). Before conducting this survey, a pilot test was done in which 39 normal volunteers had their blood glucose level determined by both a capillary glucose test (Omnitest Sensor) and a venous glucose test in the fasting condition. The mean and standard deviation of the blood glucose concentration

from the two methods were calculated. There was a significant linear correlation between simultaneously measured FCBG and FPG (Pearson's correlation coefficient $r = 0.75$, $P < 0.001$). The 1998 WHO [17] and American Diabetes Association (ADA) diagnostic criteria [18], in which diabetes is defined as FPG level ≥ 7.0 mmol/l; and impaired fasting glucose (IFG) as 6.1 mmol/l ≤ FPG level < 7.0 mmol/l, were used to classified glucose metabolic status. Previously diagnosed Type 2 diabetes was defined by the current use of oral hypoglycemic treatment and FPG level ≥ 7.0 mmol/l by the above blood tests.

The age, sex-adjusted prevalence of diabetes and IFG was calculated according to the 1999 Ho Chi Minh census data [11].

Statistical analysis

Data are presented as percentage and mean ± SD. One-way analysis of variances (ANOVA) was used to test the trend of mean values among diabetes, those with IFG and the normal group. Analyses of differences in locality, education level, occupation and physical activity level between diabetes and those with IFG and normoglycemic subjects were performed using chi-square analysis. A history of gestational diabetes, and a history of having a large for gestational age (LGA) baby were also analysed by chi-square test for female subjects only. Multiple logistic regression was used to test several models for the association of diabetes and IFG and other variables. A P-value < 0.05 was considered to be significant. All statistical analyses were carried out with the Statistics Package for the Social Sciences software release 9.0 (SPSS, Chicago, IL, USA).

Results

Of the 3000 subjects scheduled for the survey, 68 subjects declined to participate. Because of Vietnamese society features,

Table 1 Crude prevalence of diabetes and IFG in 2932 people age 15 years old and above

Variables	Total population	Diabetes			IFG
		Previous	New	Total	
All	2932	118 (4.0)	76 (2.6)	194 (6.6)	93 (3.2)
Male					
Locality					
Urban	630	19 (3.0)	14 (2.2)	33 (5.2)	13 (2.1)
Rural	120	5 (4.2)	1 (0.8)	6 (5.0)	3 (2.5)
Age (years)					
15–24	96	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
25–34	101	0 (0.0)	1 (1.0)	1 (1.0)	1 (1.0)
35–44	172	7 (4.1)	1 (0.6)	8 (4.7)	5 (2.9)
45–54	144	5 (3.5)	2 (1.4)	7 (4.9)	4 (2.7)
55–64	104	5 (4.8)	3 (2.9)	8 (7.7)	3 (2.9)
≥ 65	133	7 (5.3)	8 (6.0)	15 (11.3)	3 (2.3)
Occupation					
Unskilled workers	385	4 (1.0)	5 (2.3)	9 (2.3)	4 (1.0)
Office workers	120	4 (3.3)	1 (0.9)	5 (4.2)	4 (3.3)
home-makers	4	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Retired workers	241	16 (6.6)	9 (3.8)	25 (10.4)	8 (3.3)
Female					
Locality					
Urban	1860	84 (4.5)	56 (3.0)	140 (7.5)	74 (4.0)
Rural	322	10 (3.1)	5 (1.6)	15 (4.7)	3 (0.9)
Age (years)					
15–24	181	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.1)
25–34	290	1 (0.3)	1 (0.3)	2 (0.7)	1 (0.3)
35–44	570	9 (1.6)	11 (1.9)	20 (3.5)	20 (3.5)
45–54	488	11 (2.3)	23 (4.7)	34 (7.0)	18 (3.7)
55–64	347	33 (9.5)	10 (2.9)	43 (12.4)	17 (4.9)
≥ 65	306	40 (13.1)	16 (5.2)	56 (18.3)	19 (6.2)
Occupation					
Unskilled workers	768	15 (2.0)	11 (1.4)	26 (3.4)	19 (2.5)
Office workers	231	6 (2.6)	2 (0.9)	8 (3.5)	5 (2.2)
home-makers	857	40 (4.7)	36 (4.2)	76 (8.9)	39 (4.6)
Retired workers	325	33 (10.1)	12 (3.7)	45 (13.8)	14 (4.3)

