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Defining risk thresholds: Appropriate body mass index cut-off for hypertension in Thai Cohort Study

Nipa Sakolchai¹, Prasutr Thawornchaisit^{2,*}, Ferdinandus de Looze³, Christopher M Reid⁴, Sam-ang Seubsman⁵ and Adrian Sleigh⁶

¹Kleang Hospital, Ministry of Public Health, Thailand

²Institute of Medical Research and Technology Assessment, Department of Medical Services, Ministry of Public Health, Thailand

³School of Medicine, University of Queensland, Australia

⁴School of Public Health, Curtin University, Perth, Australia

⁴School of Public Health and Preventive Medicine, Monash University, Australia

⁵School of Human Ecology, Sukhothai Thammathirat Open University, Thailand

⁶National Centre for Epidemiology and Population Health, Research School of Population Health, ANU College of Health and Medicine, The Australian National University, Australia

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Abstract

Body mass index (BMI) is used to predict the risk of hypertension in some Western countries. But to date the appropriate BMI cut-off for hypertension among Thais remains unresolved. This study aims to determine the proper BMI cut-off for risk of hypertension in Thailand.

Health-risk factors and their effects on incidence of hypertension were evaluated prospectively in the national Thai Cohort Study from 2005 to 2013. All derived from 40548 initially normotensive Sukhothai Thammathirat Open University students returning mail-based questionnaire surveys in both 2005 and 2013. Adjusted relative risks of association between baseline BMI and 8-year incidence of hypertension were calculated after controlling for a wide array of confounding factors. A smooth model with a linear fit of associations between BMI and hypertension risk was compared to a non-linear model using cubic splines.

In Thailand, the 8-year incidence of hypertension was 5.1% (men 7.1%, women 3.6%). Hypertension was strongly associated with ageing and high BMI. Non-linear modelling showed the best fit with a significant upwards inflection pointing to the risk threshold occurred in the third BMI category of 20.75 (aRR = 1.89, 95% CI 1.54-2.32) compared to a reference BMI of 20.00 kg/m².

The health risk transition Thailand has led to a rising prevalence of hypertension which is an important risk factor for many chronic diseases. A BMI cut-off point of 21 kg/m^2 , two points lower than the current 23 kg/m^2 , would be appropriate for defining the threshold of hypertension risk in Thai adults. Lowering BMI cut-off for risk of hypertension will encourage people to have more awareness of their health. Our results support population level interventions design to increase exercise and decrease overweight and obesity in Thailand.

Keywords: hypertension, body mass index, cut-off point for hypertension, Thailand Article history: Received 23 March 2019, Accepted 30 August 2019

1. Introduction

Rapid economic growth in recent decades moved Thailand from a low- to a middle-income country with a concomitant steady increase in urbanization. As a result, the proportion living in cities increased from 20.9% in 1970 to 34.1% in 2011 and it is estimated that over one million Thais (1.6% of population) will be urbanized each year [1]. Urban residence tends to accompany a sedentary life-style, junk food consumption [2], higher meat and lower rice consumption and other unhealthy behaviours, especially excessive drinking and smoking [3]. There is also a higher risk of obesity [2, 4, 5]. The socio-economic and environmental transformations are changing disease patterns of Thais to resemble those in developed countries, especially emerging non-communicable diseases including hypertension [6]. Many studies concluded that overweight and obesity are major risk factors of hypertension [7-12]. Increasing BMI is associated with increased morbidity and mortality due to increasing risk of obesity related problems such as cardiovascular disease, stroke and diabetes mellitus [13, 14]. WHO

