

PREVALENCE AND RISK FACTORS OF METABOLIC SYNDROME AMONG ADULTS IN A NORTHEASTERN PROVINCE OF THAILAND

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Abstract

This cross-sectional study aimed to determine the prevalence of metabolic syndrome (MetS), and its associated risk factors among adults aged ≥ 35 years in a northeastern province of Thailand. The study was conducted with 829 adults recruited from rural and urban areas of Amnat Charoen Province, Thailand. MetS was defined according to “revised ATP III criteria”. Data were collected by face-to-face interview, anthropometric assessment and blood examination. About 27.5% of the participants had MetS. Twenty-four new cases with high TG were detected. Among MetS components, abdominal obesity had the highest prevalence (61.1%), followed by high triglycerides (45.6%) and low high-density lipoprotein cholesterol (36.1%). All participants had health insurance. Logistic regression analyses revealed that the significant predictors of MetS were: being older (odds ratio [OR], 1.03; 95% confidence interval [CI], 1.01 to 1.05), being female (OR, 1.50; 95%CI, 1.04 to 2.24), having a family history of hypertension (OR, 2.07; 95%CI, 1.41 to 3.04), and having a high BMI (OR, 2.03; 95%CI, 1.73 to 2.04). In conclusion, the prevalence of MetS among the participants was moderately high. Health personnel should conduct periodic surveys to monitor for MetS and arrange tailored lifestyle modification interventions to improve intake of healthy and high-quality food, and increase physical activity. These interventions should be an integral part of the clinical management of MetS.

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Introduction

Metabolic syndrome (MetS) and related diseases are the leading cause of preventable mortality in Thailand and the world (Aekplakorn *et al.*, 2011a, 2011b; IHME, 2017; Mendrick *et al.*, 2018). MetS is a group of interrelated risk factors that increases the risk of several chronic diseases. MetS requires the presence of three out of the following five components: abdominal obesity, high triglycerides (TG), low high-density lipoprotein cholesterol (HDL-C), high blood pressure (BP) and high fasting plasma glucose (FPG) (Alberti *et al.*, 2009). Patients with MetS are five times more likely to develop type 2 diabetes (Siewert *et al.*, 2007; Mendrick *et al.*, 2018); three times more likely to have cardiovascular complications and two times more likely to die from cardiovascular diseases (CVD) compared to people without MetS (Isomaa *et al.*, 2001; Eckel *et al.*, 2010; Mendrick *et al.*, 2018). Furthermore, MetS was found to be associated with the occurrence of pancreatic, liver, breast and colon cancer (O'Neill *et al.*, 2015; Mendrick *et al.*, 2018).

There have been a number of slightly different diagnostic criteria for MetS including those used by the World Health Organization (Alberti and Zimmet, 1998), the revised National Cholesterol Education Program Adult Treatment Panel III, ATP III (NCEP, 2002), the modified International Diabetes Federation, IDF (Alberti *et al.*, 2005) and the latest proposed “revised ATP III criteria” (Alberti *et al.*, 2009).

In Asia-Pacific countries, the estimated prevalence of MetS in adults ranges from 11.9% to 49.0% (Zuo *et al.*, 2009; Lim *et al.*, 2013; Yu *et al.*, 2014; Xiao *et al.*, 2016; Ranasinghe *et al.*, 2017b). The prevalence varies based on the MetS definition used, the age of study participants, and the year and the geographical area of the study. In Thailand, the InterASIA survey of CVD risks reported that the prevalence of MetS among adults aged ≥ 35 years was 32.6% (male 28.7% and female 36.4%) (Aekplakorn *et al.*, 2011a). Previous studies revealed that

socio-economic status (Zuo *et al.*, 2009; Yu *et al.*, 2014; Cheong *et al.*, 2015; Yang, 2017), physical activity (PA) (Xiao *et al.*, 2016), alcohol consumption (Aekplakorn *et al.*, 2011b) and smoking (Xiao *et al.*, 2016), BMI (Aekplakorn *et al.*, 2011b; Lim *et al.*, 2013), family history of hypertension (Ranasinghe *et al.*, 2015a), family history of diabetes (Moon *et al.*, 2017), sleep duration (Yu *et al.*, 2014) and health care access (Tyrovolas *et al.*, 2011) were associated with MetS.

