The Prevalence and Management of Diabetes in Thai Adults

The International Collaborative Study of Cardiovascular Disease in Asia

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OBJECTIVE — The aim of this study was to determine in Thai adults aged ≥35 years the prevalence and management of diabetes and the associations of diabetes with cardiovascular risk factors.

RESEARCH DESIGN AND METHODS — The International Collaborative Study of Cardiovascular Disease in Asia was a complex sample survey. Data from a structured questionnaire, brief physical examination, and blood sample were collected from 5,105 individuals aged ≥35 years (response rate 68%). Population estimates were calculated by applying sampling weights derived from the 2000 Thai census.

RESULTS — The estimated national prevalence of diabetes in Thai adults was 9.6% (2.4 million people), which included 4.8% previously diagnosed and 4.8% newly diagnosed. The prevalence of impaired fasting glucose was 5.4% (1.4 million people). Diagnosed diabetes, undiagnosed diabetes, and impaired fasting glucose were associated with greater age, BMI, waist-to-hip ratio, systolic blood pressure, total cholesterol, and serum creatinine levels. The majority of individuals with diagnosed diabetes had received dietary or other behavioral advice, and 82% were taking oral hypoglycemic therapy. Blood pressure–lowering therapy was provided to 67% of diagnosed diabetic patients with concomitant hypertension.

CONCLUSIONS — Diabetes is common in Thailand, but one-half of all cases are undiagnosed. Because diagnosed diabetes is likely to be treated with proven, low-cost, preventive therapies such as glucose lowering and blood pressure lowering, initiatives that increased diagnosis rates would be expected to produce substantial health benefits in Thailand.

Diabetes Care 26:2758–2763, 2003

D iabetes is a large and growing global health problem. It is projected that the number of individuals with diabetes will rise from an estimated 135 million in 1995 to a projected 300 million in 2025 (1). The greatest increase is projected for economically developing countries, such as Thailand, that already account for approximately two-thirds of all individuals with diabetes. In these countries, the number of people with diabetes is projected to increase almost threefold over this time period from 84 to 228 million (1). Diabetes greatly increases the risks of macro- and microvascular diseases (2), with similar proportional effects on disease risk observed in Western (3) and Asian (4) populations. As such, diabetes is likely to be an important determinant of the vascular disease burden in countries such as Thailand, where coronary heart disease has been the leading cause of death for over a decade (5). However, reliable national data about the prevalence of diabetes and glucose intolerance and the associations of these conditions with other determinants of cardiovascular disease in Thailand were not previously available. The International Collaborative Study of Cardiovascular Disease in Asia (InterASIA) (6) was a population-based survey of cardiovascular risk factors conducted in Thailand and China during 2000. In this study, we report comprehensive new data about the prevalence of diabetes, the associations of diabetes with cardiovascular risk factors, and the management of diabetes in Thailand.

RESEARCH DESIGN AND
METHODS — InterASIA was conducted collaboratively between academic institutions in Australia, China, Thailand, and the U.S. (see ACKNOWLEDGMENTS). The Thai component of the study was approved by the Institutional Review Board at Mahidol University and by the local ethics committee at each of the collaborating centers in Thailand. All participants provided written informed consent, and the study was conducted in line with the Declaration of Helsinki and subsequent amendments. Data collection was conducted between May and October 2000.

Sample design
The sample design has been described in detail previously (6). In brief, one representative province was selected from each of the four main geographic regions of Thailand. From these provinces and Bangkok, a total of five representative ur-

Table 1—*Mean fasting plasma glucose levels (mg/dl) overall and by age, sex, and area of residence*