^{*}Corresponding author; e-mail: prasutt@yahoo.com

recommends that bodyweight classifications be based on body-mass index calculated as weight in kilograms divided by height in meters squared (kg/m²) and categorized by standard cut-offs [14]. In addition, WHO approved different BMI cut-offs for "normal", "overweight" and "obese" for Asian populations as follows: less than 18.5 kg/m² underweight; $(18.5 \le BMI <$ 23.0) kg/m² normal; $(23 \le BMI < 25)$ kg/m² overweight at risk; and 25 kg/m² obeseI [15]. Even these criteria may not be strict enough and we know that the lower levels of BMI still increase cardiovascular and metabolic disorder rates in some Asian populations [16-18]. The BMI cut-off values at 23 and 25 kg/m² respectively for overweight and obesity, recommended by WHO for Asian populations, is still too high for Singaporeans. They should be lower by $2-3 \text{ kg/m}^2$ (18, 19). Many studies showed that the association of BMI and percentage of body fat among different ethnic groups was not similar [20-23] so BMI cut-off point based on body fat should be defined according to ethnicity. At the same percentage of body fat, Singaporean should have a BMI lower than Caucasian people [19, 24]. Our Thai Cohort Study (TCS) is focused on the transition in health risks due to modernization. Here we study the impacts on population health, investigating demography, socioeconomy, physical activities, personal behaviour and other health risks associated with hypertension during 8 years of prospective follow-up. The normal Asian body mass index cut-offs ($18.5 \le BMI < 23$) may be too high for Thais since participants at normal body mass index still have an annual incidence of hypertension of nearly 3% [9]. Therefore, in Thailand BMI cut-offs for hypertension could need national adjustment so we performed an incidence study to determine the risk.

2. Methods

2.1. Study Population and Data

The Thai Cohort Study (TCS) began in 2005 with 87151 distance learning students enrolled at Sukhothai Thammathirat Open University (STOU) then representing 44% of the enrolled student population [6]. The STOU student body and the TCS members were similar to the Thai people for geography and socioeconomic status [25] but their age distributions are different. The student body and cohort members were younger with 56.2% and 51.5% respectively in the 21-30 year age range compared to 23.9% in the general Thai population and fewer were older than 50 years (1.2% and 2% respectively) compared with 24.7% of the Thai population. Also, in comparison with the general population, the STOU student body and TCS members had a higher education. TCS baseline data were generated from a 20-page mail-out questionnaire which included questions on demography, socio-economic status (SES), personal health and diseases (diabetes mellitus, high blood lipids, high blood pressure, stroke, chronic kidney disease, various cancers, goitre, epilepsy, asthma, arthritis, chronic bronchitis and depression). As well there are questions on hearing, vision, dental impairment, use of health services, transport, injury, social networks, personal well-being, health-related behaviour and family background. Baseline data have been published [6, 25]. The number of cohort members participating at 4-year follow up was 60569 (70%) in 2009 and there were 42785 responders (49%) in 2013 at 8-year follow up.

2.2. Incident hypertension

Incident hypertension was defined as self-report of doctor diagnosed hypertension in 2013 after being normotensive in 2005. Hypertension incidence was the binary dependent variable for analyses and the person-time denominator included all individuals at risk—those 40548 (94.8%) of the 42785 participants with 8-year longitudinal data (2005 to 2013) who were negative for hypertension at the start (2005).

2.3. Independent variables

The independent variables that were available for analysis included age, sex, marital status, socioeconomic status (SES - income, household assets, and education), urbanization, body mass index (BMI), and underlying diseases (diabetes mellitus, high lipids and kidney disease). Other variables assessed included sedentariness (screen time, sitting time and housework or gardening), other lifestyle features (physical exercise, tobacco smoking, alcohol consumption, soy bean consumption, fruit and vegetable intake and soft drinks) and food preferences (Western, roast, smoked, instant, deep fried).

BMI calculation was based on self-report weight and height which were considered to be accurate due to the report of validation study [26]. Asian cut-offs following guidelines of the International Obesity Task Force [13]: underweight (BMI < 18.5), normal (18.5 \leq BMI < 23.0), overweight (23 \leq BMI < 25.00), or obese (BMI \geq 25) were used to calculate and categorize BMI. In addition, we also created 8 categories (< 18.5BMI, 18.5 \geq BMI < 20.75, 20.75 \geq BMI < 23, 23 \geq BMI < 25, 25 \geq BMI < 27.5, 27.5 \geq BMI < 30,30 \geq BMI < 32.5, and BMI \geq 32.5) which divided normal into two categories and more categories for obese.

Age was divided into three categories ($\leq 30.31-40$, > 40). Marital status was defined as married/living with a partner or single. Urbanization status was classified in childhood (aged 12 years) and at baseline (2005) producing 4 lifelong categories: ruralites (RR), urbanizers (RU), de-urbanizers (UR) and urbanites (UU). Education level was grouped into three categories (High school, Diploma, University). Personal monthly income was divided into four categories in baht. In 2005, one US dollar was equivalent to 42 baht.

Household assets were classified into three categories (low, medium, high in baht).