Amnat Chareon is a northeastern Thai province in the Mekong valley bordering Laos. The main occupations of the people are jasmine rice farmers, and rubber plantation workers (Wikipedia, 2016). In 2016, about 24.0% of the population reported they were living in poverty and faced difficulty with resource allocation (Amnat Charoen Provincial Statistical Office, 2016a). MetS related diseases, such as CVD, diabetes and cancer, were the five leading causes of morbidity and mortality in the province (Amnat Charoen Provincial Statistical Office, 2016b).

In 2002, Thailand's universal coverage scheme (UCS or the ‘30-baht’ scheme) was launched nationwide to improve healthcare access and utilization of the population. Since launching, it has provided essential healthcare, with a small co-payment, for about 75% of the Thai population.

MetS can occur in children or adolescents (Aekplakorn *et al.*, 2011a; Macpherson *et al.*, 2016). However, this study focused on adults aged ≥ 35 years since they are the higher risk group (Zuo *et al.*, 2009; Aekplakorn *et al.*, 2011b). To our knowledge, there has been no community based survey regarding the prevalence and risk factors of MetS in this province that covers both in rural and urban areas. This study aimed to examine the prevalence of MetS and identify its associated risk factors to help fill this information gap.

Materials and Method

Study Sites and Participants

This community- based cross-sectional study was conducted in Amnat Charoen a low-income province in the northeastern region of Thailand, about 585 km away from the capital Bangkok. The total population is 162,945 people (Wikipedia, 2016). Urban areas were defined as the sub-districts in the city of Amnat Charoen. These had a good level of infrastructure. Rural areas were defined as sub-districts outside the city. These had a lower quality level of infrastructure and/or were isolated. In some rural areas it is difficult to access health facilities. Amnat Charoen Province has seven districts and 56 sub-districts. Five out of the 56 sub-districts were randomly selected as the study areas. Two sub-districts, Nonnamtang and Namohma, were randomly selected as the urban areas. Three sub-districts, Mhad, Raikhee and Phakor, were randomly selected as rural areas.

Sample size was estimated using the single proportion formula (Daniel and Cross, 2013). A sample size of 338 was determined based on the MetS prevalence of 32.6% in the InterASIA survey (Aekplakorn *et al.*, 2011a). Precision was set at 5% for the 95% confidence interval (95% CI). This sample size was multiplied by the design effect of two to detect the clustering effect, giving a sample size of 676 adults. To allow for an about 20% non-respondent rate, the final sample size was 812. The participants were selected using probability proportional to size (PPS) sampling to obtain participants that represent each sub-district and village. The five sub-districts have 31 villages and 20-43 households per village were randomly selected. One eligible participant in each household was chosen at random. All adults aged ≥ 35 years, able to communicate in Thai and willing to participate in the study were included. Exclusion criteria were professional athletes such as body builders, and football players; pregnant women and those unavailable for interview or physical examination during data collection period. In total, 829 participants were included in the data analysis.

Instruments

The research instruments consisted of a structured questionnaire and physical examination.

Baseline characteristics included sex, age, family history of hypertension, family history of diabetes, education, occupation, alcohol consumption, smoking status, physical activity, sleep duration, and use of antihypertensive, lipid-lowering and glucose-lowering drugs.

Alcohol consumption and smoking status In this study never drinker was defined as a participant who had never tried any kind of alcoholic beverages i.e. wine or hard liquor or <12 drinks in lifetime. Former drinker was defined as a participant who used to consume any kind of alcoholic beverages i.e. beer, wine, or hard liquor in at least 12 drinks but none during the past 12 months. Moderate drinker was defined as a participant who had consumed up to 1 drink per day for woman and up to 2 drinks for man (Rostron, 2012; National Institute on Alcohol Abuse and Alcoholism, 2017). Never smoke was defined as a participant who had never smoked, or who had smoked <100 cigarettes in his or her lifetime and did not currently smoke. Former smoker was defined as a participant who had smoked ≥ 100 cigarettes in his or her lifetime but who had quit smoking in the last 28 days. Current smoker was defined as a participant who had smoked ≥ 100 cigarettes in his or her lifetime and who had smoked in the last 28 days (Ministry of Health, Manatu Hauora, 2017).

