Characteristics and clinical outcomes of people with hypertension receiving continuous care in Thailand: a cross-sectional study

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Summary

Background Hypertension (HT) is a major global health concern, including in Thailand. The present study aimed to identify the characteristics and clinical outcomes of people with HT receiving continuous care in Thailand in 2018.

Methods We conducted a nationwide cross-sectional study in 2018. People with HT aged 20 years and older receiving medical care at outpatient clinics in the targeted hospitals for at least 12 months were included.

Findings A total of 36,557 people with HT nationwide were enrolled in the current study. 61.5% of the participants were women, and the average age of the participants was 64.7 years. Most participants (53.3%) required two or more antihypertensive medications to control blood pressure (BP). The overall prevalence of BP control (systolic BP, <140 mmHg; diastolic BP, <90 mmHg) was 66.6% and 49.4% at the latest visit and the latest two consecutive times, respectively. BP control rate was lower for people with HT residing in the southern region compared to other regions. The prevalence of achieving the target goal of LDL cholesterol level (<100 mg/dL) was 39.9%, and that of BMI $\geq$ 25 kg/m^2 was 47.6%. Only 15.2% of participants received a 12-lead electrocardiogram (ECG) screening; among them, 2.8% had atrial fibrillation and 2.2% had left ventricular hypertrophy. The prevalence of the history of cerebrovascular, cardiovascular, and renal complications was 4.2%, 4.3%, and 13.1%, respectively, among people with HT.

Interpretation The findings indicated a potential for further improvement in the quality of HT care in Thailand. Accessibility to continuous care among males with HT requires additional responsiveness. BP control rate should be enhanced, especially in the southern region. A coverage of 12-lead ECG screening in people with HT should be increased. Weight management and reduction of LDL cholesterol levels should be encouraged to prevent cardiovascular complications.

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Keywords: Hypertension; Chracteristics; Clinical outcomes; Blood pressure control; Thailand; Nationwide

Introduction

Hypertension (HT) is a major global health issue and exhibits a constantly increasing trend. Global adults with HT doubled from approximately 650 million in 1990–1200 million in 2019, with two-thirds of the people with HT living in low-income and middle-income countries (LMICs).[1] Likewise, the rising prevalence of HT among the Southeast Asian population, including Thailand, was observed.[1,2]

In Thailand, the sixth National Health Examination Survey (NHES VI) in 2019 indicated that the prevalence of HT among Thai adults was 25.4, 26.7, and 24.2% among total adults, men, and women, respectively.[2] Nevertheless, the percentage of undiagnosed HT was 57.0% and 40.5% among men and women with HT, respectively. Furthermore, 4.1% of men and 3.0% of women were diagnosed with HT but went untreated. The prevalence of HT among Thai adults in urban and rural areas was comparable regarding residence.[2] Currently, HT is a major health problem in Thailand. The disability-adjusted life years from HT complications, including stroke and ischemic heart disease (IHD) in Thailand, constituted the second and third leading cause of morbidity, respectively, among men and women in 2018.[3]

Proper blood pressure (BP) control will reduce the risk of HT complications, including cerebrovascular, cardiovascular, and renal complications. Therefore, BP control was adopted as the outcome indicator and was

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Research in context

Evidence before this study

We searched PubMed with the terms ("Hypertension" or "blood pressure,") and ("characteristics" or "outcomes,") and ("Thailand") from the year 2000 to December 20, 2022. This search retrieved 637 results. These studies, all in English, demonstrated the situation of hypertension (HT), awareness, and control in Thailand based on the National Health Examination Survey data since 2009. Moreover, evidence reported the rate of uncontrolled HT at the latest visit and its associated factors among Thai patients with HT in 2014. However, the national representative information on characteristics, including the pattern of antihypertensive medication used, coverage and outcomes of laboratory testing results and electrocardiography screening, and HT complications in patients receiving continuous care in Thailand, was limited.

Added value of this study

This nationwide cross-sectional study provides extended, comprehensive, and up-to-date information about patients' characteristics and clinical outcomes of patients receiving HT care at public hospitals, private hospitals, and clinics supported nationwide by Thailand's National Health Security Office program in 2018. The study shows that most patients required two or more antihypertensive medications to control their BP. Regarding BP control (systolic BP, <140 mmHg; diastolic BP, <90 mmHg), two-thirds of patients achieved the goal at the latest visit, while half of the patients had BP control at the two latest consecutive visits. BP control rate among patients in the south region was lower than that in other regions, and we also provide the age- and sex-adjusted BP control rates stratified by the province in Thailand. Approximately half of the patients have obesity (BMI>25 kg/m^2), while only two-fifths of patients with HT achieved the target goal of LDL cholesterol of less than 100 mg/dL. Furthermore, in less than one-fifth of patients, a shallow rate of 12-lead electrocardiogram (ECG) screening was observed. Finally, the study also uncovered the status of HT complications, including cerebrovascular, cardiovascular, and renal complications, in patients with HT in Thailand.

Implications of all the available evidence

The results highlight an opportunity for further improvement in the quality of HT care. Our findings indicate that increasing accessibility to continuous care among men with HT requires further attention in Thailand. Control BP outcomes among those residing in the south should be improved. Obesity and the unachieved goal of LDL level among patients with HT should be given more attention to reduce cardiovascular complications in the future. Our study's findings suggest an opportunity to improve ECG screening to facilitate appropriate treatment for patients with HT. Patients receiving care at hospitals were enrolled in the study; however, approximately half of the overall patients with HT in Thailand receive care at primary care units (PCUs). Therefore, further studies should assess HT outcomes among patients receiving care at PCUs across the country, particularly in rural areas.

implemented as a key performance index for HT care in healthcare services supported by the National Health Security Office (NHSO) in Thailand in 2010.[4] The indicated target for the attainment of BP control is systolic BP <140 mmHg and diastolic BP <90 mmHg in people with HT. Based on the Sustainable Development Goals, in 2015, numerous countries began to move toward providing universal health coverage (UHC).[5] In Thailand, the UHC was implemented in 2002 and allowed all Thai populations, regardless of socioeconomic status, to access free essential preventive and curative services, including HT.[6] The present study is a nationwide study among people with HT, with the aim of determining the updated characteristics and clinical outcomes among people with HT receiving continuous care in Thailand in 2018, approximately two decades after implementing the UHC scheme in Thailand.

Methods

Study design and participants

We carried out a nationwide cross-sectional study in 2018 (from January 01, 2018 to July 31, 2018) to identify the characteristics and clinical outcomes of HT care among people with HT attending outpatient clinics at the public hospitals of the Ministry of Public Health (MoPH) in Thailand. We also included Bangkok's public hospitals, private hospitals, and private clinics supported by Thailand's NHSO program. People with HT aged 20 years and older who visited outpatient clinics and received medical care in the targeted hospitals for at least 12 months were eligible to participate in the study. People with HT with a history of pregnancy within 12 months or participating in other clinical trials were excluded.

We utilised a multistage sampling proportional to the size method used to select a national and provincial sample of people with HT in Thailand. The study sample was a stratified sample drawn from target hospitals and private clinics under the NHSO program. Hospitals were stratified into two levels. The first level was the provinces in Thailand, constituting 77 strata (77 provinces). The second level was the hospitals in each province, stratified into five strata: regional centre hospital, provincial general hospital, community hospital, private hospital, and private clinic. The primary sampling unit was the hospital. In the current study, all public hospitals outside Bangkok (931 hospitals) were

included, while 23 private hospitals under the NHSO program outside Bangkok were included. Meanwhile, 118 of 257 hospitals and private clinics in Bangkok (45.9%) were included in the present study. All university hospitals were not included in the study. We aimed to represent nationally the characteristics and clinical outcomes of people with HT. Therefore, the sample size of study participants for each province was calculated separately based on the total number of people with HT in each province. After the study site received the assigned sample size of study participants, the study site's coordinator calculated the quota of study samples for every clinic providing care for people with HT in each participating hospital.[7] In each hospital, an eligible individual with HT was invited to participate in the study.

Data collection

At each clinic, healthcare workers (usually registered nurses) invited people with HT with a preexisting diagnosis of HT in a consecutive sequence to participate in the study. Information about the current study, including study objectives and procedure, was provided to people with HT and were also asked to sign a consent form to allow the investigators to review and retrieve the data from their medical records. A standardised case report form (CRF) was utilised for medical record abstractions. The CRF was completed by a well-trained registered nurse using standard protocol. Subsequently, the information in the CRF was transferred to the electronic database of the study, which was linked to the Medical Research Network of the Consortium of Thai Medical Schools' central data management unit in Nonthaburi, Thailand. Data extracted from the patients' medical records included demographic information, medications prescribed to control their BP, BP level, the results of laboratory tests, and the status of HT complications.

Outcome variables

Information regarding demographic characteristics included the following: sex, age, health insurance scheme (UHC scheme, civil servant medical benefits [CSMB], social security scheme [SSS], and others), occupation, duration of HT treatment, behavioural factors (current smoking and current alcohol use), comorbidities (type 2 diabetes [T2D] and dyslipidaemia [DLP]), and status of follow-up with doctor appointment at the latest visit. Additionally, the prescription information for antihypertensive medications at the latest visit was collected. The medications were divided into five groups: (i) angiotensin-converting enzyme inhibitors (ACEI) or angiotensin receptor blockers (ARB); (ii) calcium channel blockers (CCB); (iii) beta-blockers (BB); (iv) diuretics (including mineralocorticoid receptor antagonist); (v) others.

Typically, a BP measurement station is provided at outpatient clinics, and people with HT self-measure BP using an automated BP measuring device attached to a printer. Then, the clinical nurse measures the BP again if the self-measured reading is ≥140/90 mmHg. Finally, the nurse enters the latest single BP reading in the patient's electronic health record to be reviewed by the physician.[8] In the current study, BP measurements of people with HT were collected for the latest three visits within the last 12 months: at the latest visit, one time before the latest visit, and two times before the latest visits. BP was categorised according to the Thai Hypertension Society Guidelines on HT treatment.[9] BP control was defined as systolic BP <140 mmHg and diastolic BP <90 mmHg at the latest visit. BP control for two consecutive times was defined as BP control at the latest visit and one time before the latest visit. A hypertensive crisis was defined as systolic BP ≥180 mmHg or diastolic BP ≥110 mmHg. BMI at the latest visit was collected and divided into five classes: 18.5–22.9 kg/m^2, <18.5 kg/m^2, 23.0–24.9 kg/m^2, 25.0–29.9 kg/m^2, and ≥30 kg/m^2.

