




# Clinical audit of adherence to hypertension treatment guideline and control rates in hospitals of different sizes in Thailand

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## Abstract

A clinical audit of hospitals in Thailand was conducted to assess compliance with the national hypertension treatment guidelines and determine hypertension control rates across facilities of different sizes. Stratified random sampling was used to select sixteen hospitals of different sizes from four provinces. These included community (<90 beds), large (90–120 beds), and provincial (>120 beds) hospitals. Among new cases, the audit determined whether (i) the recommended baseline laboratory assessment was completed, (ii) the initial choice of medication was appropriate based on the patient's cardiovascular risk, and (iii) patients received medication adjustments when indicated. The hypertension control rates at six months and at the last visit were recorded. Among the 1406 patients, about 75% had their baseline glucose and kidney function assessed. Nearly 30% ( $n = 425/1406$ ) of patients were indicated for dual therapy but only 43% of them ( $n = 182/425$ ) received this. During treatment, 28% (198/1406) required adjustments in medication but this was not done. The control of hypertension at six months after treatment initiation was 53% varying between 51% in community

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and 56% in large hospitals ( $p < .01$ ). The hypertension control rate at last visit was 64% but varied between 59% in community hospitals and 71% in large hospitals ( $p < .01$ ). Failure to adjust medication when required was associated with 30% decrease in the odds of hypertension control (OR 0.69, 95% CI 0.50 to 0.90). Failure to comply with the treatment guidelines regarding adjustment of medication and lost to follow-up are possible target areas to improve hypertension control in Thailand.

## 1 | INTRODUCTION

Cardiovascular disease (CVD) was the leading cause of mortality in Thailand 2017.<sup>1</sup> The burden of hypertension in Thailand, usually defined as systolic blood pressure of at least 140mmHg or diastolic blood pressure of at least 90 mmHg or on medication to lower blood pressure, is a major risk for CVD, remains high with a prevalence of one in four adults.<sup>2,3</sup> According to the Ministry of Public Health (MoPH) of Thailand, the number of people registered for hypertension treatment has risen from nearly 4 million in 2013 to over 5.5 million in 2017.<sup>4</sup> The health system in Thailand has evolved to adapt to the population dynamics and disease epidemiology geared toward the aging population and epidemiological transition toward non-communicable diseases.<sup>5</sup> Since achieving universal health coverage (UHC) in 2002, and also with the incorporation of antihypertensive drugs into the benefits package of UHC in 2011, the awareness and coverage of hypertension screening services in Thailand reached 55% by 2013.<sup>3,6</sup>

Introduction of the updated Thai hypertension clinical practice guidelines in 2015 was a major move to improve hypertension care.<sup>7</sup> Among other things, these guidelines provide: recommendations on cardiovascular risk stratification based on 10-year risk of CVD mortality; list of assessments required to identify subclinical organ damage; detailed strategies for using combination strategy if patients have high (CVD mortality risk 5%–10%) to very high CVD mortality risk (>10%); and a stepped approach to blood pressure monitoring for patients in different risks groups. However, despite these advances, population-based surveys have suggested that the overall hypertension control among Thai patients is still at 30%, with varying capacity to diagnose and treat hypertension at the hospital level across different provinces of Thailand.<sup>8,9</sup> This may be due to poor adherence to suggested treatment guidelines. A recent review in Hong Kong showed that only 11% of patients received a cardiovascular disease (CVD) risk assessment at diagnosis,<sup>10</sup> while a study in Romania found that 30% did not receive drug adherence counseling.<sup>11</sup>

Another reason for suboptimal control rates in Thailand may be attributable to how the hypertension services are organized and delivered at the different levels of care (primary, secondary, and tertiary care) across different levels of treatment facilities (community hospitals and provincial hospitals).<sup>3,8</sup> With the development of the universal health coverage plan, all Thai citizens have access to health care which has reduced inequalities across Thailand.<sup>5,12,13</sup> Over 85%

of all outpatient visits in Thailand are provided by public hospitals which has a strong network of two-way referrals between provincial hospitals, community hospitals, and health centers.<sup>8</sup> Most new patients with hypertension are diagnosed at the community hospitals by physicians. While hypertension is treatable at all levels of care and in both community and provincial hospitals, the initiation of treatment in uncomplicated cases is usually at primary care level in community hospitals. Complex cases with other uncontrolled co-morbidities or cases with signs and symptoms of cardiovascular complications at diagnosis are usually treated by internists or specialists at secondary care level in bigger provincial hospitals. Thus, patients treated at smaller community hospitals generally have easier access to the providers and are usually cared for by primary care physicians and nurses. Patients who are treated at larger provincial Thai hospitals and referral hospitals generally have easier access to specialists when needed, but may face longer waiting times and shorter contact time. These issues may affect the delivery of hypertension care and control rates.<sup>14</sup>