Physical activity was measured using a physical activity index (PAI) (Kusnitz and Fine, 2016). The participants were asked about the frequency, duration and intensity of physical activity during the past week. PA frequency was scored as 0 = <1 time a week to 4 = 4 times a week, duration scored as 0 = <5 min to 5 = >60 min, and intensity scored as 0 = no change in pulse from resting level to 5 = sustained heavy breathing and sweating. The total PAI score was calculated from frequency $\times$ duration $\times$ intensity. A total score of <15 was classified as 'sedentary', 15-24 as 'low activity', 25-40 as 'moderate activity', 41-60 as 'active' and >60 as 'high activity'.

Perception of healthcare access was measured using the concept of access proposed by Penchansky and Thomas (1981). The concept was modified and the questionnaire asked the participants about their perception of healthcare access in the following areas: 1) whether they have any health insurance; 2) adequacy of medical supplies and equipment at their close health facility; 3) adequacy of health promotion programs by health facilities; 4) convenience of healthcare services; 5) affordability of any additional healthcare costs; and 6) satisfaction with the services provided by doctors, nurses, and other health personnel at their close health facilities.

MetS was defined according to the “revised ATP III criteria” which requires the presence of three out of following five components (Alberti *et al.*, 2009): 1) abdominal obesity (using the south Asian waist circumference (WC) cutoff points of ≥ 90 cm for men and ≥ 80 cm for women; 2) high TG (≥ 150 mg/dL) or on lipid-lowering drugs; 3) low HDL-C (< 40 mg/dL for men and < 50 mg/dL for women); 4) high BP (systolic blood pressure, SBP ≥ 130 mmHg or diastolic blood pressure, DBP ≥ 85 mmHg) or on antihypertensive drugs; 5) high FPG (≥ 100 mg/dL) or on glucose-lowering drugs.

Anthropometric, BP measurements and blood examination Weight and height were measured according to standard procedures. WC was measured around the navel twice by a tape measure in centimeters and the average value was calculated. BMI was derived from body weight in kilograms divided by body height in square meters. All participants were seated quietly for 15 min before BP measurement on the left arm using an Omron HEM 7310 digital sphygmomanometer (Omron Corporation, Kyoto, Japan). Cigarette smokers were asked to refrain from smoking for at least 30 min prior to BP measurement. BP was measured twice at a 1-2 min interval. A third BP reading was recorded if the two BP readings differed by more than 5 mmHg, then the three BP readings were averaged (Pickering *et al.*, 2005). Participants' blood samples were collected by trained registered nurses in the morning after 8-12 h fasting, 2.5 ml was used

for examining lipid panels and 2.5 ml for glucose level (WHO, 2010). TG was measured using an automated enzymatic method (Boonyapiphat and Noparat, 2018). HDL-C was measured using an automated direct method (Boonyapiphat and Noparat, 2018) and FPG was measured using the hexokinase method (Steffes, 2016). The blood samples were analyzed at the central laboratory of Ubon Ratchathani Regional Hospital.

Data Collection

Before collecting data, five registered nurses were trained in the standard protocols. Data were collected by the principal investigator and other five trained research assistants between October and December 2017. After written informed consent was gained, participants were interviewed using the structured questionnaire, the interview was followed by the anthropometric and BP measurements and then the blood sample examination.

Data Analysis

Data were analyzed using SPSS for Windows version 18.0. Descriptive statistics such as mean, standard deviation (SD) and percentage were used to describe all study variables. For inter-group comparison of study variables among participants, chi-square test was used for categorical data and Student's t-test was used for continuous data. The pattern of MetS component combination was calculated from abnormal MetS components, i.e., abdominal obesity, low HDL-C, high TG, high BP and high FPG. The pattern ranged from presence of zero to five MetS component combinations. Multiple logistic regression was used to examine the association between study factors and MetS. After testing for multicollinearity of the study variables, affordability of additional healthcare costs was not entered into the final regression model due to its collinearity with income. A p value of ≤ 0.05 was considered statistically significant.

Ethical Issues

The study's protocol was approved by the Ethics Committees of the Faculty of Public

Health, Mahidol University (COA. No. MUPH 2017-173; 2017 September 6) and Ethics Review Committees of Amnat Charoen Provincial

Hospital (No.05-2017, September 28, 2017). All collected data were kept confidential.