Age-group	Population group				
	Men	Women	Urban	Rural	All
All ages	101.0 ± 1.5	99.1 ± 1.4	106.6 ± 1.4	97.0 ± 1.1	100.0 ± 1.0
35–44 years	98.2 ± 2.6	93.0 ± 1.7	101.9 ± 2.0	92.5 ± 1.5	95.5 ± 1.6
45–54 years	101.7 ± 2.5	102.1 ± 2.5	108.4 ± 1.5	98.8 ± 1.8	101.9 ± 1.8
55–64 years	102.8 ± 2.6	105.7 ± 3.3	113.9 ± 3.5	100.3 ± 1.9	104.3 ± 2.2
≥65 years	105.7 ± 2.3	102.6 ± 2.3	109.4 ± 1.5	101.7 ± 2.0	104.0 ± 1.7

Data are means ± SEM.

ban political districts (one from Bangkok and one from each chosen province) and four representative rural political districts (one from each chosen province) were selected. Up to six representative slum enumeration districts (EDs) and up to three representative non-slum EDs (each based on city blocks) were selected from each urban political district (except in Central Thailand where there were no slum EDs in the selected urban district). Up to three representative developing and three representative developed EDs (each based on villages) were selected from each rural district. Additionally, in North Thailand, the only region in which the selected rural district included undeveloped EDs, two representative undeveloped EDs were selected. At each level, selection of the units for sampling was based on their broad sociodemographic representativeness in the view of the chief Thai investigators with additional consideration given to the potential of the sites for participation in future longitudinal surveillance studies. The number of EDs of each development level selected from each district was dependent upon the size of the EDs. Within the selected EDs of a given development level in each district, the population aged ≥35 years was grouped by age (35–44, 45–54, 55–64, and ≥65 years) and sex, using lists compiled from local government registers of households. Individuals were then sampled at random from each age- and sex group, with the goal of recruiting a similar number of people from each with the proviso that only one individual be recruited from a household.

Data collection and measurements
For each individual who agreed to participate, trained study staff administered a structured questionnaire, performed a brief physical examination, and collected a blood sample. The questionnaire included questions about the prior diagnosis of diabetes by a physician and the use of glucose-lowering therapies. The examination included three measurements of blood pressure made according to American Heart Association recommendations (7), and measurement of body weight and height with participants wearing indoor clothes without shoes. BMI was calculated as weight in kilograms divided by height in meters squared.

Venous blood samples were obtained after an 8-h overnight fast. Samples were stored immediately over ice and centrifuged and separated on the day of collection. Sera were subsequently frozen and transferred on dry ice to a central laboratory (Faculty of Medicine, Ramathibodi Hospital, Bangkok), where they were stored at −70°C until analyzed. All analyses were performed using a dimension RxLHM clinical chemistry system (Dade Behring, Newark, NJ). Plasma glucose levels were measured using the hexokinase-glucose-6-phosphate dehydrogenase method (8). Serum total and HDL cholesterol were measured using enzymatic and homogeneous methods, respectively (9,10). The laboratory was standardized according to the criteria of the Centers for Disease Control and Prevention-National Heart, Lung, and Blood Institute Lipid Standardization Program (11).

Definitions
Diabetes was defined as a fasting plasma glucose value ≥126 mg/dl or a previous diagnosis of diabetes (but not a previous diagnosis of gestational diabetes) (12). Diabetes was further subclassified as "known diabetes" if the participant had been informed previously of their condition by a medical practitioner and "newly diagnosed diabetes" if the diagnosis was made on the basis of the assay performed for this study. Impaired fasting glucose was defined as a fasting plasma glucose

value 110–125 mg in the absence of a previous diagnosis of diabetes. All other participants were defined as having normal glucose tolerance. Individuals in whom the diagnosis of diabetes was made before the age of 30 years and who started insulin treatment within 6 months after diagnosis were considered type 1 diabetic subjects.

Statistical methods
Estimates of mean ± SEM or percentage and risk factor levels in the overall population aged ≥35 years among age, sex, and rural/urban subgroups of that population were calculated. Comparisons of risk factor levels between population subgroups were performed using Student's *t* tests for continuous variables and χ^2 tests for categorical variables. Age trends were investigated using linear regression models. All analyses allowed for the complex survey design using STATA 7.0 statistical software (StataCorp, College Station, TX): EDs were taken as primary sampling units, age and sex as strata, and weights were the population (13) to sample size ratios for each combination of age, sex, and type of ED.

