Health-Risk Transition and 8-Year Hypertension Incidence in a Nationwide Thai Cohort Study

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Abstract

Objective: Rapid economic growth is transforming Thailand into a middle-income country. Also emerging are chronic diseases particularly hypertension, diabetes mellitus and kidney disease. There are few studies of the incidence of hypertension. We analyse the effect on 8-year incidence of hypertension of transitional health-risk factors including demography, socioeconomic status (SES), body mass index (BMI), sedentariness, physical activity, underlying diseases, personal behaviours, food, fruit and vegetable consumption.

Design and Methods: Health-risk factors and their effects on the incidence of hypertension were evaluated prospectively in the national Thai Cohort Study from 2005 to 2013. All data were derived from 40,548 Sukhothai Thammathirat Open University students returning mail-based questionnaire surveys in both 2005 and 2013. Adjusted relative risks of association between each risk factor and incidence of hypertension were calculated after controlling for confounding factors.

Results: In Thailand, the 8-year incidence of hypertension was 5.1% (men 7.1%, women 3.6%). Hypertension was associated with ageing, higher BMI, diabetes mellitus, chronic kidney disease, high lipids, SES, lower education level, lower household asset, physical inactivity, smoking, instant food intake and soft drink. Sex, having a partner, urbanization and sedentary habits had no influence on hypertension.

Conclusion: In Thailand, hypertension is becoming a serious risk factor for chronic disease with a wide array of associations with modern life. As Thailand's socio-economy develops the health-risk transition will further impact on population health. Thais should be encouraged by government policy to consume less instant food, maintain normal BMI, increased physical activity, stop smoking and consume less soft drink.

Keywords: hypertension, socioeconomic status, body mass index, physical activity, underlying diseases, smoking, Thailand

1. Introduction

Hypertension is a global public health challenge contributing significantly to the population burden of cardiovascular disease (CVD) and kidney disease. This is important because CVD is the leading cause of death in the world. Globally, more than 55 million people died in 2013 and 32% of these deaths (17 million) were attributable to CVD (GBD 2013 Mortality and Causes of Death Collaborator, 2015). The majority of these CVD deaths were a consequence of ischemic heart disease (IHD) or cerebrovascular disease together with associated hypertension (Huangfu et al., 2017). Worldwide, one in four adults had hypertension in 2000 and one in three will be affected by 2025 (Kearney et al., 2005). The global prevalence of hypertension in adults is already 1 billion and rising (Cifkova, Fodor, & Wohlfahrt, 2016), causing more than ten million deaths annually (Collaborators et al., 2015). Hypertension is now the leading global health risk for world mortality (WHO, 2017).

In Thailand, National Health Examination Surveys this century revealed that the prevalence of hypertension in adults was 22% in 2004 and 21.5% in 2009 (Aekplakorn et al., 2008; Aekplakorn et al., 2012), a stable rate somewhat below that for the South Asia (approximately 27%) (Neupane et al., 2014). The leading causes of death in Thailand are cancer (19%) followed by CVD, particularly ischemic heart disease (12%) and strokes (10%) (WorldAtlas, 2017). Hypertension and diabetes are risk factors for CVD deaths for Thais. Indeed, in a large national Thai Cohort Study (TCS) observing the risk transition since 2004, population attributable fractions for CVD deaths in Thailand were calculated as 16% for hypertension and 10% for diabetes (Zhao, Kelly, et al., 2015).

There are few studies reporting directly measured incidence of hypertension in Thailand (Thawornchaisit et al., 2013c; Vathesatogkit et al., 2012). Our Thai Cohort Study (TCS), ongoing since 2005, is focused on the transition in health risks accompanying modernization. Here we report the impacts on population health, investigating demography, socio-economy, lifestyles and other health risks associated with hypertension during 8 years of follow-up. At baseline in 2005, the mostly young cohort had an overall prevalence of hypertension of 4.6% (Thawornchaisit et al., 2013a). Over the 4-year follow up from 2005 to 2009 the cumulative incidence of hypertension was 3.5% (Thawornchaisit et al., 2013c). Now we have measured the 8-year incidence of hypertension and its associations and effects and we are able to report on a larger time sample of the cohort transitions that are operating to produce CVD in Thailand.