Screen time and sitting time (hours/day) were proxies for sedentariness. Incidental exercise (frequency of housework or gardening), was categorised into 4 groups: ≤ 3 times per month; 1-2 times per week; 3-4 times per week; most days. Various forms of physical activity (at least 20 minutes of mild, moderate or strenuous exercise, 10 minutes or more walking sessions) were also included and recorded using 4-item ordinal categories.

An overall measure of planned physical activity was calculated separately at both the baseline and the 8-year mark. This was based on the cohort members reporting the number of sessions per week of strenuous and moderate exercise for at least 20 minutes, and of walking for at least 10 minutes. We weighted the measure as follows: (2×strenuous+1× moderate+1×walking) sessions per week, weighting based on the recommendation of the International Physical Activity Questionnaire and the Active Australia Survey as used in other analyses of cohort data [27, 28]. Finally, for each individual, the 'overall measures' of weekly exercise for 2005 and 2013 were added and then averaged by dividing by 2, creating a longitudinal measure of planned physical activity (LPPA).

Smoking was self-reported and grouped into never, ex-smoker or current smoker. Alcohol consumption had four categories: never, ex-drinker, occasional drinker or current-drinker. Foods that may influence hypertension (deep fried, instant, roast or smoked, soybean products and soft drinks) and Western-style fast foods were assessed for consumption frequency. Fruit and vegetable consumption were recorded as standard serves eaten per day.

2.4. Statistical Analyses

We performed all analyses using SPSS software. Hypertension incidence and 95% CI were calculated for each value of each categorical variable. For statistical inference, all p values were two tailed and significance was set at 5%.

In a large study of an uncommon disease (incidence less than 10%) relative risks (RRs) can be accurately estimated as odds ratios (ORs) [29]. Accordingly, for each risk variable, the RR and 95% CI were estimated using logistic regression to calculate the bivariate OR for hypertension. Adjusted RRs (aRRs) were estimated by multivariate logistic regression ORs controlled for confounding by age, sex, marital status, socioeconomic status (SES), BMI, underlying diseases and personal behaviours (cigarette smoking and alcohol drinking). A co-variable was included in the multivariable model if bivariate analysis had indicated a statistically significant association with incidence of hypertension. Some variables were included because earlier analyses reported elsewhere had shown a significant or substantial association with hypertension.

3. Results

3.1. Baseline characteristics

Overall, 42785 of the original cohort participated in the 8-year follow up. Of these cohort members 40548 had self-reported as normotension in 2005 are shown in Table1. The mean age at baseline of these longitudinal participants was 32 years and there were more females than males (56% vs 44%). The highest proportion of participants resided in the Central and North-eastern regions and the lowest proportion lived in the East. Sixty three percent of the participants lived in urban areas. More than half of participants had a higher education attainment than high school and their monthly incomes were lower than 10000 baht. The distribution of household assets of participants was quite similar with a slightly higher proportion of participants in the low category. Fifty-four percent of participants had a'normal' BMI and the 'overweight' and 'obese' were about 16%, followed by 'underweight' for 13%. Participants with diabetes and high lipids were 0.8% and 9.8% respectively while those with kidney disease were 2.5%. The ex- smoker participants were 16.8% while current smokers were 8%. The occasional drinkers were 58.3% while regulardrinkers and ex-drinkers were 4.6 and 8.3 respectively.

3.2. BMI and incidence and risks of hypertension

The age and multivariable adjusted association between baseline BMI and hypertension incidence by 2013 are shown in Table2 and Fig.1. Overall, the risk of hypertension increased with an increased BMI. The risk of hypertension (aRR=1.89, 95% CI 1.54-2.32) rose above a value of 1 starting with the third ordinal category of BMI (20.75 \leq BMI < 23) when compared to those with normal BMI (second ordinal category18.5 \geq BMI < 20.75) or those underweight. An exponential increase in hypertension risk followed in all the subsequent (increasing) categories of BMI. Also noteworthy, comparing to participants with normal BMI (18.5 \geq BMI<20.75), those with BMI (23.0 \leq BMI < 25.0) had a risk of incidence of hypertension about three times (aRR = 2.95, 95% CI 2.4-3.62).