RESULTS — There were 7,909 individuals invited to participate in the study, of whom 5,350 (68%) agreed and provided informed consent. Forty-five (0.8%) were subsequently excluded because their age was found to be <35 years on the day of assessment, and 200 (3.7%) were excluded because there was no assay of fasting plasma glucose available. The mean age, the female proportion, and the proportion with previously diagnosed diabetes did not differ between these 200 excluded individuals and the remainder of the eligible study population (*P* > 0.2). Among the 5,105 participants on whom all analyses were based, the data from the
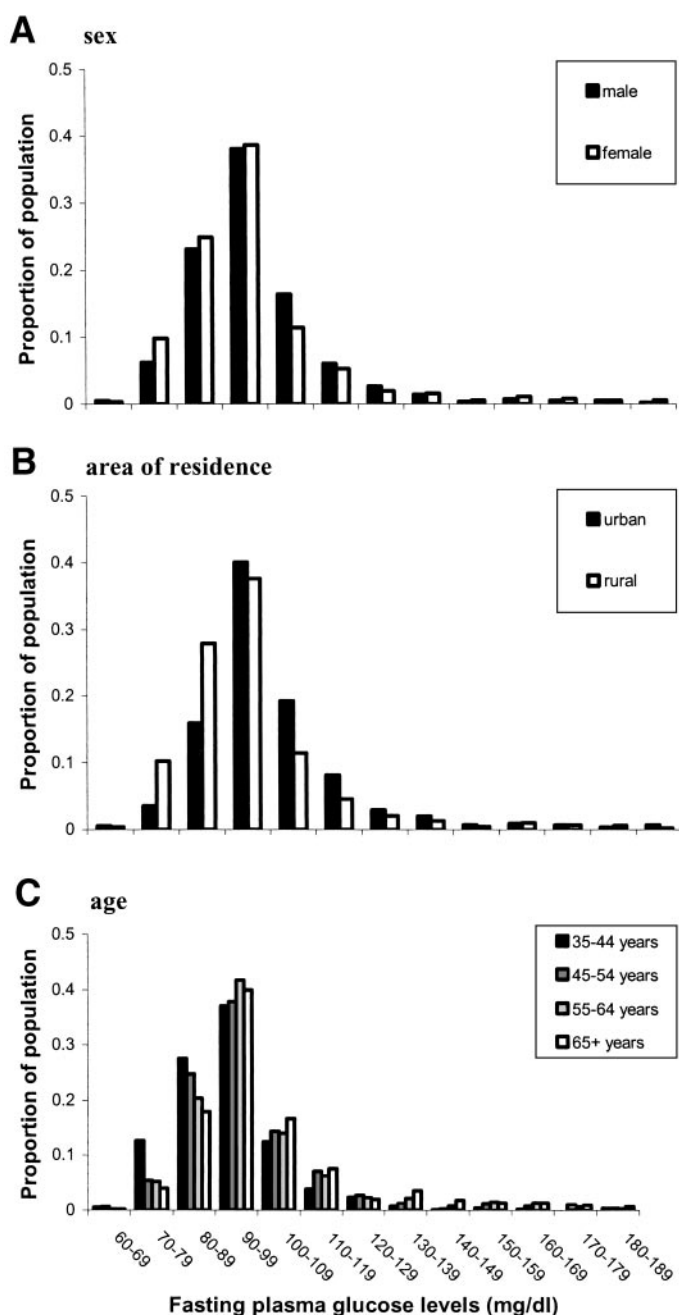
Figure 1—*Distribution of estimated population levels of plasma glucose by sex* (A)*, area of residence* (B)*, and age* (C) *in Thai adults aged ≥35 years. To improve readability, the charts do not show data for the estimated 2% of the population with fasting plasma glucose levels >189 mg/dl.*

questionnaire, anthropomorphic, and blood pressure measurements were >99% complete. The response rate to invitation to participate in the study was higher in rural than urban areas (81 vs. 61%, $P < 0.001$) and was higher among women than men (77 vs. 57%, $P < 0.001$) but did not significantly differ by age-group ($P = 0.6$).