Clinical audits are useful to help assess consistency between guideline recommendations and actual practice.<sup>15,16</sup> In this current study, an audit of Thai hospitals was conducted to (i) identify gaps between actual practice and the recommended practice as proposed by the Thai Hypertension Guideline and (ii) to identify variations in compliance of standard treatment guidelines and rate of hypertension control between hospitals of different sizes. Understanding these gaps and variations may improve hypertension care as seen in Canada where hypertension control significantly improved to over 70%.<sup>17</sup>

## 2 | METHODS

### 2.1 | Study design

New hypertensive patients are usually registered into a hospital's record system if they have two high blood pressure readings ( $\geq 140/90$  mmHg) at least two weeks apart or are referred for treatment from another hospital. An audit of these newly diagnosed/registered patients entering treatment was conducted among 16 hospitals across four Thai regions (North, Central, Northeast, and South). Within each region, a province was randomly selected. The probability assigned to each province was proportionate to the size of the population in each region. Within each province, hospitals

were stratified according to the size of the hospital. One provincial/referral hospital (>120 beds), one large hospital (90–120 beds), and two small community hospitals (<90 beds) were then randomly selected from each province using a random number generator. Within each hospital, researchers sequentially reviewed records of at least 70 consecutively enrolled newly registered patients with start date from January 1, 2017, onwards and audited their clinical records up to 30 June 2018. For all patients in the clinics, health care including laboratory investigations and medication are covered by the government through either the universal coverage scheme, social security scheme or civil servant medical benefit scheme.<sup>8</sup>

## 2.2 | Audit tools

A standard tool designed from the 2015 Thai National guidelines for Hypertension was used to collect data from newly registered hypertensive patients receiving care in the 16 hospitals. In addition to recording age, sex, weight, height, and history of co-morbidities, each patient record was assessed in three main areas regarding hypertension treatment (i) initial clinical and laboratory assessment, (ii) medication prescription and adjustment, and (iii) treatment outcomes.

1. Initial assessment: Data were collected on whether patients had all the recommended laboratory investigations within three months of diagnosis and/or registration as a hypertensive patient. According to the Thai Hypertension Guideline, this includes a baseline fasting blood glucose, full lipid profile, serum creatinine, serum potassium (K), serum sodium (Na), urine analysis, urine microalbuminuria, and EKG. In addition, the audit assessed whether the 10-year risk of cardiovascular death (or CVD risk score) was documented.
2. Medication prescription and adjustment: The audit assessed whether the patients started on the recommended therapy (monotherapy or dual therapy) based on their ten-year CVD mortality risk and baseline laboratory results. Based on the Thai CVD risk score, the Thai hypertension treatment guidelines suggest the use of more than one medication if the overall CVD risk of mortality is at least 5%. If the Thai CVD risk score was not documented in the medical records, this was calculated by the research team according to age, sex, history of smoking, and co-morbidities such as diabetes and high cholesterol.<sup>18</sup> Patients were then assessed whether they had their medication adjusted if their blood pressure was not under control. Information was also collected on whether fixed dose combination pills were used for those requiring more than one medication. Inappropriate medication adjustments were also assessed. This was defined according to any one of the following two scenarios: (i) inappropriate medication adjustment such as failure to increase medication and (ii) incorrect medication adjustment such as changed medication but no clear advantage in terms of side effects such as switching from one ACEI to another ACEI rather than another class of medication such as ARBs.

3. Treatment outcomes: Retention rate in treatment at 6 months (–30/+90 days), rate of hypertension control at 6 months, and at last reading at the time of the audit (within 12 months after treatment) was recorded.