4. Discussion

This is the first large nationwide cohort study to investigate the incidence of hypertension associated with overweight and obesity in Thai adults. The 8year follow up from 2005 to 2013 of participants initially normotensive revealed a cumulative incidence of hypertension over this period of 5.1% with 7.1% in men and 3.6% in women. Ageing and obesity were

	Particinants				
Factor	n		HT(n)	I ^a %(95% CI)	
Demographic data					
Participants	40548	100	1958	5.1 (4.9-5.3)	
Age (y) mean	32.10			· · · ·	
(SD)	(8.2)				
Age group					
$\leq 30 \text{ y}$	6852	40.8	208	3.2 (2.6-3.4)	
31-40 y	6360	37.9	444	7.0 (6.4-7.6)	
>40 y	3590	21.4	537	15.0 (13.8-16.1)	
Sex					
Male	17769	43.8	1189	7.1 (6.7-7.5)	
Female	22779	56.2	769	3.6 (3.3-3.8)	
Married/partnered					
No	20586	52.1	517	7.1 (6.7-7.4)	
Yes	18946	47.9	1371	2.9 (2.6-3.1)	
Regions					
Bangkok	6522	16.2	378	6.1 (5.5-6.7)	
Central	9630	23.9	476	5.2 (4.8-5.7)	
North	8125	20.0	422	5.5 (5.0-6.0	
North-east	8580	21.3	389	4.8 (4.4-5.3)	
East	2348	5.8	112	5.0 (4.1-5.9)	
South	5122	12.6	167	3.5 (2.9-4.0)	
Urbanization status ^a					
Rural–rural (RR)	2508	19.1	127	5.5 (4.5-6.4)	
Rural–urban (RU)	3782	28.9	152	4.3 (3.6-5.0)	
Urban–rural (UR)	2346	17.9	147	6.7 (5.6-7.7)	
Urban–urban (UU)	4461	34.1	271	6.4 (5.7-7.1)	
Socioeconomic status					
Education level					
High school	17837	44.1	923	5.6 (5.2-5.9)	
Diploma	10862	26.9	445	4.3 (3.9-4.7)	
University	11753	29.1	580	5.1 (4.7-5.5)	
Personal monthly income (baht) ^c					
≤7000	14663	36.9	417	3.0 (2.6-3.3)	
7001-10000	9214	23.2	364	4.2 (3.6-4.6)	
10001-20000	11107	27.9	675	6.4 (5.9-6.8)	
>20000	4785	12.0	476	10.3 (9.5-11.2)	
Household assetse (baht) ^d					
Low	15133	37.5	509	3.6 (3.3-3.9)	
Medium	12865	31.9	604	4.9 (4.6-5.3)	
High	12387	30.7	836	7.1 (6.6-7.5)	

Table 1. Characteristics of 40548 normotensive participants at the 2005 Thai Cohort Study baseline

^{*a*}Incidence of Hypertension

^bLocation of residence (rural, R, or urban, U) before and in 2005. The values showed only participants who moved their residences within 5 years.

^{*c*}At the time of the survey in 2005, US1 = 31 Thai baht

^{*d*}Replacement value in Thai baht, categorized into three groups: low \leq 30,000, medium 30,001-60,000 and high >60,000

	Participants				
Factor	n	%kg/m ²	HT(n)	I ^a (95%CI)	
BMI classification ^b		-			
Underweight	5252	13.0	53	1.1 (0.8-1.3)	
(BMI < 18.5)					
Normal	21915	54.0	571	2.8 (2.5-3.0)	
$(18.5 \le BMI < 23)$					
Overweight	6561	16.4	457	7.4 (6.7-8.0)	
$(23 \le BMI < 25)$					
Obese	6314	15.6	849	14.2 (13.3-15.1)	
$(BMI \ge 25)$					
Underlying diseases					
Diabetes mellitus (type 1&2)					
No	40209	99.2	1889	5.0 (4.8-5.18)	
Yes	339	0.8	69	22.0 (17.4-26.7)	
High lipids					
No	36592	90.2	1484	4.3 (4.07-4.5)	
Yes	3956	9.8	474	12.7 (11.6-13.8)	
Kidney disease					
No	39540	97.5	1875	5.0 (4.8-5.2)	
Yes	1008	2.5	83	8.9 (7.1-10.7)	
Personal behaviours					
Smoking status					
Never	29467	72.7	1127	4.0 (3.8-4.3)	
Ex-smoker	6824	16.8	510	7.9 (7.3-8.6)	
Cur-smoker ^c	3226	8.0	254	8.5 (7.5-9.5)	
Drinking status					
Never	11204	27.6	419	3.9 (3.6-4.3)	
Ex-drinker	3365	8.3	192	6.1 (5.3-7.0)	
Occ- drinker ^d	23638	58.3	1125	5.0 (4.7-5.3)	
Reg- drinker ^e	1868	4.6	198	11.3 (9.8-12.8)	
Food consumption habit					
Instant food					
<1 time/m	8470	20.9	502	6.3 (5.7-6.8)	
1-3 times/m	16247	40.1	793	5.2 (4.8-5.5)	
1-2 times/wk	9883	24.4	400	4.3 (3.8-4.7)	
3-6 times/wk	4803	11.8	209	4.6 (4.0-5.2)	
≥ 1 times/d	864	2.1	40	4.9 (3.4-6.4)	
Soft drink					
<1 time/m	10970	27.1	521	5.0 (4.6-5.5)	
1-3 times/m	11831	29.2	547	4.9 (4.5-5.3)	
1-2 times/wk	8883	21.9	433	5.1 (4.7-5.6)	
3-6 times/wk	6118	15.1	317	5.5 (4.9-6.1)	
≥ 1 times/d	2401	5.9	123	5.4 (4.4-6.3)	

