Incidence and Predictors of Type 2 Diabetes among Professional and Office Workers in Bangkok, Thailand

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Objectives: *To determine the incidence rates of type 2 diabetes and associated factors among professional and office workers in Bangkok.*
Material and Method: *Data on fasting glucose measurements and physical examination were obtained from a cohort of 6,924 workers in 43 establishments in Bangkok during 1999-2003. Impaired fasting glucose and diabetes were defined according to the American Diabetes Association criteria. The type 2 diabetes incidence rates were calculated based on the person-time of follow-up period.*
Results: *A total of 136 individuals developed type 2 diabetes during 11,581 person-years (py) of follow-up. The incidence rates of type 2 diabetes in individuals aged 35-60 years was 11.4 per 1000 py Men had a higher incidence rate than women (17.8 vs 9.2 per 1,000 py). The incidence rates increased with age. Factors associated with development of diabetes included baseline fasting plasma glucose (FPG) level, overweight and obesity status. Adjusted incidence rate ratios (IRR, 95%CI) for FPG of 93-99 mg/dl and 100-125 mg/dl were 3.2 [1.1-9.9] and 31.5 [11.4-86.8] respectively, compared to those with FPG < 93 mg/dl. The IRRs for those with BMI of 23-27.5 and > 27.5 kg/m^2 were 1.5 [0.9-2.5] and 2.7 [1.6-4.5] respectively, compared to those with BMI < 23 kg/m^2.*
Conclusion: *Findings from the present study could serve as the first marking post for estimating the risk and magnitude of type 2 diabetes in other adult populations in Thailand.*

Keywords: *Type 2 diabetes, Incidence rate, Risk factor*

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Type 2 diabetes presents an important public health burden worldwide including Thailand(1,2). It causes both social, economic, and health consequences to the nation. Disability-adjusted life years lost (DALYs) due to diabetes ranked the 3rd and the 5th for Thai women and men adult populations respectively(3). Due to population growth, aging, urbanization, and increasing prevalence of obesity and physical inactivity, the diabetes epidemic will be worse in the future(1). It was estimated that the number of people with diabetes in adults aged 20 years and over in Thailand will increase from 1,017,000 in 2000 to 1,923,000 in 2025(2).

The type 2 diabetes prevalence increases progressively in advancing age, particularly during the working age group (especially after 35 years old). Those who develop diabetes at an earlier age have a higher risk of all-cause mortality than those who have the disease at an older age(1). Early interventions to curtail the disease development and its complication among this population subgroup are then expected to have tremendous positive health and other impacts on the individual and the country as a whole.

To address this epidemic effectively, the disease epidemiologic information such as prevalence and incidence rates, and associated factors are essential for national public health planning and implementation. While a number of diabetes prevalence reports for Thailand are available, the incidence data are, however, scarce(4-7).

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The present article reports the type 2 diabetes incidence rate and its predictors among professional and office workers in Bangkok. This is first study to report the incidence of type 2 diabetes in Thai adult populations[4-7].

Material and Method

Study Population

The Chulalongkorn Memorial Hospital has provided an on-site annual health examinations for professional and office workers of approximately 43 governmental agencies and private companies in Bangkok and nearby provinces since 1999. These establishments include 17 government organizations, 15 educational institutions, 7 private companies, 2 non-governmental organizations, 1 public company, and 1 international organization. In each annual survey, blood samples were obtained from the participants who were aged 35 years and over for measurement of fasting plasma glucose(FPG) levels. Information on age, weight and height were also collected. Workers aged 35-60 yrs who participated in the annual health examination at least twice during the years 1999-2003 with measurement of fasting plasma glucose (FPG) were included in the present study. Body weight and height were measured from each participant.

Definitions

Type 2 diabetes was defined according to the American Diabetes Association (ADA) criteria as FPG level was > 126 mg/dl (7.0 mmol/l). Impaired fasting glucose (IFG) or pre-diabetes was defined as those with FPG levels > 100 mg/dl (5.6 mmol/l) but < 126 mg/dl (7.0 mmol/l)[8].