Table 1. Anthropometric, metabolic, socio-demographic, and lifestyle characteristics of 829 participants aged 35-85 years with and without metabolic syndrome (MetS)

Variable	Total n = 829	With MetS n = 228 (%)	Without MetS n = 601 (%)	p-value ¹
Sex				<0.001
Male	352	70 (30.7)	282 (46.9)	
Female	477	158 (69.3)	319 (53.1)	
Age, y	52.1±9.5	52.9±9.2	51.8±9.6	0.05
BMI, kg/m ²	24.8±4.1	27.2±4.4	23.9±3.6	<0.001
Waist circumference, cm	84.9±10.7	91.5±9.8	82.4±9.9	<0.001
Triglycerides, mg/dL	176.3±129.7	266.7±166.0	142.0±92.3	<0.001
HDL-C, mg/dL	50.0±13.6	41.3±9.6	53.4±13.4	<0.001
Systolic blood pressure, mmHg	121.9±13.9	128.2±15.1	119.5±12.7	<0.001
Diastolic blood pressure, mmHg	76.3±10.0	80.2±10.4	74.9±9.4	0.002
Fasting plasma glucose, mg/dL	88.6±22.1	100.8±31.2)	84.0±12.9	<0.001
Family history of hypertension				<0.001
No	619	146 (64.0)	473 (78.7)	
Yes	210	82 (36.0)	128 (21.3)	
Family history of diabetes				0.046
No	553	140 (61.4)	413 (68.7)	
Yes	276	88 (38.6)	188 (31.3)	
Education level				0.02
≤Primary school	558	167 (73.2)	391 (65.0)	
Secondary school	229	56 (24.6)	173 (28.8)	
≥Diploma, degree	42	5 (2.2)	37 (6.2)	
Occupation				0.08
Government service or small business	67	21 (9.2)	46 (7.7)	
Agricultural or daily worker	700	183 (80.3)	517 (86.0)	
Unemployed	62	24 (10.5)	38 (6.3)	
Smoking status				0.001
Never or former smoker	729	215 (94.3)	514 (85.5)	
Current smoker	100	13 (5.7)	87 (14.5)	
Alcohol consumption				0.03
Never drink	462	144 (63.2)	318 (52.9)	
Mild drinker	266	60 (26.3)	206 (34.3)	
Moderate/ heavy drinker	101	24 (10.5)	77 (12.8)	
Physical activity				0.014
Moderate (≥25 points)	95	21 (9.2)	74 (12.3)	
Low (15-24 points)	118	45 (19.7)	73 (12.2)	
Sedentary (<15 points)	616	162 (71.1)	454 (75.5)	
Sleep duration				0.69
>7 h	280	78 (34.2)	202 (33.6)	
5-7 h	493	132 (57.9)	361 (60.1)	
<5 h	56	18 (7.9)	38 (6.3)	

Data are presented as number (%) or mean ± SD

BMI = body mass index; HDL-C = high-density lipoprotein cholesterol

¹ p-value by chi-square or student's t-test

Results

Baseline Characteristics

Table 1 describes the anthropometric, metabolic, socio-demographic, and lifestyle characteristics of 829 participants with and without MetS. In total, 228 participants had MetS. The proportion of females with MetS was significantly higher than the proportion of females without MetS (69.3% vs 53.1%). The mean age of the participants was 52±9.5 years. The participants with a family history of hypertension, with a family history of diabetes, with a lower education level, being a current smoker, drinking any level of alcohol, and with moderate level of physical activity, were significantly associated with MetS ($p < 0.05$).

Table 2 shows that health insurance schemes and the participants' perception of

healthcare access were not statistically associated with MetS ($p < 0.05$) except for affordability of additional healthcare costs. All participants used at least one type of health insurance scheme when they got sick. About 92.2% (764/829) used the universal coverage or '30-baht' scheme. 41.0% (340/829) perceived that the health facilities they used had adequate medical supplies and equipment to provide health services. 17.9% (148/829) perceived that the health facilities provided adequate health promotion programs. 76.0% (630/829) reported they felt the health services were always convenient. 43.8% (363/829), and 53.8% (446/829) reported they had high or moderate satisfaction, respectively, with services of doctors, nurses or other health personnel. However, 43.3% (359/829) reported they were unaffordable to pay additional healthcare costs when they were needed.