2. Methods

2.1 Study Population and Data

The Thai Cohort Study (TCS) commenced in 2005 and was comprised of 87151 distance-learning students enrolled at Sukhothai Thammathirat Open University (STOU). In comparison with the Thai population, the STOU student body and the TCS members were comparable for social geography and socio-economic status (Seubsman, Yiengprugsawan, Sleigh, & the Thai Cohort Study, 2012) but differed in age. 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%. In addition, the STOU student body and TCS members tended to have a higher education level than the general population.

TCS baseline data were generated from a 20-page mail-out questionnaire which included questions on demography, socio-economic status (SES), personal health (chronic kidney disease, diabetes mellitus, high blood lipids, high blood pressure, stroke, various cancers, goitre, epilepsy, asthma, arthritis, chronic bronchitis and depression). As well there were 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 (Seubsman et al., 2012; Sleigh, Seubsman, & Bain, 2008). 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 being normotensive in 2005 and self-reporting doctor diagnosed hypertension in 2013. 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, urbanization, socio-economic status (SES - income, household assets, and education), body mass index (BMI), and underlying diseases (diabetes mellitus, high lipids and kidney disease). Other variables we analysed included sedentary habits (screen time, sitting time and house-work or gardening), other lifestyle factors (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).

Age was divided into three categories (≤ 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).

Asian cut-offs following guidelines of the International Obesity Task Force (Kanazawa et al., 2005): underweight (BMI < 18.5), normal (18.5 ≤ BMI < 23.0), overweight (23 ≤ BMI < 25.00), or obese (BMI ≥ 25) were used to

calculate and categorize BMI.

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 (Australian Institute of Health and Welfare, 2003; Banks, Lim, Seubsman, Bain, & Sleigh, 2011). 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.

2.3 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) (Webb & Bain, 2011). 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 Table 1. 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 regions and North-eastern 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.

3.2 Incidence and Risks of Hypertension

In Thailand, the incidence of self-reported doctor diagnosed hypertension in adults was 5.1% and the rate in men was approximately twice the corresponding rate in women (7.1% vs 3.6%; Table 2). The incidence of hypertension increased with age. Sex, marriage or having a partner, and personal income had no influence on the risk hypertension. However, the risk of hypertension decreased with increased level of educational attainment and household assets.

The risk of hypertension increased with an increased BMI. Planned physical activity, averaged across the 8-year follow-up, was a protective factor. The higher LPPA categories (≥8-14 and ≥15 sessions/week) were associated incrementally with lower incidence of hypertension, but the trend is not statistically significant. Hypertension risk increased in those who had diabetes mellitus, high blood lipids or kidney disease. Current smokers had a higher risk of developing hypertension than non-smokers. However alcohol drinking had no influence on the risk of incident hypertension. Hypertension directly associated with frequency of instant food consumption and drinking soft drinks. Fruit and vegetable intake had no influence on hypertension.

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

Factor	Participants	
	n	percent
Demographic data		
Participants	40548	
Age (y) mean	32.10	
(SD)	(8.2)	
Age group		
≤30 y	19682	48.5
31-40 y	14206	35.0
>40 y	6660	16.4
Sex		
Male	17769	43.8
Female	22779	56.2
Married/partnered		
No	20586	52.1
Yes	18946	47.9
Regions		
Bangkok	6522	16.2
Central	9630	23.9
North	8125	20.0
North-east	8580	21.3
East	2348	5.8
South	5122	12.6
Urbanization status[a]		
Rural–rural (RR)	2508	19.1
Rural–urban (RU)	3782	28.9
Urban–rural (UR)	2346	17.9
Urban–urban (UU)	4461	34.1
Socioeconomic status		
Education level		
High school	17837	44.1
Diploma	10862	26.9
University	11753	29.1
Personal monthly income (baht) [b]		
≤7000	14663	36.9
7001–10000	9214	23.2
10001–20000	11107	27.9
>20000	4785	12.0
Household assets[e] (baht) [d]		
Low	15133	37.5
Medium	12865	31.9
High	12387	30.7

[a]Location of residence (rural, R, or urban, U) before and in 2005. The values showed only participants who moved their residences within 5 years;

[b]At the time of the survey in 2009, US$1 = 31 Thai baht;

[e]Replacement value in Thai baht, categorized into three groups: low ≤30,000, medium 30,001-60,000 and high >60,000.