Mean fasting plasma glucose levels
The estimated overall mean fasting plasma glucose level for Thai adults aged ≥35 years was 100.0 ± 1.0 mg/dl (Table 1). Fasting plasma glucose was slightly higher in men (101.0 mg/dl) compared with women (99.1 mg/dl, $P = 0.4$) and substantially greater in the residents of urban (106.6 mg/dl) compared with rural

(97.0 mg/dl, $P < 0.001$) areas (Table 1). Levels were higher in older compared with younger individuals peaking in the 55- to 64-year age-group (Table 1). The graphs in Fig. 1 show that the estimated population distributions of fasting plasma glucose are shifted to the right for men, urban populations, and older individuals.

Prevalence of diabetes and impaired fasting glucose
The estimated overall prevalence of diabetes in Thai adults aged ≥35 years was $9.6 \pm 0.7\%$ (known diabetes, $4.8 \pm 0.5\%$; newly diagnosed diabetes, $4.8 \pm 0.5\%$). An estimated additional $5.4 \pm 0.6\%$ had impaired fasting glucose levels (Table 2). The mean duration of disease in those with known diabetes was 6.4 ± 0.5 years, and the prevalence of type 1 diabetes was estimated to be $0.2 \pm 0.2\%$. Overall prevalence rates of diabetes did not significantly differ between sexes ($P = 0.6$) but were greater in urban compared with rural areas ($P = 0.01$) and were higher among older age-groups ($P = 0.01$). The proportion of diabetes that was diagnosed did not significantly differ between women and men (53 vs. 47%, $P = 0.4$) or between urban and rural areas (57 vs. 46%, $P = 0.1$), but was substantially greater for older people than younger people (63% for ≥55 years vs. 37% for ≤54 years, $P = 0.01$) (Table 2).

Based on the findings of the 2000 Thai population census (13), the number of Thai adults aged ≥35 years with diabetes was estimated to be 2.4 ± 0.2 million. This estimate comprises 1.1 ± 0.1 million men and 1.3 ± 0.2 million women, with 1.4 ± 0.2 million residing in rural areas and 1.0 ± 0.2 million in urban areas. The numbers of people with known diabetes, newly diagnosed diabetes, and impaired fasting glucose were estimated to be 1.2 ± 0.1, 1.2 ± 0.1, and 1.4 ± 0.1 million, respectively.

Association of diabetes and impaired fasting glucose with cardiovascular risk factors
In general, the levels of cardiovascular risk factors progressively worsened across the four population groups defined as "normal glucose tolerance," "impaired fasting glucose," "newly diagnosed diabetes," and "known diabetes" (Table 3). The principal exceptions were the proportion of individuals reporting current smoking or regular alcohol consumption (both of

Table 2—*Percent with diabetes and percent with impaired fasting glucose overall and by sex, area of residence, and age-group*

Parameters	Impaired fasting glucose	Newly diagnosed diabetes	Known diabetes	Total diabetes
Men	6.1 ± 0.8	5.0 ± 0.8	4.3 ± 0.6	9.3 ± 1.0
Women	4.8 ± 0.8	4.7 ± 0.5	5.3 ± 0.8	9.9 ± 0.9
Urban	7.6 ± 1.0	5.2 ± 0.5	6.9 ± 0.9	12.1 ± 1.0
Rural	4.4 ± 0.6	4.6 ± 0.7	3.8 ± 0.6	8.4 ± 0.9
35–44 years	4.2 ± 0.9	3.2 ± 0.6	1.6 ± 0.5	4.9 ± 0.7
45–54 years	7.3 ± 1.2	6.0 ± 1.1	3.8 ± 0.6	9.8 ± 1.2
55–64 years	5.4 ± 1.1	5.0 ± 0.9	9.0 ± 1.0	14.0 ± 1.6
≥65 years	5.4 ± 1.0	6.7 ± 1.3	10.4 ± 1.7	17.2 ± 1.1
Overall	5.4 ± 0.6	4.8 ± 0.5	4.8 ± 0.5	9.6 ± 0.7