Body mass index (BMI) was calculated as (weight in kg)/(height in meters)^2. Physical status of individuals was classified based on the BMI as: underweight for BMI < 18.5 kg/m^2; normal for BMI 18.5-22.9 kg/m^2; overweight for BMI 23.0-27.5 kg/m^2, and; obesity for BMI > 27.5 kg/m^2[9].

Statistical Analysis

Individuals with diabetes at baseline defined according to the ADA criteria were excluded. The remaining participants were then followed until having type 2 diabetes diagnosis (based on FPG results) or until the latest year of available FPG results for those without DM. Workers with incomplete or missing data on age or gender were excluded.

Due to an unequal follow-up period for each individual, the diabetes incidence rates (IRs), as well as their corresponding 95% confidence intervals (CIs) were calculated as number of incident diabetes cases divided by person-years of follow-up and reported as rate per 1,000 person-years (py). Person-time for each individual was the period of time between the first survey year until the year of first diagnosis of diabetes or until the last survey year for those without diabetes diagnosis. Specific diabetes incidence rates were calculated for gender, age group (5-year age ranges), physical status (underweight, normal, overweight and obesity), and FPG levels (for IFG or for each quartiles for those without IFG).

To examine the possible interaction among these predictors in determining the risk of diabetes, age-gender-specific incidence rate of diabetes were calculated and stratified by BMI categories and baseline FPG status. The predictor variables were recategorized in order to increase sample sizes in each category as follows: BMI was reclassified into 2 groups, those with BMI< 23 and BMI $\geq$ 27.5 group; FPG was reclassified as those with normal FPG (< 100 mg/dl) and those with IFG (FPG: 100-125 mg/dl); and age were divided into 2 groups as 35-44 yr and 45-59 yr.

Crude and adjusted incidence rate ratios (IRRs) with 95% confidence interval (CI) were then estimated using Poisson regression analyses[10,11]. In the multivariable analyses, backward selection procedure was used in the statistical modeling. Variables with p-value < 0.2 were eligible for addition into the modeling procedures[12]. P-value of < 0.05 was the cut-off for the statistically significant level. All the statistical analysis was performed using Stata version 8.0[13].

Results

Subject Characteristics

There were 7,232 workers aged 35- 59 yrs who participated in the annual health examination at least twice from 1999 to 2003. A total of 308 (4.3 percent) had diabetes at baseline examination and were then excluded. A total number of 6,924 workers without diabetes were included in the beginning of the study: 4,765 (68.8 percent) were women and 2,159 (31.2 percent) were men (Table 1). Most of them were 35-49 years old at baseline survey, with an average follow-up time of 1.67 years. Thirty two percent of participants were of BMI > 23 kg/m^2. The proportion of men with BMI > 23 was higher than that of women (64.33 versus 48.08 percents). The FPG levels were generally higher in men. The overall prevalence of IFG was 13.86 percent. The prevalence in men was twice as high as that in women (20.57 versus 10.83 percent respectively).

Table 1. Subjects characteristics at the start of follow-up

Characteristics		Female number	(%)	Male number	(%)	Total number	(%)
Gender		4,765	(68.82)	2,159	(31.18)	6,924	(100)
Age-group at start (years)							
30-34		59	(1.24)	27	(1.25)	86	(1.24)
35-39		1,154	(24.22)	536	(24.83)	1,690	(24.41)
40-44		1,297	(27.22)	511	(23.67)	1,808	(26.11)
45-49		1,123	(23.57)	488	(22.60)	1,611	(23.27)
50-54		797	(16.73)	385	(17.83)	1,182	(17.07)
55-59		335	(7.03)	212	(9.82)	547	(7.90)
Total		4,765	(100)	2,159	(100)	6,924	(100)
Physical status(Body mass index; BMI in kg/m^2)*							
Underweight	($\leq$ 18.4)	214	(4.91)	56	(2.91)	270	(4.30)
Normal	(18.5-22.9)	2,050	(47.01)	630	(32.76)	2,680	(42.65)
Overweight	(23.0-27.4)	1,547	(35.47)	932	(48.47)	2,479	(39.45)
Obese	($\geq$ 27.5)	550	(12.61)	305	(15.86)	855	(13.61)
Total		4,361	(100)	1,923	(100)	6,284	(100)
Follow-up time(years)							
Mean (SD)		1.68	(0.75)	1.66	(0.76)	1.67	(0.75)
Median (range)		2	(1-4)	1	(1-4)	2	(1-4)
Fasting plasma glucose (FPG) level							
Quartile 1	(< 83 mg/dl)	1,373	(28.81)	371	(17.18)	1,744	(25.19)
Quartile 2	(84-87 mg/dl)	974	(20.44)	321	(14.87)	1,295	(18.70)
Quartile 3	(88-92 mg/dl)	898	(18.76)	389	(18.02)	1,283	(18.53)
Quartile 4	(93-99 mg/dl)	1,008	(21.15)	634	(29.37)	1,642	(23.71)
IFG	(100-125 mg/dl)	516	(10.83)	444	(20.57)	960	(13.86)
Total		4,765	(100)	2,159	(100)	6,924	(100)