Table 2. Perception of healthcare access of 829 participants aged 35-85 years with and without metabolic syndrome (MetS)

Variable	Total	With MetS	Without MetS	p-value ¹
Health insurance schemes				0.104
Universal coverage scheme (UCS) ²	764	207 (27.1)	557 (72.9)	
Social security scheme (SSS)	26	5 (19.2)	21 (80.8)	
Civil servant medical benefit scheme (CSMBS)	39	16 (41.0)	23 (59.0)	
Adequacy of medical supplies and equipment				0.097
Adequate	340	83 (24.4)	257 (75.6)	
Not adequate	489	145 (29.7)	344 (70.3)	
Adequacy of health promotion programs				0.383
Adequate	148	45 (30.4)	103 (69.6)	
Not adequate	681	183 (26.9)	498 (73.1)	
Convenience of health services				0.664
Not convenient	13	5 (38.5)	8 (61.5)	
Sometimes convenient	186	50 (26.9)	136 (73.1)	
Always convenient	630	173 (27.5)	457 (72.5)	
Affordability of additional healthcare costs				0.005
Not affordable	359	81 (22.6)	278 (77.4)	
Affordable	470	147 (31.3)	323 (68.7)	
Satisfaction with services of doctors, nurses and other health personnel				0.713
High	363	105 (28.9)	258 (71.1)	
Moderate	446	118 (26.5)	328 (73.5)	
Low	20	5 (25.0)	15 (75.0)	

¹ p-value by chi-square

² UCS = universal coverage scheme or '30-baht scheme' (30 baht = 0.95 USD)

Prevalence MetS and Distribution of Its Components

Table 3 depicts the prevalence of MetS components defined according to the Joint Interim Statement or “revised ATP III criteria” (Alberti *et al.*, 2009). The overall prevalence of MetS was 27.5%. Twenty-four new cases with high TG were detected and all were referred to treatment at the community hospitals nearby his/ her accommodations. The prevalence of MetS was higher in females than in males. The prevalence of MetS also increased with age. When considering the distribution of MetS components, the most common single MetS component prevalence was abdominal obesity (55.0%), followed by high TG (45.6%) and low HDL-C (36.1%). In the age group 35-44 years, abdominal obesity (61.0%) had the highest component prevalence, followed by high TG (38.5%) and low HDL-C (33.8%). The MetS component with the highest prevalence in females was abdominal obesity (72.8%), followed by low HDL-C (42.8%) and high TG (40.0%), whereas in males it was high TG (53.4%), followed by abdominal obesity (31.0%) and low HDL-C (27.0%). Prevalence

of MetS components sharply increased with increasing BMI status.

Pattern of MetS Component Combinations

The MetS component combination pattern is shown in Table 4. The percentage was calculated from single count of every MetS component combination pattern of each participant. About 18.8% of the participants had no risk of MetS. 28.0% had presence of one MetS component. The most prevalent single MetS component was abdominal obesity (14.1%), followed by high TG (6.8%) and low HDL-C (3.3%). The most prevalent two MetS component combination was abdominal obesity and high TG (6.3%). The most prevalent three MetS component combination was abdominal obesity, high HDL-C and high TG (10.2%). MetS component combination in participants with MetS (presence of three or more component combinations) was 27.5% as shown in Table 4.

Figure 1 shows the distribution by sex of MetS component combinations with presence of zero to five components among the study participants. The rank of abnormal MetS

Table 3. Prevalence of MetS and its components among 829 participants aged 35-85 years

Variable	n	MetS (95% CI)	MetS component ¹				
			Abdominal obesity	High TG	Low HDL-C	High BP	High FPG
Overall	829	27.5 (24.5, 30.7)	55.0	45.6	36.1	22.4	14.5
Area							
Urban	389	27.8 (23.4, 32.5)	52.4	42.4	34.7	25.2	14.1
Rural	440	27.3 (23.2, 31.7)	57.3	48.4	37.3	20.0	14.5
Sex ²							
Male	352	19.9 (15.8, 24.4)	31.0	53.1	27.0	23.3	13.9
Female	477	33.1 (28.9, 37.4)	72.8	40.0	42.8	21.8	14.9
Age, y ³							
35-44	195	22.1 (16.4, 28.5)	61.0	38.5	33.8	14.9	11.8
45-54	323	27.9 (23.0, 33.1)	54.8	45.2	34.7	20.4	12.7
55-64	211	28.9 (22.9, 35.5)	49.8	49.3	36.5	28.0	16.6
≥65	100	34.0 (24.8, 44.2)	55.0	53.0	44.0	32.0	21.0
Monthly income (THB) ⁴							
<3,500	522	28.7 (24.8, 32.6)	57.5	46.0	40.0	23.0	15.7
3,501-7,000	171	27.5 (20.7, 34.2)	52.0	46.2	29.2	22.2	11.1
>7,000	78	21.8 (12.4, 31.2)	42.3	42.3	25.6	16.7	14.1
BMI status ⁵ , kg/m ²							
Underweight	30	6.7 (2.8, 16.0)	13.3	23.3	20.0	23.3	0.0
Normal	265	9.8 (6.2, 13.4)	20.4	35.5	27.2	15.1	4.2
Overweight	198	23.7 (17.8, 29.7)	52.0	43.9	35.4	24.2	16.7
Obese	336	45.5 (40.2, 50.9)	87.8	56.5	44.9	27.1	19.0