## 2.3 | Data analysis

Descriptive statistics were used to describe patient demographics, initial presentation, and treatment received. Variations in compliance of standard treatment guidelines across different hospital sizes and rate of hypertension control were tested using ANOVA or chi-square. The rate of hypertension control at six months and at the last visit was calculated by dividing the number of patients who obtained a systolic blood pressure (SBP) < 140 mmHg and diastolic blood pressure (DBP) < 90 mmHg by the total number of patients included. 95% confidence intervals (CIs) were estimated using logistic regression. In addition, to determine whether factors associated with hypertension control at last visit, three multivariable logistic regression models were used. Model 1 explored health systems and environment factors by including hospital size and region (North, Central, Northeast, and South) as explanatory variables. Model 2 included patient-related factors (age, sex, baseline CVD risk) as additional exploratory variables to Model 1. The last full model, Model 3, included treatment-related factors (inappropriate medication at initiation of treatment, inappropriate medication adjustment, and number of medications) as additional exploratory variables. This sequential modeling strategy can help identify whether potential variations between hospital sizes were confounded by different geographic- and patient-related factors. In addition, it will help identify aspects of treatment that may be beneficial to hypertension control while adjusting for patient, hospital, and environmental factors. Using the same sequential modeling strategy, a sensitivity analysis was conducted to explore factors associated with loss to follow-up at 6 months as loss to follow-up may be one of the key contributing factors to hypertension control.

## 2.4 | Ethics

This was a retrospective audit of routine clinical records. Patient consent was not required and ethical approval to conduct the audit was approved by The Faculty of Medicine, Chiang Mai University (No 151/2018).

## 3 | RESULTS

### 3.1 | Characterization of newly diagnosed/registered hypertensive patients

In all, 1406 cases of newly diagnosed/registered hypertension were reviewed. The mean age of the patients was 58 years (SD ± 13) of whom 56% were females. The mean BP was 157/90 mmHg. Almost

10% had a previous diagnosis of hypertension from another hospital. The majority of patients had co-morbidities including dyslipidemia, diabetes, chronic kidney disease, or CVDs (Table 1). The demographic characteristics (age and sex) of patients did not significantly differ by type of hospitals, but patients registered to treatment in provincial hospitals had higher proportions with obesity (51%) and co-morbidities (74%) compared to those registered at community hospitals where 42% were obese and 54% had co-morbidities (Table 1).

### 3.2 | Initial assessment

At initial assessment, only half of all patients had their ten-year CVD risk assessment calculated and recorded (Table 2). The majority

(>75%) had their glucose, lipid profile, and kidney function assessed within three months of diagnosis. Although recommended for all patients at initial assessment, only 12% had an EKG and 10% had their urine tested for microalbuminuria.

### 3.3 | Medication prescription and adjustment

Over half of the hypertension patients (791/1406) were at least at moderate risk for developing CVDs. Over 30% of the patients (425/1406) were recommended dual antihypertensive therapy according to the national guideline (due to 10-year CVD risk  $\geq$  5%), but only 43% (182/425) of these patients received dual therapy. The most commonly prescribed medications for hypertension management were calcium channel blockers (68%) and angiotensin-converting

TABLE 1 Baseline demographics of patients newly diagnosed/registered with hypertension entering treatment by size of hospitals

	Total (n = 1406)	Provincial (>120 beds) (n = 280)	Large (90–120 beds) (n = 456)	Community (<90 beds) (n = 670)	p-value
Sex: Male (column %)	44.2	41.8	45.2	44.5	.65
Baseline mean age years (SD)	58.4 (13.0)	57.0 (11.9)	59.0 (13.3)	58.5 (13.1)	.12
Blood pressure at baseline					
Mean SBP mmHg (SD)	157.1 (22.2)	155.5 (24.9)	158.0 (22.3)	157.2 (21.0)	<.01
Mean DBP mmHg (SD)	90.1 (15.3)	89.8 (18.8)	91.5 (13.9)	89.4 (14.6)	<.01
Age group in years (column %)					
<30	1.4	0.7	1.3	1.6	.23
30–40	6.8	8.2	6.1	6.7	
40–50	20.6	18.6	22.8	19.8	
50–60	27.5	32.9	24.1	27.5	
60–70	26.6	26.4	26.3	26.9	
70+	17.2	13.2	19.3	17.5	
BMI category in kg/m <sup>2</sup> (column %)					
Underweight (<18.5)	6.3	4.1	8.0	6.0	.05
Normal (18.5 to < 23)	27.4	21.7	27.2	29.7	
At risk (23 to < 25)	20.8	22.9	18.9	21.2	
Obese I (25 to < 30)	32.7	38.8	31.4	30.9	
Obese II ( $\geq$ 30)	12.8	11.5	14.5	12.2	
Co-morbidity (column %)					
None	35.6	25.7	27.0	45.8	<.01
Diabetes	12.4	17.1	11.0	11.3	.03
Chronic kidney disease	5.6	6.4	6.1	4.8	.48
Cardiovascular diseases	4.8	6.4	4.2	4.6	.36
Dyslipidemia	40.1	48.6	48.9	30.6	<.01
Smoking (column %)					
Not recorded	4.0	5.4	3.3	4.0	<.01
None	77.9	78.9	72.6	81.0	
Ex-smoker	8.3	9.3	14.0	4.0	
Current smoker	9.7	6.4	10.1	10.9	