* exclude subjects with missing data

Type 2 diabetes incidence

During a total follow-up time of 11,581 person-years, 136 individuals developed diabetes. This accounted for the average type 2 diabetes incidence rate of 11.4 per 1000 py. Specific incidence rates by gender, age group, physical status and baseline FPG level are presented in Table 2. The incidence rate of type 2 diabetes for men was almost twice of that for women. The incidence rate of diabetes increased in the older age-groups and in the higher BMI groups. Diabetes incidence also increased as the FPG levels increased.

Stratified Analysis

Table 3 shows that all age-specific diabetes incidence rates were higher in men than in women, with the range of 11.0-28.9 and 4.9-20.2 per 1,000 person-years respectively. The average incidence rate in men was almost 2 times higher than in women.

The age and gender-specific diabetes incidence rates among those with normal weight and overweight as well for those with normal FPG and high FPG (100-125 mg/dl) are presented in Fig. 1. The effect of baseline FPG on diabetes risk was the most obvious, particularly in the overweight group. Those who were overweight, aged $\geq$ 45 yrs and having high blood glucose were at highest risk (Fig. 1(d)). Increased age and BMI also related to higher diabetes incidence rates, although to a much lesser extent. The incidence rates in men and women were not statistically significantly different.

Factors associated with diabetes incidence

The univariable and multivariable analytical results are shown in Table 4. The univariable results showed that the diabetes risk for men was almost twice that for women. The risk of diabetes increased in the

Table 2. Incidence rates (IRs, per 1,000 person-years) of type 2 diabetes among workers with different characteristics

Characteristics		(cases/person-years)	Incidence rate (IR) per 1,000 person-years (95%CI)
Gender			
Female		(73/7,926)	9.2 (7.2-11.6)
Male		(63/3,539)	17.8 (13.7-22.8)
Age-group (years)			
35-39		(18/2,644)	6.8 (4.0-10.8)
40-44		(25/3,066)	8.2 (5.3-12.0)
45-49		(33/2,736)	12.1 (8.3-16.9)
50-54		(37/2,026)	18.3 (12.9-25.2)
55-59		(23/973)	23.6 (15.0-35.5)
Physical status (Body mass index; BMI in kg/m^2)			
Underweight	(≤ 18.4)	(0/450)	0.0
Normal	(18.5-22.9)	(23/4,376)	5.3 (3.3-7.9)
Overweight	(23.0-27.4)	(47/3,965)	11.9 (8.7-15.8)
Obese	(≥ 27.5)	(43/1,345)	32.0 (23.1-43.1)
Fasting plasma glucose (FPG) level			
Quartile 1	(< 83 mg/dl)	(7/2,952)	2.4 (1.0-4.9)
Quartile 2	(84-87 mg/dl)	(10/2,146)	4.7 (2.2-8.6)
Quartile 3	(88-92 mg/dl)	(6/2,098)	2.9 (1.1-6.2)
Quartile 4	(93-99 mg/dl)	(17/2,726)	6.2 (3.6-10.0)
IFG	(100-125 mg/dl)	(96/1,543)	62.2 (50.4-76.0)

Table 3. Observed DM incidence rates (IRs, per 1,000 person-years) among the study subjects, stratified by age and gender