Table 2. Hypertension incidence and association with risk factors in participants

	HT(n)	I[a]%(95% CI)	aRR[b](95% CI)	
Participants	1958	5.1 (4.9-5.3)		
Demography				
Age group				
≤30 y	356	1.9 (1.7-2.1)	1	
31-40 y	752	5.6 (5.2-6.0)	2.43 (2.06-2.86)	
>40 y	850	13.7 (12.8-14.6)	5.39 (4.45-6.53)	
P-trend				<0.0001
Sex				
Female	769	3.6 (3.3-3.8)	1	
Male	1189	7.1 (6.7-7.5)	1.11 (0.96-1.28)	
Socio-economic status				
Education level				
University	580	5.1 (4.7-5.5)	1	
Diploma	445	4.3 (3.9-4.7)	1.04 (0.89-1.21)	
High school	923	5.6 (5.2-5.9)	1.17 (1.02-1.34)	
P-trend				<0.05
Household asset				
High	836	7.1 (6.6-7.5)	1	
Medium	604	4.9 (4.6-5.3)	1.67 (1.02-1.33)	
Low	509	3.6 (3.3-3.9)	1.15 (1.0-1.34)	
P-trend				<0.0001
BMI classification[c]				
Underweight (BMI <18.5)	53	1.1 (0.8-1.3)	0.56 (0.41-0.76)	
Normal (18.5 ≤ BMI < 23)	571	2.8 (2.5-3.0)	1	
Overweight (23 ≤ BMI < 25)	457	7.4 (6.7-8.0)	2.03 (1.75-2.36)	
Obese (BMI ≥25)	849	14.2 (13.3-15.1)	4.01 (3.51-4.58)	
P-trend				<0.0001
Physical activities				
Weighted total sessions exercise-related physical activity (average between 2005 and 2013)				
0-7 ses/w[d]	552	5.2 (4.8-5.7)	1	
8-14 ses/w	653	5.0 (4.6-5.3)	0.86 (0.75-1.0)	
≥15 ses/w	495	4.9 (4.5 -5.3)	0.77 (0.65-0.92)	
P-trend				0.237

[a]Incidence of Hypertension;

[b]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;

[c]Asian standard BMI classification;

[d]Sessions/week .

Table 2. (continued...)

	HT(n)	I[a]%(95% CI)	aRR[b](95% CI)	
Underlying diseases				
Diabetes mellitus (type1&2)				
No	1889	5.0 (4.8-5.18)	1	
Yes	69	22.0 (17.4-26.7)	1.61 (1.14-2.27)	
High lipids				
No	1484	4.3 (4.07-4.5)	1	
Yes	474	12.7 (11.6-13.8)	1.4 (1.23-1.62)	
Kidney disease				
No	1875	5.0 (4.8-5.2)	1	
Yes	83	8.9 (7.1-10.7)	1.74 (1.32-2.3)	
Personal behaviours				
Smoking status				
Never	1127	4.0 (3.8-4.3)	1	
Ex-smoker	510	7.9 (7.3-8.6)	1.01 (0.87-1.17)	
Cur-smoker[c]	254	8.5 (7.5-9.5)	1.33 (1.10-1.6)	
P-trend				<0.0001
Drinking status				
Never	419	3.9 (3.6-4.3)	1	
Ex-drinker	192	6.1 (5.3-7.0)	1.19 (0.95-1.49)	
Occ- drinker[d]	1125	5.0 (4.7-5.3)	1.1 (0.96-1.28)	
Reg- drinker[e]	198	11.3 (9.8-12.8)	0.83 (0.66-1.06)	
P-trend				<0.0001
Food consumption habit				
Instant food				
<1 time/m	502	6.3 (5.7-6.8)	1	
1-3 times/m	793	5.2 (4.8-5.5)	1.03 (0.9-1.19)	
1-2 times/wk	400	4.3 (3.8-4.7)	1.14 (1.0-1.35)	
3-6 times/wk	209	4.6 (4.0-5.2)	1.24 (1.0-1.53)	
≥1 times/d	40	4.9 (3.4-6.4)	1.45 (1.0-2.2)	
P-trend				<0.0001
Soft drink				
<1 time/m	521	5.0 (4.6-5.5)	1	
1-3 times/m	547	4.9 (4.5-5.3)	1.01 (0.9-1.17)	
1-2 times/wk	433	5.1 (4.7-5.6)	1.17 (1.0-1.37)	
3-6 times/wk	317	5.5 (4.9-6.1)	1.34 (1.12-1.6)	
≥1 times/d	123	5.4 (4.4-6.3)	1.34 (1.12-1.60)	
P-trend				0.192

[a]Incidence of Hypertension;

[b]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;

[c]Current-smoker;

[d]Occasional drinker;

[e]Regular drinker.