Data are means ± SEM.

which trended in the opposite direction) and diastolic blood pressure levels, which were greatest in the group with impaired fasting glucose.

Treatment patterns in patients with diabetes

The majority of patients with known diabetes had been advised to modify their diet (85.1 ± 3.4%), exercise more (78.7 ± 4.0%), and lose weight (63.8 ± 4.4%). In addition, 81.9 ± 3.4% were using oral glucose-lowering drugs, although insulin was used by only 2.8 ± 1.0%. Other treatments such as Chinese medicines or herbs were used by 31.2 ± 4.1%. One-third (31.3 ± 4.3%) reported that a doctor had told them that diabetes had affected their eyes and 10.9 ± 2.5% that diabetes had affected their kidneys. Of individuals with diabetes and concurrent hypertension (previous diagnosis, systolic blood pressure ≥140 mmHg, or diastolic blood pressure ≥90 mmHg), 66.5 ± 4.5% were receiving prescribed blood pressure–lowering therapy.

CONCLUSIONS — The InterASIA study has clearly demonstrated that diabetes and impaired fasting glucose are common in Thai adults and that these conditions are associated with adverse levels of cardiovascular risk factors. The estimated prevalence of diabetes and impaired fasting glucose and the cross-sectional associations of these conditions with cardiovascular risk factors are analogous with those of industrialized Western populations such as the U.S. (14) and Australia (15). The rise to Western levels in the prevalence of diabetes and associated cardiovascular risk factors in Thailand (16–18) and other newly industrializing countries of the Asia-Pacific region (19,20) appears to be largely attributable to changes in sociodemographic factors (21), in particular the greater age of the population (5,13), the increased proportion living in an urban environment (22), and mounting levels of obesity (23). Because each of these is likely to rise still further, the burden of diabetes-related diseases in Thailand and the Asia-Pacific region will continue to increase for at least the next few decades (1).

The InterASIA study was designed to provide reliable nationwide estimates of adult cardiovascular risk factor levels and incorporated thorough staff training, monitoring, and standardization of practical procedures, including central assays of blood glucose levels. The large size of the study ensured that the overall estimates of risk factor levels were precise. Similarly, the rigorous sampling procedure, the good response rates, and the statistical weighting process should have minimized any biases due to nonparticipation or missing data. Economic and

Table 3—*Risk factor levels among individuals with normal glucose levels, impaired fasting glucose levels, newly diagnosed diabetes, and known diabetes*

Risk factor	Normal glucose tolerance	Impaired fasting glucose	Newly diagnosed diabetes	Known diabetes
Mean age (years)	49.9 ± 0.9	52.0 ± 1.0	54.0 ± 1.3	58.6 ± 1.3
Proportion male (%)	47.9	54.0	49.6	43.1
Mean BMI (kg/m^2)	23.8 ± 0.2	25.2 ± 0.5	25.4 ± 0.5	25.4 ± 0.4
Waist-to-hip ratio	0.87 ± 0.01	0.90 ± 0.01	0.91 ± 0.01	0.94 ± 0.01
Mean systolic blood pressure (mmHg)	118.4 ± 0.7	126.3 ± 1.5	126.6 ± 1.7	127.2 ± 1.8
Mean diastolic blood pressure (mmHg)	75.3 ± 0.5	80.3 ± 1.0	78.9 ± 1.0	76.0 ± 1.0
Mean total cholesterol (mg/dl)	197.9 ± 2.1	208.6 ± 4.2	213.9 ± 5.1	224.7 ± 4.7
Mean HDL cholesterol (mg/dl)	44.8 ± 0.7	44.6 ± 1.3	40.9 ± 0.8	41.7 ± 1.1
Mean serum creatinine (mg/dl)	0.92 ± 0.01	0.96 ± 0.02	0.96 ± 0.03	1.11 ± 0.06
Regular drinker of alcohol (%)	35.7	40.6	33.3	20.5
Current smoker (%)	25.7	25.9	22.5	12.1
Family history of diabetes (%)	18.0	18.5	24.8	38.4