In terms of laboratory tests, we collected the laboratory testing results of each patient within 12 months, including fasting plasma glucose (FPG), total cholesterol (TC), triglyceride (TG), LDL, HDL, estimated glomerular filtration rate (eGFR), and proteinuria test by urinalysis. If the results were available in multiple visits, the results at the latest visit would be collected. FPG was classified into three groups: <100 mg/dL, 100–125 mg/dL, and ≥ 126 mg/dL; TC into two groups: <200 mg/dL and ≥200 mg/dL; TG into two groups: <150 mg/dL and ≥ 150 mg/dL; LDL into two groups: <100 mg/dL and ≥ 100 mg/dL; and HDL into two groups: <40 mg/dL for men and <50 mg/dL for women; ≥ 40 mg/dL for men and ≥ 50 mg/dL for women.

eGFR (mL/min/1.73 m^2) was calculated through the use of the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation and was classified into six categories: stage I (≥90), stage II (60–89), stage IIIa (45–59), stage IIIb (30–44), stage IV (15–29), and stage IV (<15).[10] Proteinuria test result from urinalysis was categorised as negative and positive, 1+ to 4+. Regarding the 12-lead electrocardiogram (ECG), we collected the essential information from ECG, which was performed within 12 months and interpreted by the physician, including atrial fibrillation (ECG-AF), left atrial enlargement (ECG-LAE), and left ventricular hypertrophy (ECG-LVH).

A history of lifetime HT complications occurring after diagnosing HT was determined according to the International Classification of Diseases, Tenth Revision (ICD-10) codes.[11] Cerebrovascular complications comprised ischemic stroke (I63), haemorrhagic stroke (I60–I62), stroke unspecified (I64), transient ischemic attack (G45), cerebral aneurysm (I67.1), and cerebral atherosclerosis (I67.2). Cardiovascular complications included IHD (I20–I22, I25, and a history of coronary revascularisation) and heart failure (HF) (I50). Finally,

chronic kidney diseases (N18) were divided into three groups: renal insufficiency without dialysis, renal insufficiency with haemodialysis, and renal insufficiency with peritoneal dialysis.

Statistical analysis

All data analyses were performed using StataCorp. 2021 (Stata Statistical Software: Release 17. College Station, TX: StataCorp LLC). The analysis was restricted to the respondents, with the sample weighted against the NHSO database for the HT population in 2018. The svyset command was utilised for standard weighting procedures to construct sample weights considering the multistage sampling survey scheme.[12]

The characteristics and outcomes of participants were calculated using descriptive statistics. The information on some variables was missing, including smoking status (2.8%) and alcohol use (1.5%). For a large sample size, the existing data would be included in the analysis.

Categorical variables were presented as percentages with a 95% CI, while continuous variables were presented as mean, SD, and 95% CI when appropriate. The direct standardisation method was utilised to adjust for age and sex for the study population using the following six age and sex categories: men aged 20–44 years, 45–64 years, and ≥65 years; women aged 20–44, 45–64, and ≥65 years. χ^2 statistics were used for statistical analysis to determine differences among the percentages of the categorical outcomes of interest.

The logit model was utilised for determining the associated factors of BP control at the latest visit and BP control for the latest two consecutive times. The multivariable analysis was performed using the margins command (adjrr) after running the logit model in order to calculate the adjusted prevalence ratio (PR).[13] The following variables were included in the final model: sex, age, national region, health insurance scheme, occupation, location of outpatient clinics, current smoker, current alcohol use, T2D comorbidity, DLP, BMI, and follow-up with a doctor appointment. The magnitude of the association was presented as adjusted PR with 95% CI. Furthermore, we also identified the associated factors of BP control at the latest visit and BP control for the latest two consecutive times, stratified by age and sex. The interaction between age, sex, and other variables was also tested.

Ethics consideration

The current study was reviewed and approved by the Institutional Review Board, the Royal Thai Army Medical Department, Bangkok, Thailand, in accordance with international guidelines including the Declaration of Helsinki, the Belmont Report, CIOMS Guidelines, and the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use—Good Clinical Practice (ICH—GCP) (Approval No. S055 h/65). The study was also approved by the Ethics Review Committee for Research in Human Subjects, Ministry of Public Health, Thailand, and the local institutional review boards of the local participating hospitals. Written informed consent was obtained from the participants after they had read the information sheet and signed the consent form. The participants consented to the WMA Declaration of Helsinki–Ethical Principles for medical research involving human subjects.

Role of the funding source

The funding source had no role in the study design, collection, analysis, or interpretation of data or reporting of results.

Results

Characteristics of study participants

Table 1 displays the demographic characteristics of the study participants. A total of 36,667 people with HT in Thailand were enrolled in the current study; among them, 22,477 (61.5%) were women. The average age of study participants was 64.7 ± 11.9 years. About one-third of the participants (33.3%) resided in the central region, and most participants (74.0%) were under the UHC scheme 33.1% of the study participants were agriculturists, while 36.8% were unemployed or retired. As regards the location of the outpatient clinic, 69.3% of the study participants received HT care at community hospitals. The duration of HT treatment was on average 6.3 ± 4.2 years. The prevalence of current smoking was 9.0% in men and 0.5% in women. Moreover, the prevalence of T2D comorbidity was 13.6%, 16.8%, and 15.6% among men, women, and the total study population, respectively. On the contrary, approximately three-fourths (72.6%) of people with HT suffered from comorbid dyslipidaemia.

Prescription information for antihypertensive medications for people with HT

Table 2 presents a prescription for antihypertensive medications for people with HT in Thailand. Single therapy was prescribed to 44.5% of people with HT, while dual therapy and polytherapy were prescribed to 38.3% and 15.0%, respectively. ACEI or ARB was the most prescribed medication for single therapy for people with HT aged 20–44 years (48.8%), while CCB was mainly prescribed for people with HT aged 45–64 and ≥65 years (45.1% and 46.1%, respectively). Regarding dual therapy, the sex-adjusted percentage of ACEI or ARB + CCB prescription was the highest in all age groups, about half of those. Similarly, ACEI or ARB + CCB + BB was mainly prescribed for people with HT using polytherapy in all age groups, accounting for 31.5%, 29.3%, and 23.9% among those aged 20–44, 45–64, and ≥65 years, respectively.

	Men (n = 14,080)	Women (n = 22,477)	Total (n = 36,667)
Sex distribution	38.50%	61.50%	
Age, years			
20–29	36 (0.3%)	31 (0.1%)	67 (0.2%)
30–39	244 (1.7%)	306 (1.4%)	550 (1.5%)
40–49	1137 (8.1%)	1999 (8.9%)	3136 (8.6%)
50–59	3088 (21.9%)	5435 (24.2%)	8523 (23.3%)
60–69	4563 (32.4%)	7035 (31.3%)	11,598 (31.7%)
70–79	3491 (24.8%)	5080 (22.6%)	8571 (23.4%)
80–89	1369 (9.7%)	2338 (10.4%)	3707 (10.1%)
≥90	152 (1.1%)	253 (1.1%)	405 (1.1%)
Mean (SD)	64.9 (11.9)	64.5 (11.9)	64.7 (11.9)
National region			
North	3423 (24.3%)	4738 (21.0%)	8161 (22.3%)
Central	4513 (32.1%)	7647 (34.0%)	12,160 (33.3%)
Northeast	3840 (27.3%)	6175 (27.5%)	10,015 (27.4%)
South	2304 (16.4%)	3917 (17.4%)	6221 (17.0%)
Health insurance scheme			
Universal health coverage	9995 (71.0%)	17,062 (75.9%)	27,057 (74.0%)
Civil servant medical benefits	3081 (21.9%)	4190 (18.6%)	7271 (19.9%)
Social security	733 (5.2%)	870 (3.9%)	1603 (4.4%)
Others	271 (1.9%)	355 (1.6%)	626 (1.7%)
Occupation			
Agriculturist	4795 (34.1%)	7317 (32.6%)	12,112 (33.1%)
Employee	2266 (16.1%)	3050 (13.6%)	5316 (14.5%)
Government officer	1208 (8.6%)	801 (3.6%)	2009 (5.5%)
Private officer	156 (1.1%)	144 (0.6%)	300 (0.8%)
Business owner	593 (4.2%)	1157 (5.1%)	1750 (4.8%)
No occupation	4330 (30.8%)	9124 (40.6%)	13,454 (36.8%)
Others	732 (5.2%)	884 (3.9%)	1616 (4.4%)
Location of outpatient clinics			
Regional hospital	959 (6.8%)	1544 (6.9%)	2503 (6.8%)
General hospital	2309 (16.4%)	3669 (16.3%)	5978 (16.4%)
Community hospital	9726 (69.1%)	15,607 (69.4%)	25,333 (69.3%)
Private hospital	142 (1.0%)	298 (1.3%)	440 (1.2%)
Others	944 (6.7%)	1359 (6.0%)	2303 (6.3%)
Duration of hypertension treatment, years			
1–3	4592 (32.6%)	6590 (29.3%)	11,182 (30.6%)
>3–6	4014 (28.5%)	5909 (26.3%)	9923 (27.1%)
>6–9	2938 (20.9%)	5011 (22.3%)	7949 (21.7%)
>9	2536 (18.0%)	4967 (22.1%)	7503 (20.5%)
Mean (SD)	6.0 (4.0)	6.5 (4.2)	6.3 (4.2)
Current smoker	1231 (9.0%)	100 (0.5%)	1331 (3.7%)
Current alcohol use	1712 (12.3%)	261 (1.2%)	1973 (5.5%)
Diabetes	1915 (13.6%)	3770 (16.8%)	5685 (15.6%)
Dyslipidaemia	10,026 (71.2%)	16,510 (73.5%)	26,536 (72.6%)