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; SBP, systolic blood pressure.

enzyme inhibitors (36%). At the initiation of treatment, the proportion receiving appropriate medication (monotherapy or dual therapy) were 53% (242/456), 42.5% (119/280), and 40% (270/670) among the large hospitals, provincial hospitals, and community hospitals, respectively ( $p < .01$ ) (Table 3). About 26% (365/1406) of patients were able to achieve BP control without needing further dose adjustments and about 40% (564/1406) received dose adjustments when required. During treatment, about 28% (398/1406) of patients required adjustments in medication but did not receive it. At the end of the year, 59% of patients were prescribed monotherapy (822/1403). Only one person was prescribed a single-pill combination.

### 3.4 | Treatment outcomes

For treatment outcomes, 8.7% were completely lost to follow-up by 6 months, varying between 3.5% at large hospitals and 12.5% at community hospitals (Table 4). The median follow-up time at the last visit was 355 days (IQR 231 to 449). Overall, 52.8% (95%CI 50.2 to 55.5) of patients had their hypertension controlled at six months and 64.1% (95%CI 61.6 to 66.6) at last visit. For hypertension control at last reading, 71% (95% CI 66.9 to 75.2) of patients receiving care at large hospitals had their BP under control at their last visit while 65%

(95% CI 59.4 to 70.6) of patients had their BP under control during their last visit at provincial hospitals and 59% (95% CI 55.2 to 62.7) of patients at community hospitals ( $p < .01$ ) (Figure 1).

### 3.5 | Factors associated with hypertension control

The variations in hypertension control rate were still significant despite adjusting for geographic factors (Table 5 Model 1). When patient-related factors were included in the model, data suggested that very old age and female sex were significantly associated with hypertension control (Table 5 Model 2). Hypertension control varied by hospital size ( $p = .03$  and region ( $p < .01$ )) despite adjusting for patient-related factors. For treatment-related factors (Table 5 Model 3), patients who did not receive appropriate medication adjustments were 31% less likely to have their hypertension controlled (OR 0.69, 95% CI 0.53 to 0.90,  $p < .01$ ), whereas appropriate medication initially did not increase the likelihood of hypertension control. In addition, those with uncontrolled hypertension were more likely to be on more than one medication. The odds ratio for hypertension control was 0.66 for those with more than one medication (95% CI 0.51 to 0.85,  $p < .01$ ).

Sensitivity analysis exploring factors associated with loss to follow-up at 6 months found similar patterns to hypertension control.

TABLE 2 Initial presentation and baseline assessment of patients newly diagnosed/registered with hypertension entering treatment by size of hospitals

	Total (n = 1406)	Provincial (>120 beds) (n = 280)	Large (90–120 beds) (n = 456)	Community (<90 beds) (n = 670)	p-value*
Treatment type (%)					
New	88.3	82.1	92.7	87.9	<.01
Referral from other hospitals	10.7	17.9	7.3	12.1	
New cases from screening program (%)	12.2	9.3	12.9	12.9	.25
Cardiovascular risk score assessed <sup>a</sup> (%)	51.8	26.3	49.7	63.7	<.01
Receiving baseline assessment recommended by national hypertension guideline at first visit (within 3 months) (%)					
Fasting blood glucose	76.6	71.2	83.3	74.1	<.01
Total cholesterol	69.5	68.8	64.7	72.9	.01
HDL	67.3	67.0	63.2	70.2	.04
LDL	74.1	69.6	81.8	70.7	<.01
Triglyceride	74.7	71.0	82.5	70.8	<.01
eGFR	74.7	72.5	85.5	68.3	<.01
Serum potassium	38.5	54.0	47.6	25.9	<.01
Serum sodium	35.5	50.2	46.5	21.9	<.01
Urinalysis	26.7	40.4	28.9	19.5	<.01
Urine microalbuminuria	10.0	5.8	18.4	6.0	<.01
EKG	12.3	32.4	9.9	5.7	<.01

Abbreviations: eGFR, estimated glomerular filtration rate; EKG, electrocardiogram; HDL, high-density lipoprotein cholesterol; LDL, low-density lipoprotein cholesterol.