¹ Percentage was calculated from repeated count of every MetS component combination pattern of all participants
Chi-square test: p-value ² <0.001, ³ ≤0.05; ⁴ 1 USD = 31.4 baht; ⁵ BMI = body mass index

components was the same as the repeated count methods but with a different percentage. The presence of a single MetS component was dominant in both males and females (27.6% and 28.3%), followed by presence of two MetS component combinations (27.0% and 24.7%). The proportion of males with no MetS risk (i.e. zero MetS components) was much higher than the proportion of females (25.6% vs 13.8%). The remaining MetS component combinations for females were also higher than for males.

Factors Associated with MetS

In the multivariate analysis, age, sex, education level, income and all other variables that were found to be statistically significant in the univariate analysis except for the affordability of additional healthcare costs variable were simultaneously entered into the final model. After adjusting for all other variables in the model, the significant predictors were: older age (OR, 1.03; 95%CI,

1.01 to 1.05), being female (OR, 1.50; 95%CI, 1.04 to 2.24), having a family history of hypertension (OR, 2.07; 95%CI, 1.41 to 3.04), and higher BMI (OR, 2.03; 95%CI, 1.73 to 2.04). The Hosmer and Lemeshow goodness-

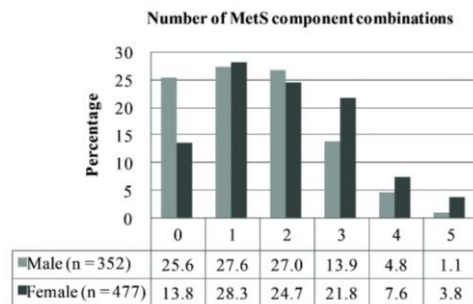


Figure 1. Distribution of MetS component combinations by sex among 829 participants aged 35-85 years in Amnat Charoen Province, Thailand

Table 4. Pattern of MetS component combinations among 829 participants aged 35-85 years

MetS component combination	Number	% ¹
No risk	156	18.8
Presence of one component	232	28.0
Abdominal obesity	117	14.1
High triglyceride (TG)	56	6.8
Low high density lipoprotein-cholesterol (HDL-C)	27	3.3
High blood pressure (BP) or on hypertension medications	25	3.0
High fasting plasma glucose (FPG) or on diabetes medications	7	0.8
Presence of two components ²	213	25.7
Abdominal obesity + high TG	52	6.3
Abdominal obesity + low HDL-C	44	5.3
Presence of three components ²	153	18.5
Abdominal obesity + high HDL-C + high TG	85	10.2
Abdominal obesity + high FPG + high TG	17	2.1
Presence of four components ²	53	6.3
Abdominal obesity + high HDL-C + high TG + high BP	17	2.1
Abdominal obesity + high HDL-C + high TG + high FPG	17	2.1
Presence of five components		
Abdominal obesity + high HDL-C + high TG + high BP + High FPG	22	2.7
MetS component combination in participants with MetS (presence of ≥ 3 components)	228	27.5

¹ Percentage was calculated from single count of every MetS component combination pattern of each participant.

² The two most prevalent MetS component combinations were listed in as there were several MetS component combinations with cell size $n < 10$. The number was too low to provide accurate statistical estimates