Table 1: **Demographic of study population.**

BP outcomes of people with HT

Table 3 shows the BP outcomes of people with HT in Thailand. The average systolic and diastolic BP at the latest visit were 134.1 and 75.9 mmHg, respectively. The overall prevalence of BP control among people with HT was 66.6%, 64.1%, and 49.4% at the latest visit, one time before the latest visit, and the latest two consecutive times, respectively. Fig. 1 illustrates the age- and sex-adjusted prevalence of BP control stratified by province in Thailand (Supplementary Table S1). Moreover, a substantially low BP control rate was observed in three provinces of Thailand's deep south, including Pattani,

Age groups, year	Men			Women			p-value	Sex-adjusted			p-value	Overall
	20–44	45–64	≥65	20–44	45–64	≥65		20–44	45–64	≥65		
Study participants, N	**693**	**6112**	**7275**	**960**	**10,390**	**11,127**		**1653**	**16,502**	**18,402**		**36,557**
No medication use, N (%)	**14 (2.2%)**	**117 (1.7%)**	**182 (2.4%)**	**18 (1.7%)**	**246 (2.4%)**	**277 (2.4%)**		**32 (1.9%)**	**363 (2.1%)**	**459 (2.4%)**		**854 (2.2%)**
Single therapy, N (%)							<0.0001				<0.0001	
ACEI or ARB	146 (47.9%)	1170 (42.4%)	1069 (35.2)	228 (49.4%)	2189 (42.9%)	1873 (37.7%)		374 (48.8%)	3359 (42.7%)	2942 (36.8%)		6675 (40.0%)
CCB	112 (41.2%)	1274 (47.6%)	1438 (38.2%)	185 (39.1%)	2098 (43.5%)	2234 (46.7%)		297 (39.9%)	3372 (45.1%)	3672 (46.1%)		7341 (46.1%)
***β*-blocker**	18 (6.6%)	133 (4.7%)	147 (5.5%)	26 (5.2%)	301 (6.4%)	313 (6.8%)		44 (5.7%)	434 (5.8%)	460 (6.0%)		938 (6.0%)
Diuretic	7 (2.3%)	89 (3.5%)	141 (5.1%)	21 (4.8%)	276 (5.9%)	306 (6.2%)		28 (3.8%)	365 (5.0%)	447 (5.3%)		840 (5.3%)
Other	7 (2.0%)	52 (1.9%)	135 (5.0%)	8 (1.5%)	57 (1.3%)	111 (2.5%)		15 (1.7%)	109 (1.5%)	246 (2.5%)		370 (2.5%)
Total	**290 (42.1%)**	**2718 (44.2%)**	**2930 (40.8%)**	**468 (49.5%)**	**4921 (47.6%)**	**4837 (43.8%)**		**758 (46.6%)**	**7639 (46.3%)**	**7767 (42.6%)**		**16,164 (44.5%)**
Dual therapy, N (%)							<0.0001				<0.0001	
ACEI or ARB + CCB	178 (59.9%)	1468 (57.9%)	1441 (46.8%)	199 (50.9%)	2087 (51.9%)	2113 (49.1%)		377 (54.3%)	3555 (54.2%)	3554 (48.2%)		7486 (51.2%)
ACEI or ARB + ***β*-blocker**	32 (12.6%)	256 (10.9%)	254 (9.1%)	53 (17.1%)	457 (11.7%)	433 (9.8%)		85 (15.4%)	713 (11.4%)	687 (9.5%)		1485 (10.6%)
ACEI or ARB + Diuretic	15 (5.3%)	177 (7.7%)	205 (7.2%)	25 (8.4%)	436 (11.8%)	426 (10.3%)		40 (7.2%)	613 (10.2%)	631 (9.0%)		1284 (9.5%)
ACEI or ARB + Other	4 (1.4%)	64 (2.8%)	198 (6.4%)	3 (0.8%)	79 (2.1%)	143 (3.5%)		7 (1.1%)	143 (2.4%)	341 (4.6%)		491 (3.5%)
CCB + ***β*-blocker**	27 (9.5%)	213 (9.6%)	256 (9.3%)	41 (12.3%)	377 (10.3%)	436 (10.6%)		68 (11.2%)	590 (10.0%)	692 (10.1%)		1350 (10.1%)
CCB + Diuretic	15 (6.6%)	104 (4.7%)	162 (6.1%)	14 (4.8%)	242 (6.5%)	329 (8.1%)		29 (5.5%)	346 (5.8%)	491 (7.3%)		866 (6.6%)
CCB + Other	8 (3.2%)	84 (3.2%)	270 (9.7%)	8 (2.2%)	59 (1.3%)	149 (3.5%)		16 (2.6%)	143 (2.1%)	419 (5.9%)		578 (4.0%)
***β*-blocker + Diuretic**	3 (1.1%)	29 (1.2%)	52 (1.7%)	9 (2.6%)	102 (2.9%)	110 (2.8%)		12 (2.1%)	131 (2.2%)	162 (2.4%)		305 (2.3%)
***β*-blocker + Other**	1 (0.4%)	20 (1.0%)	56 (2.2%)	4 (1.0%)	16 (0.5%)	47 (1.2%)		5 (0.8%)	36 (0.7%)	103 (1.6%)		144 (1.1%)
Diuretic + Other	0 (0%)	20 (1.0%)	46 (1.7%)	0 (0.0%)	29 (0.9%)	41 (1.1%)		0 (0%)	49 (1.0%)	87 (1.3%)		136 (1.1%)
Total	**283 (40.0%)**	**2435 (40.0%)**	**2940 (40.0%)**	**356 (36.5%)**	**3884 (36.7%)**	**4227 (37.2%)**		**639 (37.9%)**	**6319 (38.0%)**	**7167 (38.3%)**		**14,125 (38.3%)**
Poly therapy, N (%)							<0.0001				<0.0001	
ACEI or ARB + CCB +***β*-blocker**	39 (34.5%)	253 (28.1%)	271 (21.4%)	35 (29.6%)	426 (30.0%)	466 (25.4%)		74 (31.5%)	679 (29.3%)	737 (23.9%)		1490 (26.7%)
ACEI or ARB + CCB + Diuretic	18 (20.3%)	165 (19.7%)	187 (15.6%)	21 (16.0%)	255 (19.1%)	341 (19.1%)		39 (17.6%)	420 (19.3%)	528 (17.8%)		987 (18.4%)
ACEI or ARB + CCB + Other	15 (14.4%)	114 (14.4%)	234 (19.5%)	15 (10.4%)	126 (9.8%)	218 (12.1%)		30 (11.9%)	240 (11.6%)	452 (15.0%)		722 (13.3%)
CCB + ***β*-blocker** + Diuretic	10 (10.3%)	83 (11.6%)	90 (7.6%)	13 (12.6%)	165 (12.5%)	201 (11.4%)		23 (11.7%)	248 (12.2%)	291 (10.0%)		562 (11.0%)
CCB + ***β*-blocker** + Other	18 (15.7%)	73 (8.5%)	139 (10.9%)	9 (8.0%)	79 (6.1%)	132 (6.9%)		27 (11.0%)	152 (7.0%)	271 (8.5%)		450 (7.9%)
***β*-blocker + Diuretic + Other**	2 (1.3%)	46 (4.8%)	89 (7.1%)	5 (5.8%)	63 (4.8%)	123 (7.1%)		7 (4.1%)	109 (4.8%)	212 (7.1%)		328 (5.9%)
Other combinations	4 (3.5%)	108 (12.9%)	213 (17.8%)	20 (17.7%)	225 (17.8%)	305 (17.9%)		24 (12.2%)	333 (15.9%)	518 (17.9%)		875 (16.7%)
Total	**106 (15.6%)**	**842 (14.1%)**	**1223 (16.9%)**	**118 (12.3%)**	**1339 (13.3%)**	**1786 (16.1%)**		**224 (13.6%)**	**2181 (13.6%)**	**3009 (16.4%)**		**5414 (15.0%)**

ACEI: angiotensin-converting enzyme inhibitors, ARB: angiotensin receptor blockers, ***β*-blocker**: beta blockers, CCB: calcium channel blockers.