<sup>a</sup>Those with already established CVD are excluded from the calculations

\*Chi-square p-value.

TABLE 3 Hypertension treatment of patients newly diagnosed/registered with hypertension entering treatment by size of hospitals

	Total (n = 1406)	Provincial (>120 beds) (n = 280)	Large (90–120 beds) (n = 456)	Community (<90 beds) (n = 670)	p-value
Cardiovascular disease (CVD) mortality risk based on audit					
Can't calculate	4.9	5.0	4.8	4.9	.17
Low (CVD risk < 1)	38.8	45.0	36.8	37.6	
Moderate (CVD risk 1 to ≤ 5)	26.0	25.4	24.5	27.3	
High (CVD > 5%)	30.2	24.6	33.8	30.2	
Choice of medication based on risk assessment (initial BP and CVD risk)					
Appropriate start with monotherapy when monotherapy was indicated (%)	35.0	32.5	41.9	31.3	<.01
Appropriate start of duo therapy when duo therapy indicated <sup>a</sup> (%)	9.9	10.0	11.2	9.0	
Inappropriate (%)	55.1	57.5	46.9	59.7	
First-line medication used					
Thiazide-type diuretic (%)	6.5	6.1	4.2	8.2	.03
CCBs (%)	67.6	67.1	77.0	61.3	<.01
ACEIs (%)	35.9	27.1	32.9	41.3	<.01
ARBs (%)	3.7	8.2	2.2	2.8	<.01
Dose adjustments when required (uncontrol or presented with side effects)					
Good control at all visits (no adjustment required) (%)	26.0	28.2	25.0	25.7	.27
Appropriate adjustment (%)	40.1	41.4	43.0	37.6	
Inappropriate adjustment <sup>b</sup> (%)	1.1	0.4	1.7	1.0	
No adjustment throughout (with some visits uncontrolled) (%)	28.3	26.8	25.9	30.6	
Incomplete data to evaluate (%)	4.5	3.1	4.4	5.1	
Treatment regimen prescribed					
Monotherapy (%)	58.6	51.1	54.5	64.5	<.01
Multiple pill combination therapy (%)	41.3	48.9	45.3	35.5	
Single-pill combination therapy (%)	0.1	0	0.2	0	

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blockers; CCB, calcium channel blocker.

<sup>a</sup>Thai guideline suggests dual therapy if at high risk.

<sup>b</sup>In appropriate adjustment defined as at least one of the two scenarios occurring: (1) inappropriate medication adjustment such as failure to increase medication and (2) incorrect medication adjustment such as changed medication but no clear advantage.

Adjusting for geographic variations, large hospitals had the lowest proportion of loss to follow-up, while small community hospitals had the highest proportion of loss to follow-up and provincial hospitals had the intermediate risk of loss to follow-up (Table S1 model 1 and Figure S1). No other patient-related factors (Table S1 Model 2) or treatment factors (Table S1 Model 3) were significantly associated to loss to follow-up.

## 4 | DISCUSSION

About 30% of new patients registered for treatment, irrespective of the size of the hospitals, were already at high risk of CVD mortality. Almost ten percent of newly diagnosed patients were lost to follow-up and around two thirds of newly diagnosed cases had their blood pressure controlled during their last visit to the hospital.

TABLE 4 Hypertension control by size of hospitals

	Total (n = 1406)	Provincial (>120 beds) (n = 280)	Large (90–120 beds) (n = 456)	Community (<90 beds) (n = 670)	p-value
Follow-up status (column %)					
Loss to follow-up after diagnosis	0.8	0.4	0.4	1.2	<.01
Loss before 6 months of treatment	7.9	7.5	3.1	11.3	
Completed 6 months follow-up	91.3	92.1	96.5	87.5	
Hypertension control control at 6 months (–30/+90 days after treatment) (column %)					
Loss to follow-up after diagnosis	0.8	0.4	0.4	1.2	<.01
Loss to follow-up before 6 months	7.9	7.5	3.1	11.3	
No reading at 6 months	9.1	10.4	11.0	7.3	
Uncontrolled hypertension at 6 months	29.4	30.4	29.4	29.0	
Controlled at 6 months	52.8	51.4	56.1	51.2	
Hypertension control (last reading <sup>a</sup> ) (column %)					
Loss to follow-up after diagnosis	0.8	0.4	0.4	1.2	<.01
Loss to follow-up before 6 months	7.9	7.5	3.1	11.3	
Uncontrol hypertension at last visit	27.2	27.1	25.4	28.5	
Control hypertension at last visit	64.1	65.0	71.0	59.0	

<sup>a</sup>Last reading: average follow time 342 days (SD ± 129 days), median follow-up time 355 days (IQR 231 to 449).