Table 1. (continued...)

^cCurrent-smoker

^dOccasional drinker

^eRegular drinker



Figure 1: Adjusted relative risks of hypertensionby body mass index (Use data from table 2 model 2aRRb plot graph) aRR^a is adjusted relative risks were calculated from multi-variable logistic regression models of hypertension adjusted for age, sex, marital status, socioeconomic status (exclude type of house), BMI classification, sedentary habits, physical activities, underlying diseases and personal behaviours.

fable 2. Association between baseline	body mass index and	eight-year incidence	of hypertension.
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Body Mass Index (kg/m ²)		Incident case	Adjusted RR estimates relating BMI and HT		
at baseline in 2005	HT(n)	by 2013 ^a I ^a	Model 1 ^b aRR ^d	Model 2 ^c aRR ^d	
		%(95% CI)	(95% CI)	(95% CI)	
BMI ^a					
BMI <18.5	81	1.5 (1.1-1.8)	1.01 (078-1.33)	1.0 (0.74-1.35)	
$18.5 \le BMI < 20.75$	174	1.6 (1.4-1.9)	1	1	
$20.75 \le BMI < 23.0$	397	4.0 (3.6-4.4)	2.03 (1.69-2.43)	1.89 (1.54-2.32)	
23.0≤ BMI < 25.0	462	7.4 (6.8-8.1)	3.26 (2.72-3.91)	2.95 (2.4-3.62)	
25.0≤ BMI < 27.5	431	11.8 (10.7-12.8)	5.27 (4.38-6.34)	4.51 (3.65-5.56)	
$27.5 \le BMI < 30.0$	223	15.7 (13.8-17.6)	7.39 (5.98-9.14)	6.98 (5.51-8.84)	
30.0≤ BMI < 32.5	111	19.5 (16.2-22.7)	10.48 (8.06-13.63)	9.34 (6.98-12.51)	
BMI ≥32.5	79	26.8 (21.7-31.9)	18.79 (13.81-25.57)	18.26 (12.93-25.78)	

^{*a*}Incidence of Hypertension

^bModel1 is adjusted relative risks were calculated from multi-variable logistic regression models of hypertension adjusted for age.

 c Model2 is adjusted relative risks were calculated from multi-variable logistic regression models of hypertension adjusted for age, sex, marital status, socioeconomic status (exclude type of house), BMI classification, sedentary habits, physical activities, underlying diseases and personal behaviours.

^dAdjusted relative risk

strongly associated with a higher incidence of hypertension. Our study revealed that compared to the participants with normal BMI (18.5 \leq BMI < 20.75), those who have marginally higher BMI (20.75 \leq BMI < 23.0) and (23.0 \leq BMI < 25.0) significantly increased their risk of incidence of hypertension to approximately two and three times respectively. This study found that BMI (18.5 \leq BMI < 23 kg/m²), the normal range announced by WHO for Asian population; significantly increased risk of incidence of hypertension by two times compared to those with BMI below 20.75 kg/m². In addition, the BMI (18.5 \leq BMI < 25.0) at the healthy range for Caucasian population strongly increases risk of incidence of hypertension in Thai people.