Table 5. Factors associated with MetS of 829 participants aged 35-85 years

Variable	Crude		Adjusted ³		p-value
	OR	95%CI	aOR	95%CI	
Age (years) ¹	1.01	1.00, 1.03	1.03	1.01, 1.05	0.003
Sex					
Male	1.00	reference	1.00	reference	
Female	2.00	1.44, 2.76	1.50	1.04, 2.24	0.048
Family history of hypertension					
No	1.00	reference	1.00	reference	
Yes	2.07	1.49, 2.90	2.07	1.41, 3.04	<0.001
Family history of diabetes					
No	1.00	reference	1.00	reference	
Yes	1.38	1.01, 1.90	1.27	0.88, 1.82	0.20
Education level					
≤Primary school	1.00	reference	1.00	reference	
Secondary school	0.76	0.53, 1.08	0.80	0.53, 1.20	0.28
≥Diploma, degree	0.32	0.12, 0.82	0.40	0.13, 1.19	0.09
Monthly income (THB) ²					
≤3,500	1.00	reference	1.00	reference	
3,501-7,000	0.96	0.66, 1.40	1.23	0.80, 1.92	0.35
>7,000	0.71	0.40, 1.24	1.24	0.62, 2.48	0.54
Smoking status					
Never or former smoker	1.00	reference	1.00	reference	
Current smoker	0.36	0.02, 0.65	0.79	0.39, 1.59	0.51
Alcohol consumption					
Never or mild drinker	1.00	reference	1.00	reference	
Moderate or heavy drinker	0.65	0.48, 0.90	0.84	0.57, 1.22	0.35
Physical activity					
Moderate (≥25 points)	1.00	reference	1.00	reference	
Low (15-24 points)	2.17	1.18, 4.00	1.77	0.90, 3.49	0.10
Sedentary (0-14 points)	1.25	0.75, 2.10	1.16	0.65, 2.06	0.62
BMI (kg/m ²) ¹	1.24	1.18, 1.29	2.03	1.73, 2.40	<0.001

OR, odds ratio; CI, confidence interval; aOR, adjusted OR

¹ continuous data; ² 1 USD = 31.4 THB; ³ adjusted for all other variables in the model

of-fit test suggested a good fit with the data ($p = 0.45$), as presented in Table 5.

Discussion

The prevalence of MetS, as defined by the “revised ATP III criteria”, in this study was 27.5%. The most common single MetS components were abdominal obesity, high TG and low HDL-C. The overall prevalence of MetS was slightly lower than the findings of Aekplakorn *et al.* (2011a) study the InterASIA survey (27.5% vs 32.6%). The reason for the difference might that the latter study samples covered four regions of Thailand and the prevalence of

MetS varied across those regions with a higher prevalence in Bangkok and the central region, whereas, the northeast, where the present study took place, had the lowest MetS prevalence. The results of this study seem close to the findings of Aekplakorn *et al.* (2011a) study for the northeastern region which were presented only in a graph without the exact prevalence being stated. The prevalence of MetS in this study was slightly higher than a study in Korea (24.8%) with 40 year old participants (Lim *et al.*, 2013). However, it was slightly lower than a study in China (30.5%) (Zuo, *et al.*, 2009). These three studies were compared with the results of the present study as they were conducted using the same MetS criteria,

covered both rural and urban areas and had participants of similar ages.

In this study, the prevalence of MetS in urban and rural areas was not different. This is likely because the infrastructure and the majority of lifestyles of the people in both areas were not greatly different. This finding was inconsistent with several previous studies (Zuo, *et al.*, 2009; Aekplakorn *et al.*, 2011a, 2011b;) that found urban areas had a higher proportion of MetS because urbanization affected levels of physical activity and diet patterns. The prevalence of MetS was higher in females than in males and prevalence increased with age this is similar to the findings of most studies (Zuo, *et al.*, 2009; Aekplakorn *et al.*, 2011a, 2011b;). Males and females had the same three most common single MetS components: abdominal obesity, high TG and low HDL-C. However, the proportion of abdominal obesity and low HDL-C in females was higher than in males (72.8% vs 31.0%; 42.8% vs 27.0% respectively). This study also supports previous studies that abdominal obesity, high TG and low HDL-C are the most prevalent components (Aekplakorn *et al.*, 2011a; 2011b). The number of MetS component combinations of zero to five in this study was similar to Aekplakorn *et al.* (2011a) study, for example, the prevalence of zero components or no risk of MetS was 18.8% in this study and 15.5% in Aekplakorn *et al.* (2011a) study; and the presence of three components of MetS was 18.5% vs 18.9%.

In this study the most common MetS component was abdominal obesity (55.0%) and the prevalence of obesity was 45.5%. The high prevalence of these two risks indicates an increased risk of CVD and the independent predictors of 346 high FPG, high BP and high cholesterol levels (Zuo *et al.*, 2009; Aekplakorn *et al.*, 2011b; Lim *et al.*, 2013; Veghari, *et al.*, 2015). However, it was not clear why the prevalence of the high FPG component in this study was lower than the findings in the study in China (Zuo *et al.*, 2009) (14.5% vs 30.7%) and Aekplakorn *et al.* (2011a) study (14.5% vs 29.8%). This issue needs to be further investigated in the next study.