Data were presented as *n* (%).

the men have to work to provide for their family and working men often stay in dormitories of factory or industrial zones and so were unavailable for study. Finally, the complete data of 2932 (2182 female and 750 male) were analysed. The characteristics of the subjects are shown in Table 1.

In accordance with the protocol, 608 subjects (20.7%) with capillary blood glucose concentrations > 5.5 mmol/l returned for a fasting plasma glucose test. Using this test, we found that 287 of 608 subjects (47.2%) had plasma glucose concentrations ≥ 6.1 mmol/l.

Using the 1998 WHO and ADA diagnostic criteria, the crude prevalence of diabetes and IFG in this sample of individuals from Ho Chi Minh City were found to be 6.6 and 3.2%, respectively. Of these diabetic subjects, 39.2% were newly diagnosed (Table 1).

After statistical adjustment for age and sex, the estimated prevalence of diabetes and IFG were 3.8% (95% CI 3.5–4.1) and 2.5% (95% CI 2.1–3.0), respectively.

Table 2 Prevalence of diabetes and IFG in relation to variables

Variable	Diabetes	*P*	IFG	*P*
Age				
< 40 year	1.8	< 0.001	1.7	< 0.001
≥ 40 year	9.8		4.4	
Locality				
Rural	4.8	NS	1.4	< 0.05
Urban	6.9		3.5	
Family history of diabetes				
No	6.7	NS	3.4	NS
Yes	8.7		3.7	
Education level				
High	4.7	< 0.01	2.7	NS
Medium	7.2	1, 2 vs. 3	3.7	
Low	12.1		4.6	
Occupation				
Unskilled workers	3.1	< 0.001	2.1	< 0.01
Office workers	3.8	3, 4 vs. 1; 2	2.7	1 vs. 3, 4
home-makers	9.3	< 0.05	5.0	
Retired workers	12.9	1 vs. 2	4.4	
Physical activity				
Heavy	0.0	< 0.05	1.6	NS
Moderate	6.2	1, 2, 3 vs. 4	2.1	1, 2, 3 vs. 4
Light	8.8		4.6	
Sedentary	7.8		3.1	
Gestation diabetes mellitus*				
No	6.7	< 0.05	3.4	NS
Yes	19.2		0.0	
Having an LGA baby*				
No	6.3	< 0.001	3.7	NS
Yes	16.9		5.0	

Data were presented as percentage. Data were compared with normal subjects.
NS, not significant; LGA, large for gestational age.
*Analysed in female only.

The prevalence of diabetes increased with age and a maximum prevalence was found in subjects of over 65 years old (χ^2 trend = 26.7, $P < 0.0001$).

Table 2 shows that the prevalence of diabetes in urban areas was slightly higher than that in rural areas; however, a significant difference was not observed. In contrast, the prevalence of IFG in urban areas was significantly higher than that in rural areas ($P < 0.05$).

As shown in Table 2, the prevalence of diabetes and IFG in subjects over 40 years of age was significantly higher than that in subjects under 40 years of age ($P < 0.001$). There was no significant difference in the family history of diabetes among people with diabetes, or IFG and normoglycemic subjects. The prevalence of diabetes was significantly lower in subjects with a high level of education than in subjects with a low level of education (4.7 vs. 12.1%, respectively; $P < 0.01$). When occupation of the subjects was classified, the maximum rate of diabetes was seen among retired subjects and the difference in the prevalence of diabetes among classified groups of occupation was significant ($P < 0.001$). In comparison, the difference of prevalence of diabetes among physical activity level groups were significant ($P < 0.05$) and the maximum rate of diabetes was seen among those reporting a light level of physical activity. A significant difference was found in IFG prevalence among unskilled subjects and both home-makers and retired subjects ($P < 0.01$) (Table 2).