***Table 2:* Uses of antihypertensive medication among people with hypertension in Thailand.**

Age group, years	Men			Women			p-value	Sex-adjusted			p-value	Overall
	20–44	45–64	≥65	20–44	45–64	≥65		20–44	45–64	≥65		
Study participants, N	**693**	**6112**	**7275**	**960**	**10,390**	**11,127**		**1653**	**16,502**	**18,402**		**36,557**
Number of blood pressure measurement within 12 months							0.57				0.02	
0	2 (0.3%)	17 (0.3%)	16 (0.3%)	0 (0%)	15 (0.2%)	30 (0.3%)		2 (0.1%)	32 (0.2%)	46 (0.3%)		80 (0.2%)
1	11 (1.3%)	69 (1.3%)	66 (1.0%)	5 (0.4%)	106 (1.2%)	120 (1.0%)		16 (0.7%)	175 (1.1%)	186 (1.0%)		377 (1.1%)
2	41 (5.8%)	277 (4.4%)	271 (3.8%)	51 (5.5%)	475 (4.6%)	459 (4.1%)		92 (5.6%)	752 (4.5%)	730 (4.0%)		1574 (4.3%)
3	639 (92.6%)	5749 (94.0%)	6922 (95.0%)	904 (94.2%)	9794 (94.3%)	10,518 (94.5%)		1543 (93.6%)	15,543 (94.2%)	17,440 (94.7%)		34,526 (94.4%)
Interval between latest BP and before latest BP measurement, days							0.62				<0.0001	
<30	74 (11.5%)	514 (8.9%)	700 (9.9%)	97 (10.7%)	916 (9.2%)	1006 (9.9%)		171 (11.0%)	1430 (9.1%)	1706 (9.9%)		3307 (9.6%)
30–59	129 (20.0%)	1196 (20.3%)	1597 (23.1%)	201 (21.9%)	2026 (20.5%)	2360 (22.3%)		330 (21.2%)	3222 (20.4%)	3957 (22.6%)		7509 (21.5%)
60–89	236 (34.7%)	2271 (38.1%)	2679 (36.7%)	351 (35.6%)	3837 (36.7%)	4124 (36.8%)		587 (35.2%)	6108 (37.2%)	6803 (36.8%)		13,498 (36.9)
>90	241 (33.8%)	2045 (33.8%)	2217 (30.3%)	306 (31.8%)	3490 (33.6%)	3487 (31.1%)		547 (32.6%)	5535 (33.3%)	5704 (30.7%)		11,786 (32.0%)
Mean (95% CI)	77.6 (74.4–80.8)	78.5 (77.5–79.5)	76.6 (75.6–77.5)	76.6 (74.1–79.2)	79.4 (78.6–80.3)	77.6 (76.9–78.4)		77 (75.0–79.0)	79.1 (78.4–79.7)	77.2 (76.6–77.8)		78.1 (77.6–78.5)
Systolic blood pressure (latest visit), mmHg							0.01				<0.0001	
<120	59 (8.0%)	660 (10.6%)	900 (12.3%)	112 (12.2%)	1328 (12.7%)	1373 (12.2%)		171 (10.6%)	1988 (11.9%)	2273 (12.3%)		4432 (12.0%)
120–129	179 (25.6%)	1360 (22.0%)	1512 (20.7%)	231 (22.7%)	2324 (22.1%)	2110 (18.9%)		410 (23.8%)	3684 (22.1%)	3622 (19.6%)		7716 (20.9%)
130–139	280 (41.1%)	2343 (38.9%)	2567 (35.2%)	365 (39.5%)	3903 (37.4%)	3973 (35.6%)		645 (40.1%)	6246 (38.0%)	6540 (35.4%)		13,431 (36.8%)
140–159	150 (22.2%)	1505 (24.7%)	1849 (25.5%)	207 (21.0%)	2381 (23.6%)	2921 (26.6%)		357 (21.4%)	3886 (24.0%)	4770 (26.2%)		9013 (25.0%)
160–179	20 (2.6%)	202 (3.3%)	381 (5.6%)	36 (3.9%)	386 (3.7%)	602 (5.6%)		56 (3.4%)	588 (3.6%)	983 (5.6%)		1627 (4.6%)
≥180	3 (0.5%)	25 (0.5%)	50 (0.8%)	9 (0.8%)	53 (0.6%)	118 (1.2%)		12 (0.7%)	78 (0.5%)	168 (1.0%)		258 (0.8%)
Mean (95% CI)	133.7 (132.7–134.7)	133.8 (133.4–134.2)	134.3 (133.9–134.7)	133.3 (132.3–134.2)	133.3 (133.0–133.6)	135.1 (134.7–135.4)		133.4 (132.7–134.1)	133.5 (133.2–133.7)	134.8 (134.5–135.0)		134.1 (133.9–134.3)
Diastolic blood pressure (latest visit), mmHg							<0.0001				<0.0001	
<80	214 (30.1%)	2622 (42.7%)	4847 (66.6%)	295 (31.5%)	5558 (53.7%)	7825 (70.6%)		509 (30.9%)	8180 (49.4%)	12,672 (69.1%)		21,361 (58.5%)
80–84	160 (23.5%)	1593 (26.0%)	1379 (19.1%)	286 (30.4%)	2450 (23.4%)	1941 (17.3%)		446 (27.8%)	4043 (24.4%)	3320 (18.0%)		7809 (21.3%)
85–89	125 (19.0%)	888 (14.9%)	462 (6.4%)	156 (15.7%)	1205 (11.7%)	619 (5.7%)		281 (17.0%)	2093 (13.0%)	1081 (5.9%)		3455 (9.6%)
90–99	150 (21.2%)	856 (14.1%)	492 (6.7%)	176 (17.3%)	1008 (9.7%)	635 (5.7%)		326 (18.8%)	1864 (11.4%)	1127 (6.1%)		3317 (9.1%)
100–109	35 (5.1%)	118 (2.0%)	63 (0.9%)	38 (4.0%)	123 (1.2%)	67 (0.6%)		73 (4.4%)	241 (1.5%)	130 (0.7%)		444 (1.3%)
≥110	7 (1.1%)	18 (0.3%)	16 (0.3%)	9 (1.1%)	31 (0.3%)	10 (0.1%)		16 (1.1%)	49 (0.3%)	26 (0.2%)		91 (0.3%)
Mean (95% CI)	83.6 (82.8–84.5)	79.9 (79.6–80.2)	73.9 (73.7–74.2)	82.3 (81.6–83.1)	77.4 (77.2–77.7)	72.5 (72.3–72.8)		82.8 (82.3–83.4)	78.4 (78.2–78.6)	73.1 (72.9–73.2)		75.9 (75.8–76.0)
Systolic blood pressure (1 time before latest visit), mmHg							0.49				<0.0001	
<120	67 (9.9%)	686 (11.1%)	877 (12.0%)	93 (9.6%)	1263 (12.2%)	1257 (11.5%)		160 (9.7%)	1949 (11.8%)	2134 (11.7%)		4243 (11.7%)
120–129	172 (24.0%)	1283 (20.9%)	1353 (19.1%)	212 (21.5%)	2228 (21.6%)	2128 (19.1%)		384 (22.5%)	3511 (21.3%)	3481 (19.1%)		7376 (20.3%)
130–139	243 (36.5%)	2210 (36.8%)	2513 (34.9%)	366 (38.3%)	3754 (36.2%)	3807 (34.2%)		609 (37.6%)	5964 (36.4%)	6320 (34.5%)		12,893 (35.5%)
140–159	170 (25.6%)	1560 (26.5%)	1952 (26.9%)	235 (25.0%)	2537 (25.3%)	2964 (27.2%)		405 (25.2%)	4097 (25.8%)	4916 (27.1%)		9418 (26.4%)
160–179	24 (3.5%)	242 (3.9%)	414 (5.9%)	40 (4.9%)	416 (4.1%)	690 (6.7%)		64 (4.3%)	658 (4.0%)	1104 (6.4%)		1826 (5.2%)
≥180	4 (0.6%)	45 (0.8%)	84 (1.3%)	9 (0.8%)	71 (0.7%)	131 (1.3%)		13 (0.7%)	116 (0.7%)	215 (1.3%)		344 (1.0%)
Mean (95% CI)	133.9 (132.8–135.0)	134.3 (133.9–134.7)	135.3 (134.9–135.7)	134.7 (133.6–135.7)	133.8 (133.5–134.1)	135.6 (135.2–135.9)		134.4 (133.6–135.1)	134 (133.8–134.3)	135.5 (135.2–135.7)		134.8 (134.6–134.9)

(Table 3 continues on next page)

Age group, years	Men			Women			p-value	Sex-adjusted			p-value	Overall
	20–44	45–64	≥65	20–44	45–64	≥65		20–44	45–64	≥65		
(Continued from previous page)												
Diastolic blood pressure (1 time before latest visit), mmHg							<0.0001				<0.0001	
<80	206 (30.1%)	2494 (41.6%)	4557 (63.4%)	281 (28.7%)	5282 (52.0%)	7651 (69.7%)		487 (29.3%)	7776 (48.0%)	12,208 (67.4%)		20,471 (56.9)
80–84	167 (24.1%)	1642 (27.1%)	1470 (20.1%)	267 (26.9%)	2503 (24.1%)	1933 (17.6%)		434 (25.8%)	4145 (25.2%)	3403 (18.5%)		7982 (21.9)
85–89	122 (17.6%)	850 (14.2%)	542 (7.5%)	162 (16.9%)	1224 (11.7%)	617 (5.7%)		284 (17.2%)	2074 (12.6%)	1159 (6.4%)		3517 (9.7)
90–99	149 (21.9%)	866 (14.3%)	520 (7.4%)	191 (21.7%)	1079 (10.6%)	680 (6.2%)		340 (21.8%)	1945 (12.0%)	1200 (6.7%)		3485 (9.7)
100–109	28 (4.8%)	142 (2.4%)	80 (1.1%)	41 (4.4%)	154 (1.5%)	79 (0.7%)		69 (4.6%)	296 (1.9%)	159 (0.9%)		524 (1.5%)
≥110	8 (1.5%)	32 (0.5%)	24 (0.4%)	13 (1.4%)	27 (0.1%)	17 (0.2%)		21 (1.4%)	59 (0.3%)	41 (0.2%)		121 (0.3%)
Mean (95% CI)	83.7 (82.7–84.6)	80.2 (79.9–80.4)	74.5 (74.3–74.8)	83.5 (82.8–84.3)	77.8 (77.6–78.0)	72.9 (72.7–73.2)		83.6 (83.0–84.1)	78.7 (78.5–78.9)	73.6 (73.4–73.7)		76.3 (76.2–76.4)
Control blood pressure[a]												
Latest visit	440 (63.6%)	4025 (65.7%)	4842 (66.3%)	630 (66.3%)	7240 (69.2%)	7298 (65.2%)	0.04	1070 (65.3%)	11,265 (67.9%)	12,140 (65.6%)	0.0002	24,475 (66.6%)
One time before latest visit	416 (59.9%)	3846 (63.4%)	4594 (63.7%)	590 (60.5%)	6896 (66.5%)	7001 (63.2%)	0.04	1006 (60.3%)	10,742 (65.3%)	11,595 (63.4%)	<0.0001	23,343 (64.1%)
Both latest two visits	314 (44.6%)	2958 (48.8%)	3519 (48.7%)	454 (47.2%)	5436 (52.3%)	5311 (47.9%)	0.03	768 (46.2%)	8394 (50.9%)	8830 (48.2%)	<0.0001	17,992 (49.4%)
Hypertensive crisis[b]												
Latest visit	9 (1.4%)	36 (0.7%)	59 (0.9%)	16 (1.7%)	68 (0.7%)	124 (1.2%)	0.18	25 (1.6%)	104 (0.7%)	183 (1.1%)	0.0002	312 (0.9%)
One time before latest visit	11 (1.9%)	63 (1.0%)	91 (1.4%)	20 (2.1%)	85 (0.8%)	139 (1.3%)	0.23	31 (2.0%)	148 (0.9%)	230 (1.3%)	<0.0001	409 (1.2%)
Both latest two visits	1 (0.2%)	7 (0.1%)	10 (0.2%)	4 (0.3%)	14 (0.2%)	24 (0.3%)	0.43	5 (0.3%)	21 (0.2%)	34 (0.2%)	0.33	60 (0.2%)