Age	Female				Male			
(years)	# cases	# person-years	IR	95%CI	# cases	# person-years	IR	95%CI
35-39	9	1,849	4.9	(2.2-9.2)	9	815	11.0	(5.1-21.0)
40-44	8	2,204	3.6	(1.6-7.2)	17	862	19.7	(11.5-31.6)
45-49	23	1,900	12.1	(7.7-18.2)	10	836	12.0	(5.7-22.0)
50-54	21	1,380	15.2	(9.4-23.3)	16	646	24.8	(14.2-40.2)
55-59	12	593	20.2	(10.5-35.3)	11	380	28.9	(14.5-51.8)
	Crude IR		9.2	(7.2-11.6)			17.8	(13.7-22.8)

older age-groups and in the higher BMI groups. The rate of increased diabetes risk was 6 percent per one year of increasing age. Diabetes risk also increased as the FPG levels increased. Those who were classified as IFG had 26 times of diabetes risk compared to those in the lowest quartile of FPG levels (< 83 mg/dl). Even among those with normal FPG, diabetes risk for those in the highest quartile (FPG range of 93-99 mg/dl) was 2.6 times higher compared to those in the lowest quartile (FPG < 83 mg/dl).

In the multivariable analytical results, however, only baseline BMI and FPG status were significant and retained in the final model. Compared to the crude analytical results, the adjusted IRRs for physical status for overweight and obese were weaker (1.8 [1.2-2.8] and 2.3 [1.3-4.2]) respectively, compared to the crude IRRs of 2.3 [1.3-3.9] and 6.1 [3.6-10.6] respectively for both categories). However, The dose-response pattern remained. For FPG, the adjusted IRRs for IFG and the fourth quartile compared to the lowest quartile were stronger, particularly for the IFG group. The IRRs increased from 2.6 [1.0-7.5] to 3.2 [1.1-9.9] for the fourth quartile group and from 26.2 [12.3-67.0] to 31.5 [11.4-86.8] for the IFG group.

Discussion

The results of the present longitudinal study among office and professional workers in Bangkok from 1999 to 2003 are that: 1) the incidence rates of type 2 diabetes in individuals aged 35-60 years were 3.6-20.2 per 1,000 py (9.2 per 1,000 py overall) and 11.0-28.9 per 1,000 py (17.8 per 1,000 py overall), respectively, for female and male workers, and; 2) Impaired fasting glucose (IFG) and overweight/obesity independently predicted incident diabetes. Those who were aged ≥ 45 yr, overweight and having high FPG were at highest