In female subjects, there was a significantly higher proportion of diabetes in those with a history of gestational diabetes mellitus ($P < 0.05$) or having an LGA baby ($P < 0.001$) compared with those in the normoglycemic group (Table 2).

Our findings showed that subjects with diabetes and IFG had higher mean BMI, WHR, and systolic, diastolic blood pressure values compared with normoglycemic subjects (Table 3). Overweight status was seen in a total of 545 cases (18.6%),

Table 3 Characteristics of normal, diabetes and IFG subjects

Variables	Normal $n = 2645$	Diabetes $n = 194$	IFG $n = 93$
BMI			
Male	21.1 ± 3.5	22.7 ± 3.8$^{a1; b0}$	24.3 ± 4.2^{a1}
Female	21.8 ± 3.6	23.3 ± 4.1$^{a3; b0}$	24.2 ± 3.7^{a3}
WHR			
Male	0.86 ± 0.07	0.90 ± 0.07$^{a3; b0}$	0.90 ± 0.06^{a1}
Female	0.83 ± 0.08	0.90 ± 0.07$^{a3; b0}$	0.88 ± 0.1^{a3}
Overweight (%)	16.9	29.9$^{a3; b1}$	43.0^{a3}
SBP (mmHg)	119.2 ± 21.3	131.8 ± 21.8$^{a3; b0}$	131.8 ± 25.4^{a3}
DBP (mmHg)	75.5 ± 12.9	80.0 ± 11.8$^{a3; b0}$	80.7 ± 13.4^{a2}
Hypertension (%)	23.8	49.5$^{a3; b0}$	45.2^{a3}

Data were presented as mean ± SD or (%).
^{a}vs. normal group; ^{b}vs. IFG group. $^{0}P > 0.05$; $^{1}P < 0.05$; $^{2}P < 0.01$; $^{3}P < 0.001$.
Overweight was defined BMI > 25 kg/m^2.

Table 4 Associated factors of IFG and diabetes

	Diabetes		IFG	
	Odds ratio	*P*	Odds ratio	*P*
Sex				
Male	1.0		1.0	
Female	1.8 (1.2–2.8)	0.01	1.7 (0.9–3.4)	0.09
Age				
< 40 year	1.0		1.0	
≥ 40 year	3.3 (1.9–5.5)	< 0.001	1.8 (1.1–3.1)	0.048
Overweight				
Negative	1.0		1.0	
Positive	1.5 (1.1–2.0)	0.031	2.8 (1.8–4.4)	< 0.001
WHR				
Normal	1.0		1.0	
High	2.6 (1.9–3.6)	< 0.001	1.9 (1.2–3.1)	0.005
Education level				
High	1.0		1.0	
Medium	1.4 (0.9–2.0)	0.11	1.2 (0.7–2.0)	0.53
Low	1.3 (0.8–2.1)	0.3	0.9 (0.4–2.0)	0.86
Physical activity				
Heavy	1.0		1.0	
Moderate	2.7 (0.8–5.3)	0.33	0.8 (0.07–7.7)	0.81
Light	2.2 (1.2–4.2)	< 0.001	1.1 (0.2–9.2)	0.90
Sedentary	2.1 (1.2–4.1)	< 0.001	1.1 (0.2–8.1)	0.97
Occupation				
Unskilled workers	1.0		1.0	
Office workers	1.4 (0.7–2.8)	0.33	1.5 (0.8–2.9)	0.18
home-makers	2.2 (1.4–3.4)	< 0.001	1.8 (1.1–3.2)	0.038
Retired workers	2.7 (1.7–4.2)	< 0.001	1.2 (0.5–2.9)	0.6
Gestation diabetes mellitus*				
No	1.0		—	
Yes	2.4 (0.9–6.7)	0.09	—	—
Having a LGA baby*				
No	1.0		1.0	
Yes	2.7 (1.6–4.4)	< 0.001	1.9 (0.7–4.9)	0.18