[a]Systolic blood pressure <140 mmHg and Diastolic blood pressure <90 mmHg. [b]Systolic blood pressure ≥ 180 mmHg or Diastolic blood pressure ≥ 110 mmHg

Table 3: **Blood pressure outcomes among people with hypertension in Thailand.**

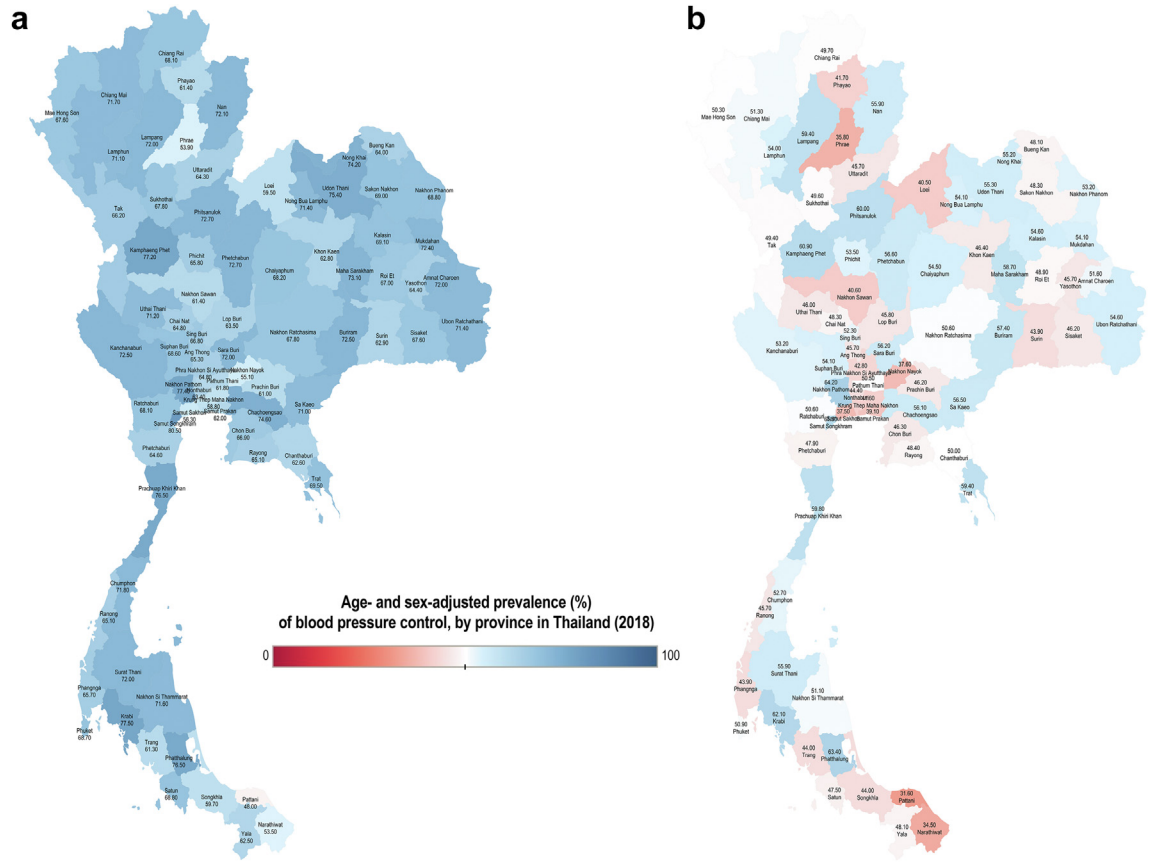

Fig. 1: Age- and sex-adjusted prevalence of blood pressure control among people with hypertension in 2018 in Thailand, stratified by province. (a) Age- and sex-adjusted prevalence of blood pressure control at the latest visit. (b) Age- and sex-adjusted prevalence of control blood pressure at the latest two consecutive times.

Yala, and Narathiwat (Fig. 1). In terms of age group, the sex-adjusted prevalence of BP control was the highest among people with HT aged 45–64 years, with 67.9%, 65.3%, and 50.9% at the latest visit, one time before the latest visit, and the latest two consecutive times, respectively. In terms of sex, among people with HT younger than 65 years, the prevalence of BP control among men was lower than that among women, while among people with HT aged ≥65 years, the prevalence of BP control was comparable between both sexes (Fig. 2).

Factors associated with BP control

Multivariable adjusted PR from the logit models is presented in Fig. 3. After mutually adjusting for demographic and behavioural factors, the prevalence of BP control was lower for men than that for women, people residing in the southern region, those who were under UHC, those receiving care at private hospitals, those who reported current alcohol consumption, those who had T2D comorbidity, and those who missed a doctor appointment. Furthermore, people with HT with BMI ≥ 25 kg/m^2 had a lower prevalence of BP control than those with a normal BMI of 18.5–22.9 kg/m^2 (Supplementary Table S2). Factors associated with BP control at the latest visit and BP control for the latest two consecutive times, stratified by age and sex, were provided in Supplementary Tables S3–S6. However, the interaction between age and sex was not observed.

Clinical outcomes of people with HT

Table 4 presents the clinical outcomes and laboratory testing results of people with HT. The overall average BMI of hypertensive people with HT nationwide was 25.1 kg/m^2. The prevalence of BMI 25.0–29.9 and ≥30 kg/m^2 was 33.8% and 13.8%, respectively. Sex-adjusted prevalence of BMI ≥ 30 kg/m^2 was 32.0, 18.4, and 7.9% among people with HT aged 20–44, 45–64, and ≥65 years, respectively. The prevalence of BMI ≥ 30 kg/m^2 among women was higher than that among men in all age groups. About 90% of people with HT nationwide had at least one LDL blood test during the previous 12 months (Supplementary Table S7). The prevalence of

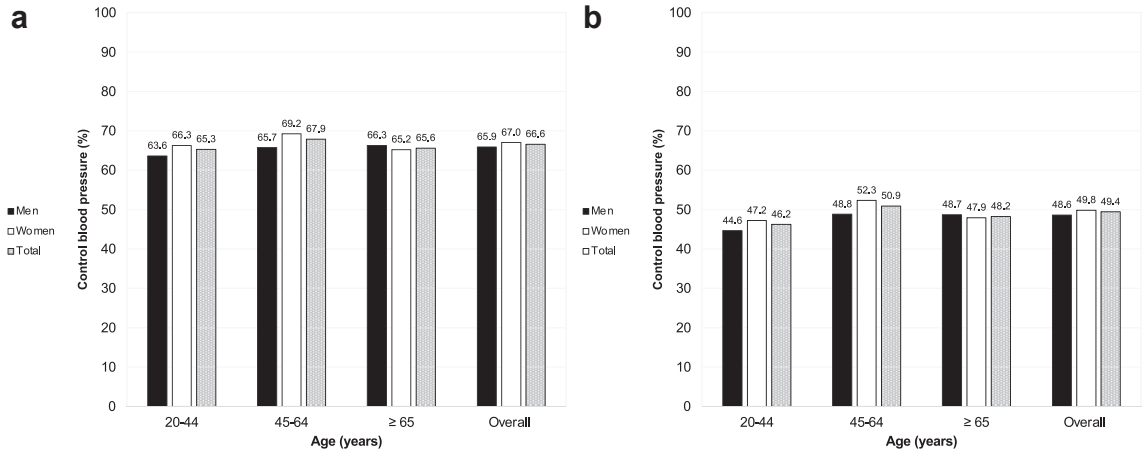

Fig. 2: Prevalence of blood pressure control among people with hypertension in 2018 in Thailand, stratified by age and sex. (a) Age- and sex-adjusted prevalence of blood pressure control at the latest visit. (b) Age- and sex-adjusted prevalence of blood pressure control at the latest two consecutive times.

people with HT achieving the target goal of an LDL level less than 100 mg/dL was 39.9%. Sex-adjusted prevalence of LDL less than 100 mg/dL was higher among people with HT aged ≥ 65 years compared to those aged 20–44 and 45–64 years. About 95% of people with HT had at least one eGFR test in the latest 12 months; the average eGFR was 76.2 mL/min/1.73 m^2. Only 35.9% of people with HT had at least one proteinuria test in the previous 12 months (Supplementary Table S7), and 83.6% of those were negative for proteinuria. Furthermore, just 15.2% of people with HT nationwide received a 12-lead ECG test during the previous 12 months (Supplementary