Our study confirmed that BMI was directly associated with the incidence of hypertension which is consistent with many studies in Asian such as in Korea [30], China [31] and India [32]. We reported that risk of incidence hypertension increased at BMI that considered to be in the normal range for Caucasian people (< 25 kg/m²). It is consistent with previous studies which suggested that for Asian population, a BMI cut-off for cardiovascular risk should be less than 23 kg/m² for overweight and 25 kg/m² for obesity [16, 33-35]. This result is comparable to the study in the US which reported that in Chinese Americans the corresponding BMI values were 20.9 kg/m² (CI, 19.7% to 22.1%) for the equivalent of the prevalence of metabolic abnormality in American whites at the BMI of 25 kg/m² [36].

The risk of hypertension may result from the effect of the amount of body fat. A study in African women in the US showed that body adiposity especially central adiposity was directly and significantly associated with an increased incidence of hypertension [32]. Further, a longitudinal study in Spain reported that body adiposity index was directly associated with an incidence of hypertension so it can be an alternative predictor of hypertension [37]. In addition, the studies showed that the relationship of BMI and body fat may differ between ethnic population [22]. At a similar BMI, Asians tend to have a higher body fat than Europeans [38, 39] especially for abdominal and visceral fat compared to that of Caucasians [40]. At the same amount of body fat percentage, BMI of Indonesians tended to have a two points lower than that of Dutch Caucasians [22]. Moreover, the Singaporean BMI cutoff points for overweight should be lower by 2 - 3points than WHO recommendation for Asian population [18, 19].

This study has many strengths. To our knowledge, it is the first 8-year longitudinal study of risks of hypertension with a large number of Thai participants. Moreover, most risk factors for hypertension were analysed as well. TCS participants live all over Thailand so the study represents the Thai population well in social geography and socio-economy [25]. Therefore, the results of this 8-year study will be quite accurate despite losing some statistical power due to cohort attrition. Worldwide many studies report on BMI cut-off point for risk for hypertension however socioeconomic, lifestyle and behaviour risks and ethnicity of each country are not similar. The results from our cohort will prevent incidence of hypertension in Thailand.

However, there are many limitation for our study. All data are self-reported so there may be some recalled error. Validation of self-reported weight, height and body mass index revealed that accuracy was acceptable [26]. Also we performed a validation study of self-reported hypertension using a random age-sex matched sample of the cohort reporting hypertension (n=240) or no hypertension (n=240) [41]. The study found that self-report of hypertension yes/no status was high for accuracy at 82% (yes) and 86% (no) respectively. We also investigated the impact of the nonresponses to the 2009 follow-up and found small effects with under-representation of young urban men; this missing group would have a minor influence on our results and would not be expected to have a high rate of incident hypertension [42]. In addition, the attrition over 8-year followed up was 50%.

5. Conclusion

Our study concludes that lowering BMI cut-off point by two points for the risk threshold of hypertension is very important for the Thai population since we found that the incidence and risk of hypertension at the BMI ($20.75 \le BMI < 23.0$) was already too high. Therefore, people need to be aware that preventing hypertension, needs BMI to be at a lower point (< 21kg/m²) than the level used at present (< 23.0 kg/m²). In Thailand, obesity, an important risk factor for many chronic diseases, is already high in prevalence so long term policies for preventing obesity from childhood should be developed by Ministry of Public health. Further study for BMI cut-off point for risk of hypertension should be performed in other Asian countries as well.

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Thai Cohort Study Team

<u>Thailand</u>: Jaruwan Chokhanapitak, Suttanit Hounthasarn, Suwanee Khamman, Daoruang Pandee, Suttinan Pangsap, Tippawan Prapamontol, Janya Puengson, Sam-ang Seubsman, Boonchai Somboonsook, Nintita Sripaiboonkij, Pathumvadee Somsamai, Prasutr Thawornchaisit, Duangkae Vilainerun, Wanee Wimonwattanaphan, Cha-aim Pachanee, Arunrat Tangmunkongvorakul, Benjawan Tawatsupa, Wimalin Rimpeekool.

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Ethical Considerations

Ethical approval was obtained from Sukhothai Thammathirat Open University Research and Development Institute (protocol 0522/10) and the Australian National University Human Research Ethics Committee (protocol 2004344 and 2009570). Informed, written consent was obtained from all participants.

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