LGA, large for gestational age.
*Analysed in female only.
Values in parentheses are 95% confidence intervals.

whereas hypertension was recorded in 768 (26.2%). There was a higher prevalence of overweight and hypertension in subjects with diabetes and IFG.

Multiple logistic regression analyses were used to assess the association of independent variables with diabetes and IFG. The findings show that sex (female gender), age, overweight status, WHR, lower levels of physical activity, and the occupational categories of retired persons and home-makers were factors that were significantly associated with the prevalence of diabetes. In addition, a history of having an LGA baby was also associated with diabetes in female subjects. Using the same statistical analysis, age, overweight, WHR and the occupational categories of home-makers were factors associated with IFG (Table 4).

Discussion

Type 2 diabetes mellitus in adults is now a major global public health problem and developing countries face the greatest risk. The results of this study show that the age, sex-adjusted prevalence of diabetes was 3.8% in Ho Chi Minh City, approximately three times higher than that observed in Hanoi in 1994 [4] Moreover, the crude prevalence of Type 2 diabetes in urban areas of Ho Chi Minh City increased from 2.5 to 6.9% compared to 8 years ago [5]. Although the prevalence of diabetes in Ho Chi Minh City is lower when compared with some developing countries in Asia such Indonesia (5.7%) [19]; Malaysia (10.5%) [20] and Thailand (13.9%) [21], it is higher than in China (2.5%) [22]. These trends suggest that diabetes will be a significant health problem in Vietnam.

According to Wahl [23], a fasting blood glucose test alone in elderly subjects may underestimate the prevalence of diabetes. However, Stolk and others have suggested a fasting blood glucose test alone is most appropriate for epidemiological studies [16,24–26]. In this study, we used fasting glucose to estimate the prevalence of diabetes; but to increase the predictive value [16], two tests were applied. For these reasons, our data represent or even underestimate the prevalence of diabetes in Ho Chi Minh City.

It is well known that the complications of diabetes are hazardous to health [7–10], and may be silently developing in the undiagnosed condition. Diabetic patients often already have complications at the time of diagnosis [9]. The present results indicate that approximately 40% of these diabetic patients were newly diagnosed; a higher figure than in previous surveys [4–6].

In developing countries, the number of people with diabetes increases rapidly in urban areas because of development industrialization and the shift of dietary habits to a high fat intake [2]; the global urban-to-rural ratio of diabetes frequency is predicted to rise 3.3-fold in 2025 [1]. Differences in the prevalence of diabetes between urban and rural areas have been demonstrated in many epidemiological studies [27–29], but in the present study, the prevalence of diabetes in urban areas was only slightly and not significantly higher than that in rural areas. This may be because in Ho Chi Minh City the rural area is only 15–20 km from the city centre. As a result, a number of adults living in rural areas work in urban industrial zones.

Our study revealed that the prevalence of diabetes and IFG in the over 40 years-olds was significantly higher than that in the under 40s as in other surveys [4,5,22,30–33]. As the largest proportion of the population (51.3%) is between 15 and 40 years of age [11], there may be a significant increase in diabetes prevalence as this population ages.

With the increasing developing and industrialization taking place in Ho Chi Minh City, there is a shift from a traditional lifestyle (higher levels of occupational as well as leisure-time physical activities, moderate body weight, and lower calorie, lower fat meals) to a more westernized one [2]. According to the nutrition survey performed in Ho Chi Minh City from 1996 to 2001, the prevalence of obesity in adults was higher in females and increased with age [3]. These changes may also be

responsible for the increase in diabetes in Ho Chi Minh City as well as in the whole country, suggesting that a national programme for the prevention and control of obesity and diabetes is needed.