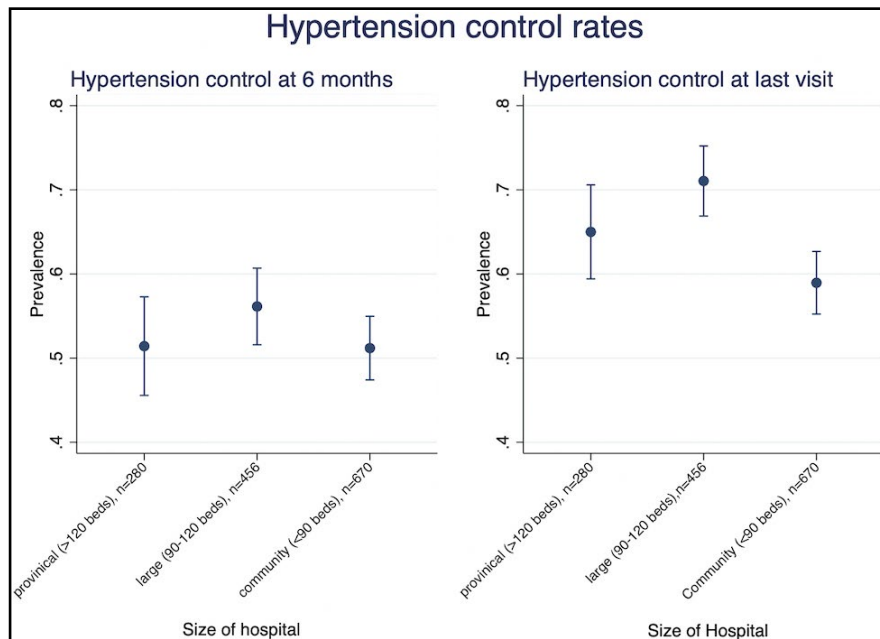


FIGURE 1 Hypertension control rates by size of hospitals

In addition, more than a quarter of the patients did not get correct medication adjustment despite being indicated for it over the period of evaluation.

Our findings are in-line with previous studies where CCBs are the most commonly used antihypertensive medication, while diuretics are less commonly used.<sup>14,19,20</sup> This is likely due to the 2011 Asian Pacific Heart Associations' recommendation for CCBs to be the preferred drug for managing hypertension in East Asian countries,<sup>21</sup> while the use of diuresis is usually avoided due to the expected problems with diuresis and the need to monitor serum potassium.

This is also reflected in our result where only about one-third had their serum potassium assessed. In addition, urine albumin creatinine ratio (UACR) is suggested as a baseline assessment especially for those with diabetes or CKD, but was only assessed in 10% of participants. This investigation is not routinely available and usually only done if impaired renal function is detected via eGFR. A national study published in 2020 also found that only about 10% of patients with diabetes had UACR tested in the past year.<sup>22</sup> The low prevalence of ARBs is likely due to the fact that only one ARB is included in the Thai National list of essential drugs and is more expensive