4. Discussion

This is the first large national cohort study to investigate the incidence of hypertension and its risks in Thai adults. The 8-year follow up from 2005 to 2013 of participants initially normotensive revealed a cumulative incidence of hypertension over this period of 5.1% with the rate in men about twice that in women. Ageing, obesity or underlying diseases (particularly diabetes, high blood lipids and chronic kidney disease) were strongly associated with a higher incidence of hypertension while education attainment and household assets were inversely related to the incidence of hypertension. Cigarette smoking, instant food and soft drinks consumption had a moderate effect on hypertension incidence but planned physical activity averaging 8 or more sessions per week over the 8-year period reduced the incidence of hypertension. Sex and marital or partner status had no influence on hypertension.

The health risks for hypertension in Thailand now are changing rapidly as the population transitions to a middle income with an ageing demographic profile (Apinonkul, Soonthorndhada, Vapattanawong, Jagger, & Aekplakorn, 2016; Sleigh et al., 2008). Obesity is rising (Aekplakorn et al., 2014; Seubsman et al., 2010) and related chronic diseases, especially CVD (Putadechakum, 2014), diabetes (Aekplakorn et al., 2011; Papier et al., 2016) and kidney disease (Thawornchaisit et al., 2015), are all increasing. Instant food is replacing traditional diets (Rimpeekool et al., 2017) as people migrate from rural to urban environments. Lifestyles are changing, physical activity is declining (Lim, Kjellstrom, et al., 2009) and alcohol intake is rising (Wakabayashi et al., 2015). In addition, people drink more soft drinks and other sugar sweetened beverages (Rimpeekool et al., 2017) which results in population weight gain (Lim et al., 2014) and diabetes (Papier, D'Este, et al., 2017). Although the trend of cigarette smoking in Thai men is declining its prevalence still exceeds 20% overall and reaches 40% in some groups (Kamsa-ard, 2013; Zhao, Pachanee, et al., 2015). Regular smoking is directly associated with a higher incidence of hypertension (Thawornchaisit et al., 2013c). The traditional expectation that females do not smoke continues to powerfully protect half of the population from tobacco related illness, including hypertension. As well, economic growth is leading to a growing proportion of people with a higher education attainment which also protects against hypertension (Thawornchaisit et al., 2013a). Educated people tend to have healthier diets with less instant food (Rimpeekool et al., 2017). In our study, ageing was associated with an increased risk of hypertension which was similar to other longitudinal studies in the US (He, Klag, Appel, Charleston, & Whelton, 1998), Korea (J. Kim et al., 2006; J. H. Lee et al., 2011), Portugal (Pereira et al., 2012) and South Asia (Prabhakaran et al., 2017) as well as cross-sectional studies in the US (Ong, Cheung, Man, Lau, & Lam, 2007; Owolabi, Goon, Adeniyi, & Seekoe, 2017), Morocco (Berraho et al., 2012), Jordan (Mubarak, Froelicher, Jaddou, & Ajlouni, 2008), India (Kishore, Gupta, Kohli, & Kumar, 2016), China (Gao et al., 2013), and Korea (Choi, Kim, & Kang, 2017).

In our cohort, at the 8-year time point sex continues to have a big influence on hypertension incidence just as we noted at the 4-year follow up, but the still doubled rate among men was no longer statistically significant due to loss of statistical power. In another cohort study from USA, the male risk was significantly higher (He et al., 1998). In India a higher male rate was found but it was not significant (Prabhakaran et al., 2017). In a Korean cohort females had a higher risk but the sex differential was not significant (J. H. Lee et al., 2011). Men had a significantly higher risk of hypertension than women in cross-sectional studies in the US (Owolabi et al., 2017), China (Gao et al., 2013; Huang et al., 2017; Liu et al., 2014; Yang et al., 2015), Brazil (Vinholes et al., 2017) and Malaysia (Abdul-Razak et al., 2016). In contrast, other cross-sectional studies have reported no sex difference in the US (Ong et al., 2007), Malaysia (Rashid & Azizah, 2011), and Morocco (Berraho et al., 2012) and in Pakistan females had higher rates (Shafi & Shafi, 2017).