In conclusion, the prevalence of diabetes has rapidly increased and become a public health priority in Vietnam. The ageing process, a high WHR level, overweight and a sedentary lifestyle may be important determinants for this increased prevalence of diabetes.

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References

1 King H, Aubert RE, Hernan WH. Global burden of diabetes, 1995–2025: prevalence, numerical estimates, and projections. *Diabetes Care* 1998; **21**: 1414–1431.
2 Khoi HH. Problems of nutrition in transition period. In: Khoi HH, ed. *Problems of Nutrition in Transition Period in Vietnam*. Hanoi: Medical Publishing House, 1996, 6: 153–226.
3 Loan TTH, Hung NTK. The overweight and obesity status in Ho Chi Minh City demographic strata 1996–2001. *The Technical, Public Health and Preventive Medicine Symposium in Ho Chi Minh City, December 2002*, 2002: 28–36.
4 Quoc PS, Charles MA, Cuong NH, Lieu LH, Tuan NA, Thomas M *et al*. Blood glucose distribution and prevalence of diabetes in Hanoi (Vietnam). *Am J Epidemiol* 1994; **139**: 713–722.
5 Trach MT, Toan DTB, Binh DTT, Thang HQ *et al*. Basic epidemiology survey on diabetes mellitus in urban areas of Ho Chi Minh City. *Pharmaceutical and Medical Magazine of Ho Chi Minh City*, 1994: 171–174.
6 Dang TH. Study of the diabetes mellitus situation and characteristics in Hue. Medical and Pharmaceutical PhD Thesis, Hanoi: The Medical University, 1996.
7 Harris MI, Klein R, Welborn TA, Knuiman MW. Onset of NIDDM occurs at least 4–7 years before clinical diagnosis. *Diabetes Care* 1992; **15**: 815–819.
8 Ballard DJ, Humphrey LL, Melton LJ, Frohnert PP, Chu PC, O'Fallon WM *et al*. Epidemiology of persistent proteinuria in type II diabetes mellitus: population-based study in Rochester, Minnesota. *Diabetes* 1988; **37**: 405–412.
9 Harris MI. Undiagnosed NIDDM: clinical and public health issue. *Diabetes Care* 1993; **16**: 642–652.
10 Thuy NH. Study of carotids and of the lower limbs wall arteries lesions of non-insulin dependent diabetes mellitus patients by echography mode B for the early detection of atheromatous lesions. Medical and Pharmaceutical PhD Thesis, Hanoi: The Medical University, 1996.
11 Population and Housing Steering Committee. The population of Ho Chi Minh City (population census data in 4/1999). *The Steering Committee of Population and Housing Survey in Ho Chi Minh City*. Ho Chi Minh City: Statistical Publishing House, June 2000.
12 The United Nation Children's Fund. Choosing the sampling. In: *Practical Handbook for Multiple-Indicator Surveys*. New York: UNICEF, 1995, 4: 1–28.
13 Kriska AM, Knowler WC, LaPorte RE, Drash AL, Wing RR, Blair SN *et al*. Development of questionnaire to examine relationship of physical activity and diabetes in Pima Indians. *Diabetes Care* 1990; **13**: 401–411.
14 Physical Education Department. The physical activity classification table. Ho Chi Minh City: Physical education department of University of Training Center for Healthcare Professional in Ho Chi Minh City, 1999.
15 WHO. International society of hypertension guidelines for the management of hypertension. *J Hypertension* 1999; **17**: 151–185.
16 Engelgau MM, Thompson TJ, Aubert RE, Herman WH. Screening for NIDDM in non-pregnant adults. A review of principles, screening tests, and recommendations. *Diabetes Care* 1995; **18**: 1606–1615.