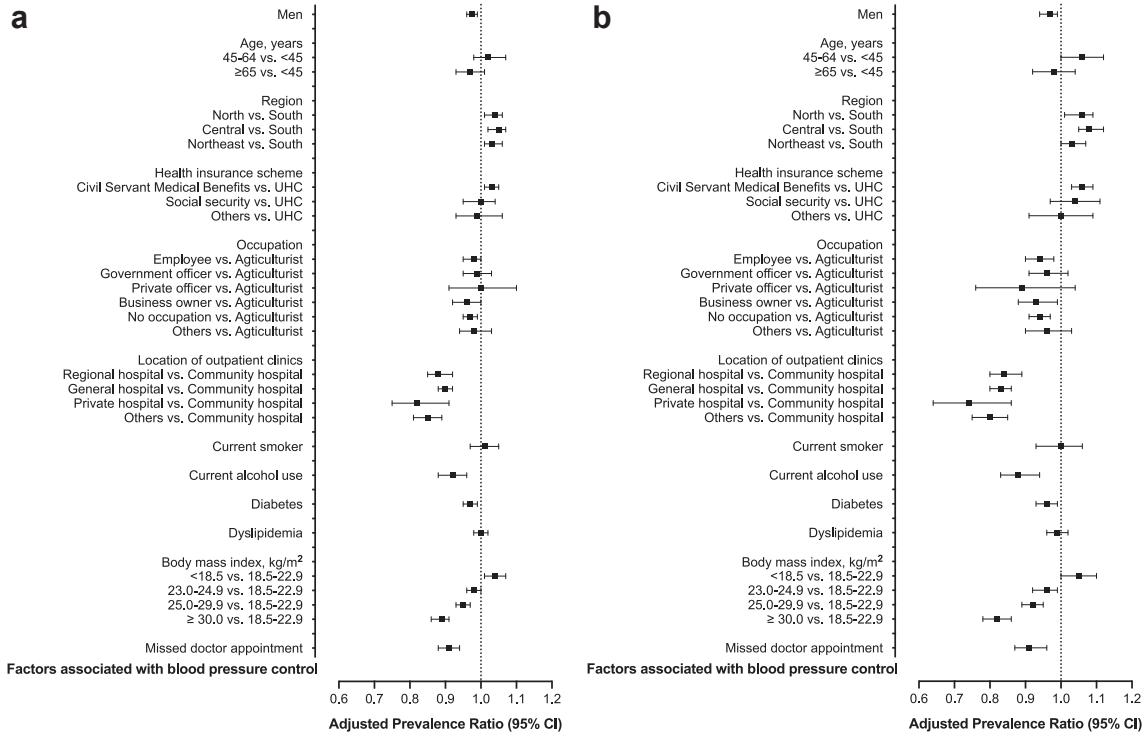

Fig. 3: Multivariable analysis factor associated with blood pressure control. (a) Factors associated with blood pressure control at the latest visit. (b) Factors associated with blood pressure control at the latest two consecutive times.

Age groups, year	Men			Women			p-value	Sex-adjusted			p-value	Overall
	20–44	45–64	≥65	20–44	45–64	≥65		20–44	45–64	≥65		
Study participants, N	693	6112	7275	960	10,390	11,127		1653	16,502	18,402		36,557
BMI, kg/m^2							<0.0001				<0.0001	
18.5–22.9	99 (13.6%)	1416 (23.1%)	2674 (37.2%)	134 (14.2%)	1944 (18.5%)	3595 (32.5%)		233 (14.0%)	3360 (20.3%)	6269 (34.4%)		9862 (27.1%)
<18.5	9 (1.3%)	158 (2.6%)	702 (9.4%)	16 (2.0%)	213 (2.1%)	1166 (10.4%)		25 (1.7%)	371 (2.3%)	1868 (10.0%)		2264 (6.2%)
23.0–24.9	100 (15.0%)	1258 (20.3%)	1555 (21.9%)	105 (11.5%)	1865 (18.3%)	2012 (18.7%)		205 (12.8%)	3123 (19.1%)	3567 (20.0%)		6895 (19.2%)
25.0–29.9	279 (39.8%)	2398 (39.7%)	1827 (26.0%)	377 (39.4%)	4122 (40.1%)	3117 (28.9%)		656 (39.5%)	6520 (39.9%)	4944 (27.7%)		12,120 (33.8%)
≥30.0	197 (30.4%)	824 (14.2%)	398 (5.5%)	322 (33.0%)	2151 (21.0%)	994 (9.4%)		519 (32.0%)	2975 (18.4%)	1392 (7.9%)		4886 (13.8%)
Mean (95% CI)	28.1 (27.7–28.5)	25.7 (25.6–25.8)	23.4 (23.3–23.5)	28.2 (27.8–28.6)	26.7 (26.6–26.8)	24.1 (24.0–24.2)		28.2 (27.9–28.5)	26.3 (26.2–26.4)	23.8 (23.8–23.9)		25.1 (25.1–25.2)
Fasting plasma glucose, mg/dL							<0.0001				<0.0001	
<100	257 (42.4%)	2265 (42.0%)	3003 (48.1%)	493 (59.2%)	4512 (49.1%)	4531 (46.6%)		750 (52.7%)	6777 (46.4%)	7534 (47.2%)		15,061 (47.1%)
100–125	236 (41.1%)	2269 (43.2%)	2489 (40.2%)	235 (29.5%)	3176 (35.5%)	3718 (39.3%)		471 (34.0%)	5445 (38.5%)	6207 (38.7%)		12,123 (38.8%)
≥126	86 (16.5%)	755 (14.8%)	697 (11.7%)	100 (11.3%)	1392 (15.4%)	1321 (14.1%)		186 (13.3%)	2147 (15.2%)	2018 (13.2%)		4351 (14.1%)
Mean (95% CI)	111.3 (108.2–114.5)	109.4 (108.4–110.3)	106.4 (105.4–107.3)	105.1 (102.6–107.7)	108.6 (107.9–109.4)	107.8 (107.2–108.5)		107.5 (105.5–109.5)	108.9 (108.3–109.5)	107.3 (106.7–107.8)		108.0 (107.6–108.4)
Total cholesterol, mg/dL							<0.0001				<0.0001	
<200	328 (58.1%)	3250 (64.2%)	4357 (72.1%)	487 (62.0%)	4971 (55.9%)	5772 (59.2%)		815 (60.5%)	8221 (59.1%)	10,129 (65.9%)		19,165 (62.6%)
≥200	235 (41.9%)	1794 (35.8%)	1627 (27.9%)	309 (38.0%)	3759 (44.1%)	3363 (40.8%)		544 (39.5%)	5553 (40.9%)	4990 (34.1%)		11,087 (37.4%)
Mean (95% CI)	194.5 (190.5–198.4)	188.2 (187.0–189.4)	179.5 (178.5–180.6)	192.7 (189.7–195.8)	197.7 (196.8–198.7)	190.7 (189.8–191.6)		193.4 (191.0–195.8)	194.1 (193.3–194.8)	186.4 (185.7–187.1)		109.2 (189.7–190.7)
Triglyceride, mg/dL							0.0122				<0.0001	
<150	261 (42.7%)	2938 (55.9%)	4325 (70.2%)	521 (63.5%)	5698 (63.3%)	6151 (65.1%)		782 (55.5%)	8636 (60.4%)	10,476 (67.1%)		19,894 (63.6%)
≥150	325 (57.3%)	2304 (44.1%)	1823 (29.8%)	296 (36.5%)	3326 (36.7%)	3276 (34.9%)		621 (44.5%)	5630 (39.6%)	5099 (32.9%)		11,350 (36.4%)
Mean (95% CI)	198.6 (185.8–211.5)	163.6 (160.5–166.7)	134.5 (132.5–136.5)	146.7 (138.4–155.0)	149.2 (147.1–151.3)	142.3 (140.7–143.9)		166.7 (159.6–173.8)	154.7 (153.0–156.5)	139.3 (138.0–140.6)		147.5 (146.4–148.5)
LDL cholesterol, mg/dL							<0.0001				<0.0001	
<100	237 (39.7%)	2160 (39.8%)	3004 (46.5)	286 (32.8%)	3287 (34.6%)	4103 (41.3%)		523 (35.5%)	5447 (36.6%)	7107 (43.3%)		13,077 (39.9%)
≥100	356 (60.3%)	3240 (60.2%)	3383 (53.5%)	556 (67.2%)	6023 (65.4%)	5663 (58.7%)		912 (64.5%)	9263 (63.4%)	9046 (56.7%)		19,221 (60.1%)
Mean (95% CI)	112.2 (109.2–115.3)	110.5 (109.5–111.5)	105.5 (104.6–106.4)	114.8 (112.3–117.3)	116.7 (115.8–117.4)	110.8 (110.0–111.6)		113.8 (111.9–115.7)	114.2 (113.6–114.9)	108.8 (108.2–109.3)		111.5 (111.0–111.9)
HDL cholesterol, mg/dL							<0.0001				0.03	
<40 in Men, <50 in Women	131 (24.0%)	1204 (24.2%)	1430 (24.2%)	389 (49.6%)	3521 (40.8%)	3795 (42.4%)		520 (39.8%)	4725 (34.4%)	5225 (35.4%)		10,470 (35.1%)
≥40 in Men, ≥50 in Women	407 (76.0%)	3614 (75.8%)	4270 (75.8%)	372 (50.4%)	4788 (59.2%)	4895 (57.6%)		779 (60.2%)	8402 (65.6%)	9165 (64.6%)		18,346 (64.9%)
Mean (95% CI)	49.0 (47.6–50.4)	49.6 (49.0–50.1)	49.5 (49.1–49.9)	51.5 (50.4–52.6)	54.2 (53.8–54.6)	53.6 (53.2–53.9)		50.5 (49.7–51.4)	52.4 (52.1–52.7)	52.0 (51.7–52.3)		52.1 (51.9–52.3)
Estimate GFR (CKDEPI)							<0.0001				<0.0001	
Stage I	482 (73.9%)	2503 (43.1%)	643 (8.9%)	722 (79.4%)	5553 (55.9%)	1548 (14.8%)		1204 (77.3%)	8056 (50.9%)	2191 (12.5%)		11,451 (32.8%)
Stage II	124 (19.8%)	2545 (43.9%)	3554 (51.1%)	136 (15.1%)	3356 (34.3%)	5238 (49.2%)		260 (16.9%)	5901 (38.0%)	8792 (50.0%)		14,953 (43.0%)

(Table 4 continues on next page)