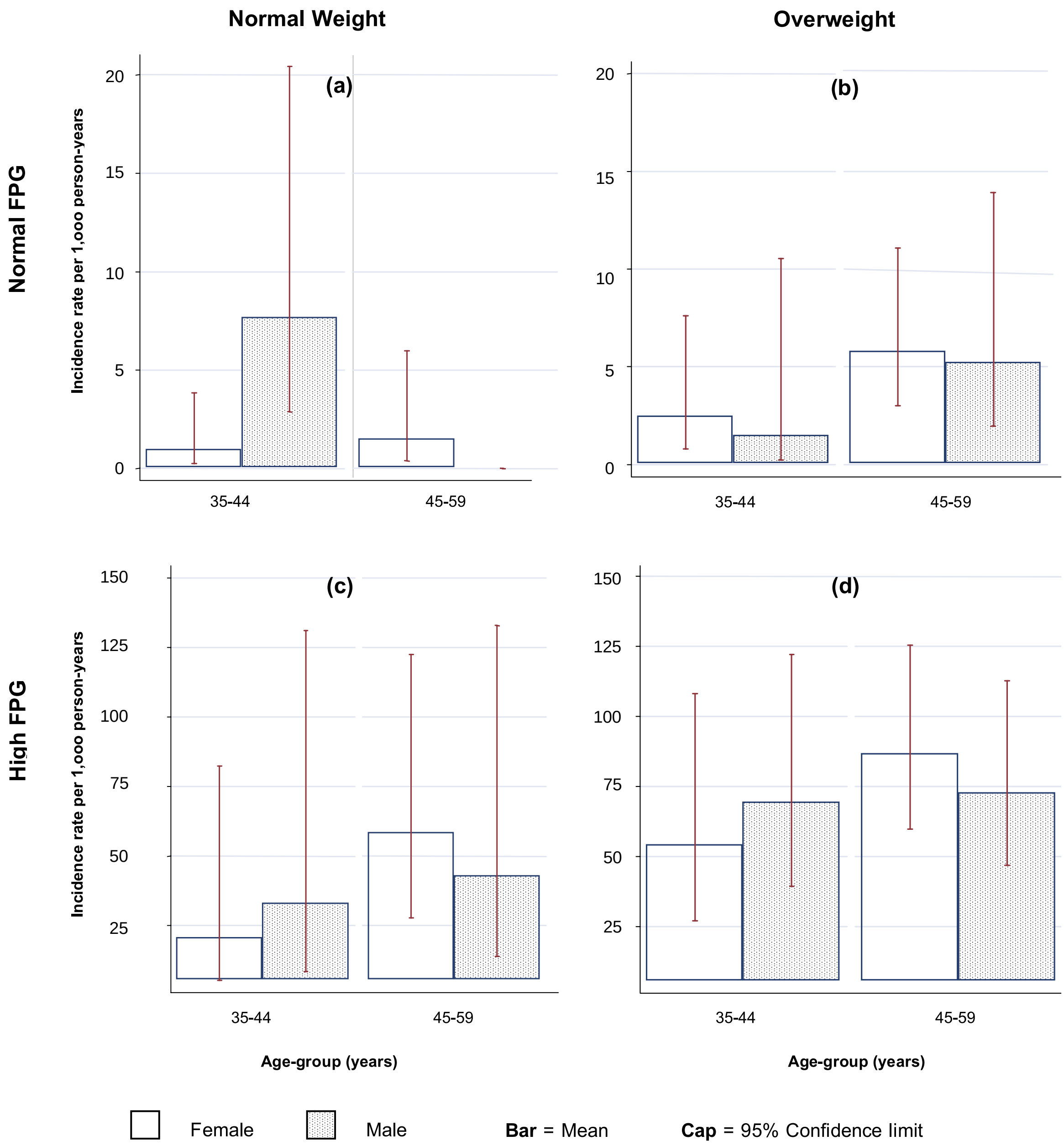

Fig. 1 DM type 2 incidence rate (per 1,000 person-years) stratified by age-group, gender, physical status, and fasting plasma glucose (FPG) level

risk. The risk of developing diabetes was found at FPG level as low as 93 mg/dl compared to those with FPG < 83 mg/dl.

As the study subjects in the present study were middle- and upper-class workers in the metropolitan area, the results may better reflect the epidemiologic picture of diabetes for a subgroup of Thai adults with high risk rather than that of the general population. People in urban areas, with a modern lifestyle (more calories and fat intake, and less physical activity), are at increased diabetes risk than those in rural area[4,14]. To the authors' knowledge, the present study is the first prospective study to demonstrate type 2 diabetes incidence in Thailand.

Comparison with studies in other countries, the presented incidence rates of 15.3 per 1,000 person-years for Thai (combined female and male) adults are higher than those for the known low-risk populations such as Western populations (non-Hispanic white Americans 2.5 per 1,000 py; Swedish 4.6/1,000 py; Dutch 2.3 per 1,000 over 3 years; Italians 7.6 per 1,000 py; Frenchmen 4.2/1,000 p.y.)[15-19], Chinese (Taiwanese 10.2 per 1,000 py; mainland Chinese 1.2-1.3 per 1,000 py)[20,21], and rural Samoans (5.7/1,000 py)[22]. The presented incidence rates were also higher than the other high-risk populations (South African Indians 9.5/1,000 py; and Mexican Americans 8.1/1,000 py)[15,23]. When compared with high-risk populations, the presented incidence rates were lower than those for Pima Indians (30.5/1,000 py)[24,25]. In relation to the high-risk Pacific Islanders, the presented incidence rates were lower than Wanigelas (24/1,000 py) and Nauruans (22.5/1,000 py); comparable with urban Samoans (16.6/1,000 py) and Indians (15.8/1,000 py); and higher than Creoles (12.2/1,000 py) and Chinese (10.4/1,000 py)[22]. However, the difference in age structure, duration, diagnostic criteria for diabetes, and research design among different studies might account for the variation.