About 53.2% of participants had two or more MetS components. These are a high risk group and should be under surveillance since the variation of the pattern of MetS component combinations among the population could mean individuals develop CVD and diabetes (Burke *et al.*, 2005; Macpherson *et al.*, 2016). Roughly 25.3% of the participants had a family history of hypertension. The results of this study also confirmed previous studies (Ranasinghe *et al.*, 2015a) that participants with a family history of hypertension were more likely to develop chronic metabolic diseases in later life. Although family history is a non modifiable risk factor of several chronic diseases, screening for a family history of hypertension is a useful measure for early detection of adults with a family risk of metabolic health problems (Solini *et al.*, 2009).

In this study healthcare access was not statistically associated with MetS. A possible explanation for this was that all participants had health insurance. The prevalence of MetS in participants with insurance under the Civil Servant Medical Benefit Scheme (CSMBS) (41.0%) was higher than those under the Universal Coverage Scheme (UCS) (27.1%) or Social Security Scheme (SSS) (19.2%). The prevalence of MetS in each scheme of health insurance indicated the proportion of participants on treatment of statins, and antihypertensive and glucose-lowering medications. Among three health insurance schemes, CSMBS members received a better benefit package compared to UCS and SSS (HISRO, 2012; Tangcharoensathien *et al.*, 2014; Paek *et al.*, 2016). CSMBS is health insurance provided to civil servant officials. The members are of working age and retirees. SSS is a compulsory health insurance scheme for private sector employees and does not cover retirees or dependents. There is tripartite contribution to SSS: 1.5% of salary, equally contributed by the employee, employer and government (HISRO, 2012). UCS covers the population uncovered by CSMBS and SSS. The majority are low-income earners or unemployed. However, they can still access essential healthcare at designated health facilities (Tangcharoensathien *et al.*, 2014;

Paek *et al*, 2016). About 50% of participants with MetS in this study were on statin. This information was relied on self-reported and it is beyond the scope of our study to research into the details of medications that the participants received from medical doctors. However, taking of statin among participants resulted in decreasing LDL cholesterol, serum triglycerides and increasing HDL (Branchi *et al*, 2001). It is also affect the finding of prevalence of metabolic syndrome this study.

Overall, 76.0% of the participants felt that health services were always convenient; 43.8% and 53.5% had high or moderate satisfaction with services of doctors, nurses and other health personnel. However, the suggested improvements for health facilities were: the adequacy of medical supplies and equipment to provide health services; adequacy of health promotion programs and the additional healthcare costs. Additional healthcare costs are those not covered by the health insurance schemes, such as medicines not on the National List of Essential Medicines, original drugs which might be more effective and have fewer side-effects than local drugs for some patients and some advanced technologies for physical examinations (such as CT scans).

There were two limitations for this study: 1) the use of statins, and antihypertensive and glucose- lowering medicines were self-reported. However, the reporting is likely to accurate since most patients require a lifelong medication because of other uncontrolled intrinsic factors. Although they have a healthy lifestyle, they still may have problems of high cholesterol, high BP and poor glycemic control. Normally, the patients having an appointment with the doctor every two months or depend on the sign and symptom of diseases of the patients and the decision of the doctors and 2) the cross-sectional study design limited the temporal relationship between study variables and MetS. In addition, some potential confounding factors such as food consumption behavior were not included in this study. The study should be replicated with larger sample size and more representative

study areas should be added to be able to extrapolate the findings to other regions.

In conclusion, our findings indicated that the prevalence of MetS among the adults aged ≥ 35 years in the study area was moderately high. Periodic surveying for early detection of new cases, and the screening and monitoring of changes in MetS risk factors among adults should be conducted. Any lifestyle modification interventions to improve healthy and high quality food intake and increase physical activity should focus on older age females with high BMI and a family history of hypertension to ameliorate the increased risk of many MetS associated health problems. The current essential healthcare access should be further improved to cover some special investigations and particular original drugs that might be more effective and have fewer side-effects than local drugs for some patients. However, the government's financial policy is the major concerns to provide a sufficient and stable budget that supports all health insurance schemes.

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Conflict of Interest

The authors declare no conflicts of interest.

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