Socioeconomic status, especially education attainment and household assets, was inversely associated with incident hypertension. A similar result for education attainment was noted in longitudinal studies in Portugal (Pereira et al., 2012), and South Asia (Prabhakaran et al., 2017). Supportive findings were found with cross-sectional studies in Korea (Choi et al., 2017; C. S. Park et al., 2016), Malaysia (Abdul-Razak et al., 2016), China (Gao et al., 2013; Ruixing et al., 2008), Brazil (Silva, Petroski, & Peres, 2012), India (Kishore et al., 2016) and the US (Ong et al., 2007). In contrast, education had no influence on blood pressure in a 7-year longitudinal study in the US (He et al., 1998) or in cross-sectional studies in United Arab Emirates (Shah et al., 2015) and Morocco (Berraho et al., 2012).

Household assets indicate family income and inverse influence of this variable on hypertension had been found in many studies including cross-sectional reports in the US (Kaplan, Huguet, Feeny, & McFarland, 2010; Owolabi et al., 2017) and Brazil (Silva et al., 2012). In contrast, income had no effect on hypertension incidence in a 7-year prospective study in the US (He et al., 1998) and in cross-sectional studies in United Arab Emirates (Shah et al., 2015) and Malaysia (Rashid & Azizah, 2011). But income had a direct association with hypertension in Ghana (Addo, Smeeth, & Leon, 2009). The association of income and hypertension in Thailand is similar to that in

high-income developed countries.

BMI was directly associated with the incidence of hypertension in our TCS. Similar findings were reported from other follow up studies spanning 10 years in Korea (Y. Kim & Jee, 2017), 46 years in the US (Shihab et al., 2012), 5 years in China (Ren et al., 2016), 4 years in Portugal (Pereira et al., 2012) and 11 years in Norway (Droyvold, Midthjell, Nilsen, & Holmen, 2005). Supportive cross-sectional results have been reported from the US (Hajjar & Kotchen, 2003; Ong et al., 2007), Morocco (Berraho et al., 2012), Jordan (Mubarak et al., 2008), India (Kishore et al., 2016) and China (Gao et al., 2013; Liu et al., 2014; Yang et al., 2015).

The sympathetic nervous system plays a major role in obesity-induced hypertension. Weight gain stimulates norepinephrine, and probably leptin, release leading to sodium retention and elevated blood pressure (Masuo, Mikami, Ogihara, & Tuck, 2000). Activation of the renin–angiotensin system of the kidney may also be an important factor in linking obesity and elevated blood pressure (Hall, Brands, Hildebrandt, Kuo, & Fitzgerald, 2000). Higher BMI was related to a significantly higher risk of hypertension and overweight accounted for 11-25 per cent of population attributable risk (PAR) in the human population (Geleijnse, Grobbee, & Kok, 2005). A study of Chinese, Filipinos and Americans (Colin Bell, Adair, & Popkin, 2002) showed that higher BMI was associated with a higher prevalence of hypertension in all ethnic groups,

We found that planned exercise had a substantial protective effect on the incidence of hypertension. Our data showed that LPPA had an inverse relationship with the risk of developing hypertension in Thai adults. Similar findings were reported from prospective studies in Korea (J. Kim et al., 2006; Y. Kim & Jee, 2017) and a cross-sectional study in Iran (Tabrizi, Sadeghi-Bazargani, Farahbakhsh, Nikniaz, & Nikniaz, 2016). As a corollary, physical inactivity would be expected to increase hypertension risk and indeed such inactivity was found to account for 5-13 per cent PAR for hypertension in the human population (Geleijnse et al., 2005). Daily walking for at least 30 minutes (Shah et al., 2015) and leisure time physical activity (Silva et al., 2012) significantly lowers the risk of hypertension. However, longitudinal studies in Portugal (Pereira et al., 2012), Korea (J. H. Lee et al., 2011), South Asia (Prabhakaran et al., 2017) and the US (He et al., 1998) reported that physical activity had no influence on the risk of hypertension. The evidence linking exercise to hypertension protection continues to accumulate without perfect agreement and further studies will be needed to clarify the relationships.