TABLE 5 factors associated with hypertension control at last visit

	Model 1		Model 2		Model 3	
	OR hypertension control at last visit (95%CI)	p-value	OR hypertension control at last visit	p-value	OR hypertension control at last visit	p-value
<i>Hospital size and geographic factors</i>						
Hospital size						
Provincial (>120 beds)	Reference	.03	Reference	.03	Reference	<0.01
Large (90–120 beds)	1.21(0.87 to 1.69, $p = .25$ )		1.18 (0.83 to 1.67, $p = .35$ )		1.32 (0.92 to 1.90, $p = .13$ )	
Community (>90 beds)	0.68 (0.60 to 1.10), $p = .18$		0.79 (0.58 to 1.08, $p = .14$ )		0.78 (0.56 to 1.08, $p = .13$ )	
Region						
North	Reference	<.01	Reference	<.01	Reference	<.01
South	0.61(0.45 to 0.84, $p < .01$ )		0.54 (0.40 to 0.76, $p < .01$ )		0.55 (0.39 to 0.78, $p < .01$ )	
Central	1.06 (0.76 to 1.48, $p = .72$ )		0.93 (0.66 to 1.31, $p = .68$ )		0.95 (0.66 to 1.37, $p = .77$ )	
Northeast	0.68 (0.49 to 0.94, $p = .02$ )		0.59 ( $p = .42$ to 0.83, $p < .01$ )		0.56 (0.39 to 0.80, $p < .01$ )	
<i>Patient-related factors</i>						
Age Group						
<30			Reference	.07	Reference	.04
30–40			2.46 (0.84 to 7.16), $p = .10$		2.93 (0.90 to 9.54, $p = .08$ )	
41–50			2.31 (0.84 to 6.32), $p = .10$		2.66 (0.87 to 8.18, $p = .09$ )	
51–60			1.84 (0.67 to 5.08), $p = .23$		1.91 (0.62 to 5.90, $p = .26$ )	
61–70			2.20 (0.77 to 6.25, $p = .14$ )		2.28 (0.71 to 7.29, $p = .16$ )	
>70			3.20 (1.09 to 9.42, $p = .03$ )		3.35 (1.02 to 11.0, $p = .05$ )	
Sex						
Male			Reference	.05	Reference	.04
Female			1.26 (1.00 to 1.61, $p = .05$ )		1.29 (1.01 to 1.65, $p = .04$ )	
Baseline CVD risk						
Low			Reference	.29	Reference	.35
Moderate			0.77 (0.54 to 1.08, $p = .13$ )		0.80 (0.56 to 1.15, $p = .23$ )	
High			0.88 (0.58 to 1.32, $p = .53$ )		0.97 (0.63 to 1.49, $p = .90$ )	
<i>Medication factors</i>						
Medication at initiation						
Appropriate <sup>a</sup>					Reference	.89
Inappropriate <sup>b</sup>					0.98 (0.77 to 1.25, $p = .89$ )	
Medication adjustments						
Appropriate <sup>a</sup>					Reference	<.01
Inappropriate <sup>c</sup>					0.69 (0.53 to 0.90, $p < .01$ )	

(Continues)



TABLE 5 (Continued)

	Model 1		Model 2		Model 3	
	OR hypertension control at last visit (95%CI)	p-value	OR hypertension control at last visit	p-value	OR hypertension control at last visit	p-value
Number of prescriptions						
One					Reference	<.01
More than one					0.66 (0.51 to 0.85, $p < .01$ )	

<sup>a</sup>Consistent with 2015 Thai Hypertension Guideline recommendations.

<sup>b</sup>Did not receive appropriate number of medication based on baseline CVD risk.

<sup>c</sup>Did not received medication adjustments when required.

compared to ACEIs.<sup>23</sup> Combined pills are not yet included in the Thai national list of essential drugs, which is likely to explain the low prevalence of fixed dose combinations.

Our clinical audit suggests that, based on the 2015 guidelines, there is still room for improvement. The variation in adherence is likely due to the fact that the use of the guideline is at the discretion of the treating physicians with no financial or other incentives provided to encourage adherence to guidelines. As physicians in Thailand do not require continuous medical education credits for relicensing, it may be possible that some physicians were unaware of the 2015 guidelines and thus being the explanation for the observed non-compliance rather than therapeutic inertia.<sup>24</sup> Our results provide evidence that medication adjustment consistent with recommendations in the 2015 Thai Hypertension Guideline was significantly associated with better hypertension control rate. In addition, our study found that those with more than one hypertensive medication were less likely to have their hypertension under control and only one patient received a fixed dose combination. Another study from Thailand suggested that higher number of antihypertensive medications was associated with lower adherence.<sup>25</sup> These two studies together with evidence from clinical trials suggest that fixed dose combination therapies may be helpful in the many patients requiring more than one antihypertensive medication. This reduces the pill load for these patients of which many also receive other drugs for co-morbidities.<sup>26-28</sup>