The present findings about the DM predictors were consistent with previous studies, although only a few such studies of comparable details are available[18,20]. Both baseline FPG level and BMI found to be associated with future DM risks. The presented magnitudes of increase DM risk for higher baseline

Table 4. Crude and adjusted incidence rate ratios (IRRs) for type 2 diabetes

Characteristics		Crude IRRs		Adjusted IRRs	
		IRR	(95%CI)	IRR	(95%CI)
gender					
Female		1.0			
Male		1.9	(1.4-2.8)***		
Age-group (years)					
35-39		1.0			
40-44		1.2	(0.6-2.3)		
45-49		1.3	(0.7-2.4)		
50-54		2.7	(1.5-5.0)***		
55-59		3.5	(1.8-6.8)***		
Per one year increase		1.06	(1.04-1.09)****		
Physical status (Body mass index; BMI)					
Normal	(> 22.9 kg/m^2)	1.0		1.0	
Overweight	(23.0-27.4 kg/m^2)	2.3	(1.3-3.9)****	1.5	(0.9-2.5)
Obese	($\geq$ 27.5 kg/m^2)	6.1	(3.6-10.6)****	2.7	(1.6-4.5)***
Fasting plasma glucose (FPG) level					
Quartile 1	(<83 mg/dl)	1.0		1.0	
Quartile 2	(84-87 mg/dl)	2.0	(0.7-6.1)	2.6	(0.8-8.7)
Quartile 3	(88-92 mg/dl)	1.2	(0.3-4.2)	1.0	(0.2-4.1)
Quartile 4	(93-99 mg/dl)	2.6	(1.0-7.5)*	3.2	(1.1-9.9)*
IFG	(100-125 mg/dl)	26.2	(12.3-67.0)****	31.5	(11.4-86.8)****

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.005$, **** $p < 0.001$

All predictors (age, gender, physical status, and baseline FPG) were put into the selection procedure

FPG (adjusted IRR for baseline IFG of 31.5 [11.4-86.8] (Table 4), was, however, much larger than those reported by Bonora et al's study in Brueneck, Italy (adjusted odds ratios of 20.5 [7.6-55.3] and 11.0 [5.6-21.9], respectively for those with baseline IFG with and without impaired glucose tolerance (OGTT))[18]. The authors also found that, among persons with normal fasting glucose, those in the high FPG group (FPG 93-99 mg/dl) had higher future diabetes risk when compared to those with the lowest FPG group (adjusted IRR [95%CI] = 3.2 [1.1-9.9]).

Age and gender were found to be associated with increased diabetes risk in the univariable but not in multivariable analyses (Tables 2 and 4 respectively). This finding was also consistent with Bonora et al's study[18]. Further analyses showed that the increased diabetes risk among men and older workers might be due to their higher baseline FPG level and IFG prevalence rates (IFG prevalence rates for men and women were; 20.57 and 10.83 percent respectively (Table 1), and; 8.45, 11.82, 14.70, 19.17 and 21.27 percent, respectively, for 35-39, 40-44, 45-49, 50-54, and 55-59 age-groups, data not shown).

Although the present study was a prospective design with a large sample size, some limitations, however, need to be mentioned. The presented diabetes diagnosis was based solely on FPG level may underestimate the diabetes incidence rate when compared to that based on oral glucose tolerance test (OGTT)[20]. However, the latter approach was not practicable for field study. Information about self-report diabetes was not available in the present study. This might have resulted in a certain degree of misclassification on baseline FPG status. Some workers with high normal FPG levels could actually be well-controlled diabetes patients who were misclassified as non-diabetes subjects. The presented high IRR of diabetes among those with baseline IFG and high normal FPG(as mentioned previously) might attribute to this misclassification. Volunteer bias may also interfere in the present study. Workers who participate consistently in the annual examinations may be either those at high diabetes risk or those who are the "worry well". So, the direction of this bias is difficult to predict. However, these limitations might results in an under-estimate of the incidence rate rather than on the association with risk factors.