In our study, diabetes mellitus strongly associated with the incidence of hypertension as reported in a previous longitudinal study in South Asia (Prabhakaran et al., 2017) and in cross-sectional studies in the US (Owolabi et al., 2017), Pakistan (Shafi & Shafi, 2017), Morocco (Berraho et al., 2012), Jordan (Mubarak et al., 2008) and China (Gao et al., 2013; Liu et al., 2014). In two of these studies duration of diabetes was positively associated with incidence of hypertension (Berraho et al., 2012; Mubarak et al., 2008). In other diabetes studies, participants with poor blood sugar control had elevated haemoglobin A1c, as well as significantly more hypertension (Salman & Al-Rubeaan, 2009) and microvascular complications (Stratton et al., 2000). Each 1% reduction in A1c reduced the risk of microvascular complications by 37%.

Our data on lipids show a strong association of self-reported hyperlipidemia and hypertension, as also noted in longitudinal studies in the US (Halperin et al., 2006; Sesso, Buring, Chown, Ridker, & Gaziano, 2005) and in Finland (Laaksonen et al., 2008) and cross-sectional studies in China (Gao et al., 2013; Li et al., 2008; Liu et al., 2014; Yang et al., 2015) and India (Kishore et al., 2016). High cholesterol associated with hypertension in prospective studies covering 11 years in American women (Sesso et al., 2005) and 14 years in American men (Halperin et al., 2006). Similar findings emerged from cross-sectional studies in India (Kishore et al., 2016) and China (Yang et al., 2015). In addition, hypertriglyceridemia significantly increased the risk of hypertension in a longitudinal study in Finland (Laaksonen et al., 2008) and in a cross-sectional study in China (Yang et al., 2015). However, such a link was not found in cross-sectional analyses in India (Kishore et al., 2016) or a 5-year longitudinal study in Korea (J. H. Lee et al., 2011). An 11-year follow up study in women (Sesso et al., 2005) and a 7-year follow up in men (Laaksonen et al., 2008) reported that low-density lipoprotein cholesterol (LDL) directly associated with an increased risk of hypertension. However, high-density lipoprotein cholesterol (HDL) was a protective factor in American women (Sesso et al., 2005), American men (Halperin et al., 2006) and Finish men (Laaksonen et al., 2008) but not in Korea adults (J. H. Lee et al., 2011).

Kidney disease (KD) has a strong connection to hypertension incidence, as has been noted many times including in cross-sectional studies in Pakistan (Shafi & Shafi, 2017), Czech Republic (Jancova et al., 2008) and the US (Kalaitzidis et al., 2009). The prevalence of HTN in patients with renal insufficiency was significantly higher than that in patients without renal insufficiency, which depended on the type of nephropathy and the degree of renal failure (Ridao et al., 2001). The activation of the renin-angiotensin system (RAS) is an important factor contributing to the pathogenesis of hypertension in KD by stimulating the sympathetic nervous system

(Augustyniak, Tuncel, Zhang, Toto, & Victor, 2002; Vaughan, Carey, Ayers, & Peach, 1979; Weidmann, Maxwell, Lupu, Lewin, & Massry, 1971).

In our cohort, cigarette smokers were at a higher risk of developing hypertension. This result was supported by various reports such as a large longitudinal study in American women showing that more than 15 cigarettes per day significantly increased risk of hypertension (Bowman, Gaziano, Buring, & Sesso, 2007) and an 11-year study of Finish men showing more than 20 cigarettes smoking per day strongly associated with risk of developing hypertension (Niskanen et al., 2004). However, longitudinal studies in Portugal (Pereira et al., 2012) and South Asia (Prabhakaran et al., 2017) and cross-sectional studies in Iran (Tabrizi et al., 2016), United Arab Emirates (Shah et al., 2015) and Brazil (Silva et al., 2012) did not connect cigarette consumption and incidence of hypertension. Indeed , cigarette smoking significantly decreased risk of hypertension in cross-sectional studies in Brazil (Berraho et al., 2012) and China (Li et al., 2008). The effect of cigarette smoking on reduced risk of hypertension may be as a result of smoking decreased body weight. In women, light cigarette smoking (1-9 cigarettes/day) had a lower BMI and blood pressure than those non-smokers (Primatesta, Falaschetti, Gupta, Marmot, & Poulter, 2001). Furthermore, a 4-year follow up study in Korea (D. H. Lee, Ha, Kim, & Jacobs, 2001) reported that cigarette smoking cessation significantly increased risk of hypertension which may associate with weight gain in smoking cessation (Niskanen et al., 2004). Data from our cohort show a rapid decline in excess mortality among those who quit smoking suggesting that regardless of the effect on hypertension ex-smokers experience a net advantage compared to those who continue smoking (Zhao, Pachanee, et al., 2015).