Age groups, year	Men			Women			p-value	Sex-adjusted			p-value	Overall
	20–44	45–64	≥65	20–44	45–64	≥65		20–44	45–64	≥65		
(Continued from previous page)												
Stage IIIa	14 (1.9%)	455 (7.9%)	1523 (21.9%)	16 (1.6%)	555 (5.8%)	1987 (18.9%)		30 (1.7%)	1010 (6.6%)	3510 (20.0%)		4550 (13.1%)
Stage IIIb	13 (2.1%)	169 (2.8%)	838 (12.1%)	12 (1.2%)	247 (2.4%)	1225 (11.6%)		25 (1.5%)	416 (2.5%)	2063 (11.8%)		2504 (7.1%)
Stage IV	6 (0.9%)	56 (1.1%)	305 (4.5%)	11 (1.5%)	81 (0.8%)	417 (4.0%)		17 (1.3%)	137 (0.9%)	722 (4.21%)		876 (2.6%)
Stage V	8 (1.4%)	67 (1.3%)	104 (1.6%)	9 (1.3%)	85 (0.9%)	156 (1.5%)		17 (1.3%)	152 (1.1%)	260 (1.6%)		429 (1.3%)
Mean (95% CI)	98.1 (96.1–100.1)	82.4 (81.8–83.0)	64.2 (63.7–64.8)	101.2 (99.5–103.0)	87.3 (86.8–87.7)	66.7 (66.3–67.2)		100.1 (98.7–101.4)	85.4 (85.0–85.7)	65.8 (65.4–66.1)		76.2 (75.9–76.4)
Proteinuria test							0.002				0.10	
Negative	202 (79.8%)	1720 (83.7%)	2068 (80.9%)	245 (85.4%)	2998 (85.4%)	3239 (83.7%)		447 (83.3%)	4718 (84.7%)	5307 (82.6%)		10,472 (83.6%)
1+	17 (5.7%)	84 (3.9%)	125 (4.6%)	17 (4.7%)	164 (4.4%)	173 (4.1%)		34 (5.1%)	248 (4.2%)	298 (4.3%)		580 (4.3%)
2+	23 (10.1%)	117 (5.8%)	192 (7.1%)	9 (2.8%)	169 (4.9%)	224 (5.6%)		32 (5.6%)	286 (5.3%)	416 (6.2%)		734 (5.8%)
3+	6 (2.1%)	80 (4.0%)	128 (4.7%)	14 (4.3%)	106 (2.8%)	156 (3.9%)		20 (3.5%)	186 (3.3%)	284 (4.2%)		490 (3.7%)
4+	8 (2.3%)	45 (2.6%)	73 (2.8%)	10 (2.8%)	81 (2.5%)	99 (2.7%)		18 (2.6%)	126 (2.5%)	172 (2.6%)		316 (2.6%)
ECG-abnormality												
Atrial fibrillation	2 (1.8%)	20 (2.0%)	54 (4.4%)	0 (0.0%)	21 (1.3%)	71 (3.9%)	0.21	2 (0.7%)	41 (1.6%)	125 (4.1%)	<0.0001	168 (2.8%)
Left atrial enlargement	2 (3.2%)	2 (0.3%)	6 (0.6%)	1 (0.6%)	7 (0.4%)	8 (0.5%)	0.69	3 (2.6%)	9 (0.3%)	14 (0.5%)	0.04	26 (0.5%)
Left ventricular hypertrophy	5 (5.0%)	21 (2.1%)	35 (2.5%)	2 (1.4%)	21 (1.6%)	51 (2.5%)	0.37	7 (2.8%)	42 (1.8%)	86 (2.5%)	0.19	135 (2.2%)

GFR: glomerular filtration rate; CKD EPI: Chronic Kidney Disease Epidemiology Collaboration equation; ECG: electrocardiogram.

Table 4: **Clinical laboratory test results of people with hypertension in Thailand.**

Table S7). Among those who had an ECG test, 2.8% had AF, 0.5% had LAE, and 2.2% had LVH.

Hypertensive complications among people with HT

Table 5 shows a history of HT complications among people with HT. The prevalence of cerebrovascular complications among people with HT nationwide was 4.2%. The prevalence of ischemic stroke, haemorrhagic stroke, and unspecified stroke among people with HT was 1.4%, 0.4%, and 2.1%, respectively. The overall prevalence of cardiovascular complications was 4.3%. A history of IHD among people with HT was 3.6%, while a history of HF was 0.9%. Regarding renal complications, 12.8% of hypertensive people with HT had a history of chronic renal insufficiency without dialysis, while 0.3% and 0.1% of people with HT had a history of chronic renal insufficiency with haemodialysis and peritoneal dialysis, respectively.

Discussion

We successfully enrolled 36,557 people with HT receiving care at public hospitals, private hospitals, and clinics supported by Thailand's NHSO program in 2018 nationwide. The current study is an extensive and updated epidemiological study involving people with HT in Thailand. We noticed that two-thirds of people with HT who received continuous care in Thailand maintained BP control at the latest visit, while half of them had BP control at the latest two consecutive visits. Simultaneously, we observed that two-fifths of people with HT achieved the target goal of an LDL level of less than 100 mg/dL. Furthermore, a meagre rate of 12-lead ECG screening, less than one-fifth of people with HT, was observed. HT complications, including cerebrovascular, cardiovascular, and renal complications, were still essential concerns for this population.

Almost two-thirds of the enrolled participants with HT were women. However, data from the NHES VI in Thailand demonstrated that HT prevalence among Thai adults was relatively comparable, with prevalence rates of 26.7% and 24.2% among men and women, respectively.[2] Nevertheless, the percentage of undiagnosed HT was 57.0% and 40.5% among males and females with HT in Thailand, respectively.[2] In addition, the NHES VI revealed that the sex distribution of Thai adults with HT receiving treatment was 61.6% for women and 38.4% for men, which was compatible with the sex distribution in the present study (Supplementary Table S8). This phenomenon of sex difference

Age group, years	Men			Women			p-value	Sex-adjusted			p-value	Overall
	20–44	45–64	≥65	20–44	45–64	≥65		20–44	45–64	≥65		
Cerebrovascular complications												
Overall	29 (4.4%)	329 (5.3%)	514 (6.8%)	17 (1.9%)	222 (2.1%)	469 (4.0%)	<0.0001	46 (2.8%)	551 (3.3%)	983 (5.1%)	<0.0001	1580 (4.2%)
Ischemic stroke	5 (0.7%)	97 (1.5%)	187 (2.4%)	2 (0.3%)	71 (0.7%)	186 (1.6%)	<0.0001	7 (0.4%)	168 (1.0%)	373 (1.9%)	<0.0001	548 (1.4%)
Haemorrhagic stroke	9 (1.4%)	45 (0.6%)	43 (0.6%)	2 (0.1%)	27 (0.3%)	31 (0.2%)	<0.0001	11 (0.6%)	72 (0.4%)	74 (0.4%)	0.15	157 (0.4%)
Stroke unspecified	15 (2.2%)	172 (2.8%)	254 (3.4%)	12 (1.3%)	106 (1.0%)	231 (2.0%)	<0.0001	27 (1.7%)	278 (1.7%)	485 (2.6%)	<0.0001	790 (2.1%)
Transient ischemic attack	1 (0.2%)	22 (0.4%)	40 (0.5%)	2 (0.2%)	21 (0.2%)	33 (0.3%)	0.01	3 (0.2%)	43 (0.3%)	73 (0.4%)	0.39	119 (0.3%)
Cerebral aneurysm	0 (0%)	0 (0%)	2 (0.03%)	0 (0%)	1 (0.004%)	1 (0.004%)	0.09	0 (0%)	1 (0.002%)	3 (0.002%)	0.27	4 (0.01%)
Cerebral atherosclerosis	1 (0.2%)	1 (0.03%)	6 (0.1%)	0 (0%)	3 (0.01%)	4 (0.04%)	0.18	1 (0.1%)	4 (0.02%)	10 (0.1%)	0.34	15 (0.04%)
Cardiovascular complications												
Overall	12 (1.4%)	237 (3.8%)	512 (6.6%)	7 (0.5%)	208 (2.1%)	647 (5.7%)	<0.0001	19 (0.9%)	445 (2.7%)	1159 (6.0%)	<0.0001	1623 (4.3%)
Ischemic heart disease	2 (0.6%)	168 (3.4%)	502 (5.8%)	5 (0.1%)	212 (1.7%)	440 (4.5%)	<0.0001	7 (0.3%)	380 (2.3%)	942 (5.0%)	<0.0001	1329 (3.6%)
Congestive heart failure	7 (0.9%)	29 (0.4%)	88 (1.0%)	5 (0.4%)	51 (0.5%)	186 (1.5%)	0.01	12 (0.6%)	80 (0.5%)	274 (1.3%)	<0.0001	366 (0.9%)
Renal complications							<0.0001				<0.0001	
Renal insufficiency without dialysis	32 (4.9%)	505 (8.3%)	1662 (22.8%)	26 (2.8%)	593 (5.4%)	1961 (16.9%)		58 (3.6%)	1098 (6.5%)	3623 (19.2%)		4779 (12.8%)
Renal insufficiency with haemodialysis	3 (0.5%)	22 (0.4%)	19 (0.3%)	6 (1.0%)	14 (0.2%)	21 (0.2%)		9 (0.8%)	36 (0.3%)	40 (0.3%)		85 (0.3%)
Renal insufficiency with peritoneal dialysis	4 (0.6%)	7 (0.1%)	3 (0.01%)	0 (0%)	11 (0.1%)	1 (0.003%)		4 (0.2%)	18 (0.1%)	4 (0.01%)		26 (0.1%)

Table 5: **Hypertensive complications of people with hypertension in Thailand.**

in HT care may be explained by health-seeking behaviour in that men may display lower health awareness, including perceiving themselves to have a health problem and engaging in HT self-management behaviour.[14,15] Lower accessibility of care among males with HT in Thailand may be exhibited by the higher proportion of females with HT receiving HT care in clinics and hospitals compared to the proportion found in the community. This finding demonstrated that specific programs aimed at increasing early detection and accessibility to continuous care among males with HT require further responsiveness in Thailand.

In Thailand, the Thai guidelines regarding the treatment of HT were established in 2012 and were revised in 2015 to improve HT care nationwide. We found that, for single therapy, ACEI or ARB was mainly prescribed for people with HT aged less than 45 years. Meanwhile, CCB was the most prescribed medication for people with HT aged ≥ 45 years, which is in accordance with the recommendations from the guidelines. Moreover, most people with HT nationwide required two or more antihypertensive medications in order to achieve target BP control, which agrees with the results of a previous report in Thailand.[16] However, while a combination of ACEI or ARB + CCB + diuretics was mainly recommended for polytherapy by the Thai guidelines, our finding exhibits that ACEI or ARB + CCB + BB was the most used combination for polytherapy in people with HT in Thailand.[9] To date, well-documented and Thai guidelines demonstrated that fixed-dose combination pills could improve drug adherence for people with HT who need dual or polytherapy.[9,17] Unfortunately, in the present study, we did not have an opportunity to access the status of fixed-dose combination pills prescription among people with HT.