Our data suggest that large hospitals had the lowest lost to follow-up rate while community hospitals and provincial hospitals higher rates. Similar to access to hypertension screening services, it is likely that provincial hospitals lose some patients due to larger distance to the hospitals.<sup>3</sup> However, the community hospitals may lose patients due to insufficient communication.<sup>29,30</sup> Reducing loss to follow-up may be one way to achieve better hypertension control. Lost to follow-up may be attributable to low perception of self-risk reducing motivation for returning for follow-up blood pressure measurement,<sup>31</sup> as well as such things as long and discouraging waiting times for consultation and drug delivery to patients.<sup>32,33</sup> Characterization of patients lost to follow-up will help identify high risk group and potentially mitigate against loss. Importantly, use of a unique patient ID with longitudinal follow-up whether in private or public hospital may help in tracing patients and avoid lost to follow-up. Currently, hospital IDs cannot connect to other hospitals. Ten percent of new

cases entering the study already had a previous diagnosis of hypertension from another hospital, thus streamlining of the referral system would help in transition of care of patients from one facility to the other, reducing loss of patients during the back and forth between different facilities<sup>34</sup>

Compliance to hypertension guidelines and hypertension control rates varied across hospital size, with the bigger hospitals doing better than the smaller community hospitals. This may be due to the organization of hypertension services between hospitals of different sizes across the country. Bigger hospitals have better infrastructure, more physicians and better access to specialists than smaller hospitals and this may help explain our results.<sup>8</sup> However, our findings are in contrast to one study that reported smaller Thai hospitals to have better blood pressure control than bigger provincial ones (77% vs 72%).<sup>14</sup> A possible explanation for this is that the more complex cases were referred for treatment in bigger provincial hospitals which may also explain the lower compliance in provincial hospitals in our study.

Our study found dose adjustment to be especially important for hypertension control, but other factors may be considered to improve the overall hypertension control rates in Thailand.<sup>20</sup> Literature suggests that suboptimal control usually reflect existing programmatic challenges including suboptimal management, long waiting times for consultation and drug collection which encourage loss to follow-up.<sup>35,36</sup> Reorganization services to include a multi-disciplinary care team may be necessary.<sup>37</sup> Delegation of duties of prescribing drugs to non-physician health care workers like nurses and pharmacists may help to reduce waiting times and improve control.<sup>38-40</sup> In Thailand, there is evidence that reorienting services to have a more patient-centered approach, allowing for continuity of care and greater patient-provider communication, may be useful for hypertension control.<sup>41</sup> Based on the results of this research, an application for including fixed dose combination pills in the national essential drug list has been submitted. The Thai Strategic and Technical Advisory Group for Hypertension, chaired by the Director-General of the Department of Disease Control, has also approved a pilot implementation of simple treatment protocol and village health volunteer training that may pave the way for improved blood pressure control.

The study has at least two limitations. We included only new cases entering treatment and thus the control rate may not apply

to cases already in long-term treatment. The long-term control rate is likely to be lower as according to the Thai 2018 MoPH statistics, only 42% of hypertensive patients in treatment had their BP controlled.<sup>42</sup> Secondly, we sampled from four regions of Thailand, with only 4 provincial (>120 beds) hospital and 4 large (90–120 bed) hospitals included in the audit, which may limit overall generalizability to the whole country. It is likely that there may be more variability across provinces as Thai MoPH statistics demonstrated that hypertension control rate in 2018 varied between 25% and 55% between provinces.<sup>43</sup>

## 5 | CONCLUSIONS

This audit of 1406 newly registered hypertensive patients attending 16 Thai hospitals demonstrated that half of patients had their hypertension controlled at six months and around two thirds of newly diagnosed cases had their blood pressure controlled during their last reading over 1 year. In large (90–120 beds) hospitals, the control rate was as high as 71%. These results are not perfect and leave room for improvement by strengthening some components of hypertension management. Failure to comply with the guidelines for antihypertensive treatment regarding dose adjustment and loss to follow-up were highlighted as possible target areas to improve blood pressure control in Thailand. Continuous training of health care providers on updated treatment guidelines, as well as availability of fixed dose combinations and simplifying treatment protocols may help reducing treatment inertia and improve control rates further.

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### CONFLICT OF INTEREST


None.

### AUTHOR CONTRIBUTION

CA, KP, SS, and RG contributed to the conception and design of the study, CA, SS, BT, PS, DT were involved with data collection, and CA, KP, SS, RG were involved in data analysis. All authors were involved in interpretation of the data. CA, EN, RG were drafted in manuscript,

KP, SS, BT, PS, DT, MHO, AD, JES critically reviewed the subsequent drafts and provided feedback. All authors have approved the final version to be submitted for publication.

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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