Data are means ± SEM, unless otherwise indicated.

practical constraints did require the selection of "representative" rather than truly random EDs for sampling, and this could have resulted in the collection of data from a nonrepresentative sample of the population. Overall, however, it seems unlikely that the results are seriously biased, and the InterASIA findings are highly comparable with the findings of related projects conducted in Thailand and elsewhere (4).

InterASIA identified little difference in the rates of diabetes in men and women, but diabetes was observed to be more prevalent in urban compared with rural areas and among older people compared with younger people. Comparability in the prevalence of diabetes across sexes is typical (1), and greater prevalence of diabetes in urban compared with rural areas is also usual in countries of the Asia-Pacific region (22). Differences in the age and sex structure of the populations living in urban and rural areas did not appear to contribute substantially to the observed urban-rural variation (6), but the progressive rise in the prevalence of diabetes with age was consistent with previous studies (1,20,22). It is of note that the prevalence of glucose intolerance was high, although levels of obesity, defined according to the current World Health Organization guidelines, were relatively low.

Undiagnosed diabetes was common, was associated with worse levels of risk factors, and is an established determinant of cardiovascular disease (24). The provision of proven preventive therapies to such individuals would be likely to avert many premature cardiovascular events (24,25). InterASIA clearly demonstrated that the Thai health system could routinely provide the majority of known diabetic individuals with behavioral advice, hypoglycemic therapy, and blood pressure–lowering therapy if there is concurrent high blood pressure. As such, increasing the proportion of diabetes that is diagnosed, perhaps through opportunistic screening of high-risk individuals, might be an appropriate and relatively low-cost means of addressing the growing diabetes-related disease burden in Thailand.

InterASIA Collaborative Group consisted of Dongfeng Gu, Xiufang Duan, Guangyong Huang, Xigui Wu, Yuefeng Ma, Ling Yu, Yingnai Chen, Ligui Wang, CaiLiang Yao, Lihua Xu, Ping Wang, Fuqiang Chen, Jianjing Mo, Xianping Wu (from China); Paibul Suriyawongpaisal, Sayan Cheepudomwit, Porntip Loelekla, Piyamitr Srithara, Poolsook Sariyaporn, Pairao Pongchoke, Somboon Jaiyavat, Charermsri Nantawan, Vachira Kasikoson, Somsak Thamthitiwat, Penprapa Siviroj, Jiraporn Suwanteerangkul, Pyatat Tasanavivat, Pattapong Kessomboon, Sujinan Horas, Virasakdi Chongsuvivatwong, Tada Yipintsoi, Nualta Apakupakul, Walla Jirathamopas, Woravut Jintapakorn, Vongsvat Kosulwat, Atitada Boonpraderm, Amornrat Wongchanapai, Chayanist Wanijjakul (Thailand); Jiang He, Paul Whelton, Lydia Bazzano, Jing Chen, Paul Muntner, Kristi Reynolds, Xue Xin (U.S.); Neil Chapman, Sam Colman, Stephen MacMahon, Bruce Neal, Ronald Stolk, and Mark Woodward (Australia). The Steering Committee consisted of Jiang He, Paul Whelton, Dale Glasser, Dongfeng Gu, Stephen MacMahon, Bruce Neal, Rajiv Patni, Robert Reynolds, Paibul Suriyawongpaisal, Xigui Wu, Xue Xin, and Xin-Hua Zhang.

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