17 Alberti KGMM, Zimmet PZ, for the WHO Consultation. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: Diagnosis and classification of diabetes mellitus. Provisional report of a WHO consultation. *Diabetic Med* 1998; **15**: 539–553.
18 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* 2000; **23**: S4–S19.
19 Sutanegara D, Budhiarta AA. The epidemiology and management of diabetes mellitus in Indonesia. *Diabetes Res Clin Prac* 2000; **50**: S9–S16.
20 Mafauzy M, Mokhtar N, Mohamad WB, Musalmah M. Diabetes mellitus and associated cardiovascular risk factors in north-east Malaysia. *Asia Pacific J Public Health* 1999; **11**: 16–19.
21 Puavilai G, Kheesukapan P, Chanprasertyotin S, Chantraraprasert S, Suwanvilaikorn S, Nitiyanant W *et al*. Random capillary plasma glucose measurement in the screening of diabetes mellitus in high-risk subjects in Thailand. *Diabetes Res Clin Prac* 2001; **51**: 125–131.
22 Pan XR, Yang WY, Li GW, Liu J. Prevalence of diabetes and its risk factors in China, 1994. *Diabetes Care* 1997; **20**: 1664–1669.
23 Wahl PW, Savage PJ, Psaty BM, Orchad TJ, Robbins JA, Tracy RP. Diabetes in older adults: comparison of 1997 American Diabetes Association classification of diabetes mellitus with 1985 WHO classification. *Lancet* 1998; **352**: 1012–1015.
24 Stolk RP, Orchad TJ, Grobbee DE. Why use the oral glucose tolerance test? *Diabetes Care* 1995; **18**: 1045–1049.
25 Cance DRM, Hanson RL, Charles MA, Jacobsson LTH, Pettitt DJ, Bennett PH *et al*. Comparison of test for glycated hemoglobin and fasting and two hours plasma glucose concentration as diagnostic method for diabetes. *Br Med J* 1994; **308**: 1323–1328.
26 Veget FD, Dekker JM, Stehouwer CDA, Nijpels G, Bouter LM, Heine RJ. The 1997 American Diabetes Association criteria versus the 1985 World Health Organization criteria for the diagnosis of abnormal glucose tolerance. *Diabetes Care* 1998; **21**: 1868–1690.
27 Ramachandra A, Snehalatha C, Dharmaraj D, Viswanathan M. Prevalence of glucose intolerance in Asia Indians. *Diabetes Care* 1992; **15**: 1348–1355.
28 Sekikawa A, Eguchi H, Tominaga M, Igarashi K, Abe T, Manaka H *et al*. Prevalence of type 2 diabetes mellitus and impaired glucose tolerance in a rural area of Japan. The Funagata diabetes study. *J Diabetes Complication* 2000; **14**: 78–83.
29 Ramachandra A, Snehalatha C, Kapur A, Vijay V, Mohan V, Das AK *et al*. High prevalence of diabetes and impaired glucose tolerance in India: national urban diabetes survey. *Diabetologia* 2001; **44**: 1094–1101.
30 Park Y, Lee H, Koh CS, Min H, Yoo K, Kim Y *et al*. Prevalence of diabetes and IGT in Yonchon county, South Korea. *Diabetes Care* 1995; **18**: 545–548.
31 Chang C, Lu F, Yang YC, Wu TJ, Chan MS, Chuang LM *et al*. Epidemiologic study of type 2 diabetes in Taiwan. *Diabetes Res Clin Prac* 2000; **50**: S49–59.
32 Lu FH, Yang YC, Wu JS, Wu CH, Chang CJ. A population-based study of the prevalence and associated factors of diabetes mellitus in southern Taiwan. *Diabetic Med* 1998; **15**: 564–572.
33 Ramachandra A, Snehalatha C, Latha E, Vijay V, Viswanathan M. Rising prevalence of NIDDM in an urban population in India. *Diabetologia* 1997; **40**: 232–237.