The data from the NHES VI reported population level HT control that approximately half of the Thai adults with HT having a history of HT treatment could control their BP.[2] Unfortunately, the NHES VI did not provide information on the duration of treatment among those with a history of HT treatment. In the present study, 66.6% of the people with HT receiving care for at least 12 months achieved the target BP control, which was higher than those in the related evidence in Asian countries, including 16.7% in Laos,[18] 36.3% in Vietnam,[19] 37.6% in Singapore,[20] and 37.5% in China.[21] At the same time, the percentages of controlled people with HT from the present study were comparable with those in the reported data from Taiwan (63.4%).[22] However, we noticed that only half of people with HT in the current study could achieve the target BP for the latest two consecutive times. A related study in a rural community in central Thailand in 2018 indicated that only 45.6% of people with HT received care at PCUs.[23] The present study included only people with HT visiting hospitals for HT care and did not include people with HT receiving care at PCUs. Further studies should be performed to evaluate HT outcomes among people with HT receiving care at PCUs in rural areas nationwide, accounting for about one-half of the overall people with HT.[2,24]

The universal healthcare policy in Thailand comprises three major healthcare schemes: the CSMB (for all civil servants and their immediate family members), the SSS (for private employees), and the UHC for the rest of the Thai people. These schemes provide essential preventive, curative services for all age groups, including people with HT.[6,7] We found that people with HT under the CSMB tended to have a higher prevalence of BP control than those under the UHC and the SSS. Similarly, a previous related study in Thailand reported that Thai people with HT under the CSMB tended to have higher BP and glycemic control rates compared to those under other health schemes.[7,16] Although people with HT under all major healthcare schemes can access HT care, the people with HT under the CSMB may have a higher opportunity to more antihypertensive medication of choice, such as fixed-dose combination pills and medication other than national essential drug lists, which have some limitations for other health schemes.[8,25,26] Our findings suggested an opportunity to enhance the quality of HT care in the UHC and the SSS, especially considering fixed-dose combination pills, which are feasible to improve drug adherence and achieve BP control.[9,17]

A difference in BP control was also observed based on the location of outpatient clinics. Several studies revealed that high rates of BP control could be achieved in referral hospitals staffed by specialists.[27–29] However, this study found that the BP control rate was highest among people with HT receiving care at a clinic in the community hospital located in each district nationwide, which agrees with a related study.[16] The community hospital's committed team of healthcare workers may support this finding. Usually, the doctor is concerned with treatment and prescribing medicines, whereas the clinical nurse is the case manager or in charge of managing the clinic.[8] The pharmacist helps in counselling for adherence and dispensing medicines. Data recorders are responsible for providing patient appointments.[8]

We found that people with HT from private hospitals had a lower prevalence of BP control compared to those from regional, general provincial, and community hospitals. Although the private hospitals enrolled in the current study were supported under Thailand's NHSO program, there is currently no regulation that requires the private hospital to report on services provided in the HT to the MoPH.[8] Therefore, there is limited information about the volume of care and treatment practices among people with HT receiving care at private hospitals. Establishing collaboration between the MoPH and private hospitals may enhance HT care, especially BP control outcomes in Thailand.

The current study reported that, among people with HT younger than 65 years, the prevalence of BP control among men was lower than that among women. Existing literature revealed that males had a lower prevalence of BP control than females due to biological factors, including higher pro-renin and renin levels.[16,30] Moreover, masculinity and influence on men's well-being also support this finding.[14]

We also established that people with HT from the southern region had a lower percentage of BP control than those from other regions. Furthermore, existing evidence may reflect these findings. The dietary behaviour of people in different national regions, such as high sodium intake, may affect BP levels.[31,32] Furthermore, we found that, in comparison with other regions, the prevalence of BP control among people with HT in three provinces of Thailand's deep south (Pattani, Yala and Narathiwat) was 22% and 29% lower at the latest visit and the latest two consecutive times, respectively (Supplementary Table S9). For over two decades, the insurgency issues in Thailand's deep south have affected health systems, transportation, family, education, and other dimensions of people in this area, which may explain our findings.[33,34] These results suggested that BP control among those residing in the south, especially in three provinces of Thailand's deep south, should be improved. The role of eHealth and telemedicine may be feasible to enhance the quality of HT care in this situation.[35,36]

Higher BMI has been well documented as a risk factor for raised BP.[16,37] We observed that approximately half of people with HT nationwide had a BMI $\geq$ 25 kg/m^2, while the data from the NHES VI in Thailand indicated that the prevalence of BMI $\geq$ 25 kg/m^2 among Thai adults was 42.2%.[2] Our findings also demonstrated that the prevalence of BP control among people with HT with a BMI $\geq$ 25 kg/m^2 was lower than those with a normal BMI. These results suggested that weight reduction should be encouraged to improve BP control among people with HT, especially those with high BMI.

Approximately 90% of people with HT had at least one LDL cholesterol test done within 12 months. We noticed that only two-fifths of those achieved the target goal of an LDL cholesterol level (<100 mg/dL). Additionally, a lower percentage of achieving the target goal of an LDL cholesterol level among people with HT younger than 65 years was observed. The Thai guidelines for treating HT recommended that, to reduce cardiovascular risks, people with HT who have three or more cardiovascular risk factors should be given lipid-lowering agents, especially statin. However, in those guidelines, high LDL cholesterol level was not considered for this treatment.[9,38] In the current study, we conducted subgroup analysis and found that 60% of people with HT with LDL cholesterol >100 mg/dL were not prescribed lipid-lowering agents. These findings suggested that high LDL cholesterol levels among people with HT should be given more attention to attenuate ASCVD in the future.[39]

Although a proteinuria test using urinalysis among people with HT was recommended by the Thai guidelines for HT treatment,[9,38] we found that approximately one-third of people with HT had at least one proteinuria test. Related cost-effectiveness analysis in the US revealed that, for people with HT, the cost-effectiveness ratio for the proteinuria screening versus no screening was highly favourable.[40] Therefore, the proteinuria test, included in the package of HT care under universal healthcare policy, should be encouraged in order to be provided for people with HT nationwide.

Regarding the 12-lead ECG screening, we noticed that the prevalence of ECG-AF and ECG-LVH was 2.8% and 2.2%, respectively. Unfortunately, a shallow rate (15.2%) of people with HT nationwide who received a 12-lead ECG was observed. A recent study in Thailand demonstrated that the prevalence of ECG-LVH among adults in a rural area was 6.6%.[41] Therefore, the ECG abnormality in the current study may be underestimated. Previous research in the Netherlands also supported the potential yield of ECG screening in unselected people with HT. The number needed to screen to prevent one death from cardiovascular disease within 10 years was lower than that in other widely accepted tests.[42] Our results suggest an opportunity for improving ECG screening to facilitate appropriate treatment for people with HT in the future.

For HT complications, we found that almost one-fifth of people with HT nationwide had renal complications. Our study also reported that approximately one in 10 people with HT nationwide had cerebrovascular or cardiovascular complications. In addition, a related study revealed that chronic kidney disease was an independent factor associated with cardiovascular complications among Thai people with HT.[43] Therefore, improving BP outcomes, reducing cardiovascular risk factors, and close monitoring should be performed in people with HT, especially those with a history of renal complications, in order to alleviate the risk for cerebrovascular or cardiovascular complications.

Our study had significant strengths, including representing a large sample of people with HT receiving continuous care nationwide. Thus, our data provided updated valuable insights into the characteristics and outcomes of people with HT in Thailand. Furthermore, these data may produce strategies for improving HT care in Thailand. However, the current study had some limitations. First, the study included only people with HT who attended clinics located at the hospital for HT care. Thus, characteristics and clinical outcomes among people with HT who received care at PCUs (primarily located in the rural community), accounting for approximately one-half of the overall people with HT in Thailand, were not assessed. Second, the study

did not include subjects from university hospitals which may bias the results. However, there are a few university hospitals across the country, and the distribution of health insurance schemes to people with HT receiving care at the university hospital may differ from other public hospitals; for example, there are a high proportion of people with HT under the CSMB, the scheme which has free choice of public provider. Third, the limitation of representativeness of the study subject is that the present study included only half of the private hospitals and private clinics under the NHSO support in Bangkok and a few private hospitals outside Bangkok. Moreover, due to the existing difference in treatment of choice between private and public hospitals, the results may be biased. Fourth, the main objective of the present study was to examine HT care outcomes systematically nationwide in Thailand. We did not have an opportunity to compare the outcomes with those before the implementation of UHC coverage in 2002. Fifth, the ECG-LVH results in this study were obtained from the ECG interpretation by the physician, recorded in the medical record, and were not interpreted using an echocardiogram. Therefore, due to the accuracy of ECG-LVH criteria, misclassification may occur.[44] Finally, for the observational study, data on some variables were missing, such as smoking status and alcohol use.

In conclusion, our study examined the current standards of HT care nationwide in Thailand. The results also indicated an opportunity for further improvement in the quality of HT care. Our findings demonstrated that increasing accessibility to continuous care among men with HT requires further attention in Thailand. Two-thirds of people with HT could maintain BP control, while less than half of people with HT achieved the target goal of an LDL level. In addition, a shallow rate of 12-lead ECG screening among people with HT was observed. Finally, HT complications were still a concern for this population. The study findings will help healthcare providers compare performance and plan quality improvement initiatives.

Contributors

BS accessed and verified the data, analysed and interpreted the data, produced the output figures, and wrote the initial manuscript. RR obtained funding, provided supervision, designed the study, and contributed to data collection. All authors contributed to subsequent revisions and approved the final version submitted for publication.

Data sharing statement

Data are available from the National Health Security Office (NHSO), Bangkok, Thailand, for researchers who meet the criteria for access to confidential data. The corresponding author has full access to all the data and takes responsibility for the accuracy of the study.

Editor note

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Declaration of interests

The study was funded by the National Health Security Office award to RR. The authors declare no other conflicts of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lansea.2023.100319.

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