In conclusion, the present study provides the incidence rates of type 2 diabetes among a working population in an urban area. This information could serve as the first marking post for estimating the risk and magnitude of type 2 DM in other adult populations in Thailand. However, its validity still needs to be verified by a well-planned prospective cohort study with sufficiently large sample size.

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อัตราอุบัติการณ์และปัจจัยเสี่ยงของโรคเบาหวานชนิดที่ 2 ในนักวิชาชีพและพนักงานสำนักงานเขตกรุงเทพมหานคร

วิโรจน์ เจียมจรัสรังษี, วิชัย เอกพลากร

วัตถุประสงค์: *ศึกษาอัตราอุบัติการณ์และปัจจัยเสี่ยงของโรคเบาหวานชนิดที่ 2 ในนักวิชาชีพและพนักงานสำนักงานเขตกรุงเทพมหานคร*

วัสดุและวิธีการ: *กลุ่มตัวอย่างประกอบด้วยพนักงานจำนวน 6,924 รายในหน่วยงาน 43 แห่งในเขตกรุงเทพมหานครที่มีผลการตรวจระดับน้ำตาลในเลือดประจำปีอย่างน้อย 2 ปีในฐานข้อมูล ทำการศึกษาติดตามระหว่างปี พ.ศ. 2542 ถึง พ.ศ. 2546 ข้อมูลในการศึกษาประกอบด้วย อายุ เพศ ส่วนสูง น้ำหนัก และผลการตรวจวัดระดับน้ำตาลในเลือด การวินิจฉัยโรคเบาหวานและภาวะน้ำตาลในเลือดบกพร่องอ้างอิงตามเกณฑ์ของ The American Diabetes Association (ADA) คำนวณอัตราอุบัติการณ์ของโรคเบาหวานโดยใช้วิธี person-time analysis*

ผลการศึกษา: *พบว่ามีพนักงานทั้งสิ้น 136 รายเป็นโรคเบาหวานในช่วงการศึกษาติดตามจำนวน 11,581 คน-ปี อัตราอุบัติการณ์ของโรคเบาหวานชนิดที่ 2 สำหรับช่วงอายุ 35-60 ปีเท่ากับ 11.4 รายต่อ 1,000 คน-ปี โดยเพศชายมีอัตราอุบัติการณ์ของโรคสูงกว่าเพศหญิง (17.8 ราย และ 9.2 รายต่อ 1,000 คน-ปี ตามลำดับ) อัตราอุบัติการณ์ของโรคสูงขึ้นตามอายุ พบว่าระดับน้ำตาลในเลือดพื้นฐานและภาวะน้ำหนักตัวเกิน/อ้วนเป็นปัจจัยเสี่ยงที่สำคัญของโรคเบาหวานชนิดที่ 2 โดยอัตราเสี่ยงที่ควบคุมตัวกวนแล้ว [ค่าความเชื่อมั่นที่ระดับร้อยละ 95] สำหรับกลุ่มที่มีระดับน้ำตาลในเลือดพื้นฐาน 93-99 มิลลิกรัม ต่อ เดซิลิตรและในกลุ่มที่มีภาวะน้ำตาลในเลือดบกพร่องเท่ากับ 3.2 [1.1-9.9] และ 31.5[11.4-86.8] ตามลำดับ และอัตราเสี่ยงที่ควบคุมตัวกวนแล้ว [ค่าความเชื่อมั่นที่ระดับร้อยละ 95] สำหรับกลุ่มที่มีภาวะน้ำหนักตัวเกินและภาวะอ้วนเท่ากับ 1.5 [0.9-2.5] และ 2.7 [1.6-4.5] ตามลำดับ*

สรุป: *ผลการศึกษานี้สามารถใช้เป็นข้อมูลเบื้องต้นสำหรับการประมาณการอัตราอุบัติการณ์และความเสี่ยงต่อโรคเบาหวานชนิดที่ 2 ในประชากรวัยผู้ใหญ่กลุ่มอื่น ๆ ในประเทศไทยต่อไป*