Regular consumption of instant food which contains high salt and carbohydrate strongly increased risk of developing hypertension. Consistent with previous studies reporting high salt diet (NaCl) increased risk of hypertension (Tabrizi et al., 2016) and aggravated extant high blood pressure (Alam & Johnson, 1999; Chidambaram et al., 2014). Instant noodle consumers are known to be at risk of high intake of energy, fat, and sodium (J. Park, Lee, Jang, Chung, & Kim, 2011), all of which increase the risk of hypertension. Yokokawa et al showed that daily salt consumption in Thailand averaged 9.9 gram per day which is about twice of daily salt intake (5 gram/ day) recommended by World Health Organization (Yokokawa et al., 2016). In a Western population (Geleijnse et al., 2005) has demonstrated that higher salt consumption relates to significantly higher risk of hypertension, accounting for 9-17 per cent PAR in the human population.

We found that soft drink intake more than one time per week increased risk of hypertension and this result was supported by a previous cross-sectional study (Song et al., 2017). Sugars and sugar-sweetened beverages (SSB), especially glucose and fructose, associated with an increase systolic and diastolic blood pressure (Brown et al., 2011; Souza Bda, Cunha, Pereira, & Sichieri, 2016). Reduced consumption of SSB significantly associated with reduced systolic and diastolic blood pressure (Chen et al., 2010). In a prospective study higher consumption of SSB associated with increased body weight and diabetes risk (Schulze et al., 2004) both of which are important risks for hypertension. In a related report from the TCS the SSB intake associated directly with diabetes mellitus incidence (Papier, Jordan, et al., 2017). The direct associations reported here for SSB/fructose intake and hypertension are consistent with hypothesized effects on the uric acid pathway (Brown et al., 2011). For instance, fructose consumption may lead to increased serum uric acid which may influence blood pressure by reducing levels of nitric oxide, a potent vasodilator (Nakagawa et al., 2006). Sugar consumption has also been associated with enhanced sympathetic nervous system activity and sodium retention (Rowe et al., 1981). Recent evidence has linked SSB to diabetes directly without requiring excess weight and this information should be of interest to policy makers for SSB regulation (Papier, Jordan, et al., 2017).

Our study has certain advantages. It is the largest prospective study in Thailand evaluating most health risk factors for hypertension. The study participants live all over Thailand and represent people well socio-demographically (Seubsman et al., 2012) even though they are younger and have a higher education attainment than average for general population. A previous 4-year follow up study in 2009 (Thawornchaisit et al., 2013c) and associated 2005 baseline cross-sectional study (Thawornchaisit et al., 2013a) identified risk factors for hypertension in Thai people. But the results of this 8-year study will be more accurate despite losing some statistical power due to cohort attrition. Worldwide many studies report on risks for hypertension however socio-economic, lifestyle and behaviour risks of each country are not similar. The results from our cohort will predict the trend of hypertension in Thailand.

However, our study has limitations. There may be recall and reporting errors. But our study of the validity of self-reported weight and height in open university students found that the accuracy was quite acceptable (Lim, Seubsman, & Sleigh, 2009). 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) (Thawornchaisit

et al., 2013b). We found that the sensitivity was high (82%) and that the negative reports were usually accurate (86%). Also published is our study validating self-reported diabetes (Papier, Jordan, et al., 2017). We also investigated the impact of the non-responses 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 (Thinkhamrop, Seubsman, & Sleigh, 2011). The findings from our study are robust and represent well the future trends of health risk transition in middle-income Thailand and in similar ASEAN countries.

In conclusion, older age, obesity and underlying morbidity due to diabetes, high blood lipids and kidney disease strongly increased risk of incident hypertension while physical inactivity, cigarette smoking, instant food and soft-drink consumption had a moderate effect. Education attainment and household assets had an inverse effect on risk of hypertension development. Sex, living with partner, sedentary lifestyle, alcohol drinking and the consumption of fruit and vegetables had no influence on hypertension. Prevention should focus on more consumption of healthy food with low fat, sugar and salt consumption, more physical exercise and less instant and soft-drink consumption. Thais should be encouraged to maintain normal BMI. A reduction of sugar consumption should be a national policy by limiting the concentration of sugar in soft-drink, ready-to-eat and industrial foods. Smoking cessation should be promoted for Thais especially men.

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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.

Competing Interests Statement

The authors declare that they have no competing or potential conflicts of interest.

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