Hypertension Subtypes among Thai Hypertensives: An Analysis of Telehealth-Assisted Instrument in Home Blood Pressure Monitoring Nationwide Pilot Project

Sakolwat Montrivade,1 Pairoj Chattranukulchai,1 Sarawut Siwamogsatham,2 Yongkasem Vorasettakarnkij,2 Witthawat Naeowong,2 Patchaya Boonchayaanant,3 Anut Sakulsupsiri,4 Aekarach Ariyachaipanich,1 Vorarit Lertsuwunseri,1 Voravut Rungpradubvong,1 Sudarat Satitthummanid,1 Sarinya Puwanant,1 Somchai Prechawat,1 Suphot Srimahachota,1 Jarkarpun Chaipromprasit,1 Wacin Buddhari,1 Smonporn Boonyaratavej,1 Surapun Sithisook,1 Peera Buranakitjaroen,5 Apichard Sukonthasarn,6 and Somkiat Sangwatanaroj1

1Division of Cardiovascular Medicine, Chulalongkorn University, King Chulalongkorn Memorial Hospital, 10330 Bangkok, Thailand
2Division of Hospital and Ambulatory Medicine, Chulalongkorn University, King Chulalongkorn Memorial Hospital, 10330 Bangkok, Thailand
3Division of Endocrinology and Metabolism, Department of Medicine, Faculty of Medicine, Chulalongkorn University, King Chulalongkorn Memorial Hospital, 10330 Bangkok, Thailand
4Pharmacy Department, King Chulalongkorn Memorial Hospital, 10330 Bangkok, Thailand
5Department of Medicine, Siriraj Hospital, Mahidol University, 10700 Bangkok, Thailand
6Thai Hypertension Society, 10310 Bangkok, Thailand

Correspondence should be addressed to Pairoj Chattranukulchai; pairoj.md@gmail.com

Received 2 October 2019; Revised 6 February 2020; Accepted 19 February 2020; Published 9 April 2020

Academic Editor: Tomohiro Katsuya

Copyright © 2020 Sakolwat Montrivade et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Background. White-coat hypertension (HT), masked HT, HT with white-coat effect, and masked uncontrolled HT are well-recognized problems of over- and undertreatment of high blood pressure in real-life practice. However, little is known about the true prevalence in Thailand. Objectives. To examine the prevalence and characteristics of each HT subtype defined by mean home blood pressure (HBP) and clinic blood pressure (CBP) using telemonitoring technology in Thai hypertensives. Methods. A multicenter, observational study included adult hypertensives who had been diagnosed for at least 3 months based on CBP without the adoption of HBP monitoring. All patients were instructed to manually measure their HBP twice a day for the duration of at least one week using the same validated automated, oscillometric telemonitoring devices (Uright model TD-3128, TaiDoc Corporation, Taiwan). The HBP, CBP, and baseline demographic data were recorded on the web-based system. HT subtypes were classified according to the treatment status, CBP (≥ or <140/90 mmHg), and mean HBP (≥ or <135/85 mmHg) into the following eight subtypes: in nonmedicated hypertensives, there are four subtypes that are normotension, white-coat HT, masked HT, and sustained HT; in treated hypertensives, there are four subtypes that are well-controlled HT, HT with white-coat effect, masked uncontrolled HT, and sustained HT. Results. Of the 1,184 patients (mean age 58 ± 12.7 years, 59% women) from 46 hospitals, 1,040 (87.8%) were taking antihypertensive agents. The majority of them were enrolled from primary care hospitals (81%). In the nonmedicated group, the prevalence of white-coat HT was 25.7% and 7.0%, respectively. Among the alog-treated patients, the HT with white-coat effect was found in 23.3% while 46.7% had uncontrolled HBP (a combination of the masked uncontrolled HT (9.6%) and sustained HT (37.1%)). In the medicated older subgroup (n = 487), uncontrolled HBP was more prevalent in male than in female (53.6% vs. 42.4%, p = 0.013). Conclusions. This is the first nationwide study in Thailand to examine the prevalence of HT subtypes. Almost one-fourth had white-coat HT or HT with white-coat effect. Approximately half of the treated patients
especially in the older males had uncontrolled HBP requiring more intensive interventions. These results emphasize the role of HBP monitoring for appropriate HT diagnosis and management. The cost-effectiveness of utilizing THAI HBPM in routine practice needs to be examined in the future study.

1. Introduction

Hypertensive patients can be divided into several subtypes based on clinic blood pressure (CBP) and out-of-office blood pressure values including white-coat hypertension (HT), masked HT and sustained HT in nonmedicated patients or HT with white-coat effect, masked uncontrolled HT, and sustained HT in patients receiving antihypertensive medications [1–3]. However, the diagnosis is very challenging and is often overlooked since it requires both CBP and out-of-office BP data [4]. Previous studies reported the prevalence of white-coat HT and masked HT as high as 35% and 10%, respectively [2, 3, 5–7]. In patients with white-coat HT and HT with white-coat effect, the overintensification of antihypertensive medications could potentially cause hypotension and worsen cardiovascular outcomes especially in the elderly [8, 9]. On the other hand, patients with masked HT and masked uncontrolled HT may be at an increased risk of stroke comparable to those in patients with sustained HT [10]. Out-of-office BP measurement is crucial to confirm the diagnosis and to titrate BP-lowering medications in the patient with these HT subtypes [11, 12]. Home blood pressure monitoring (HBPM) is recommended by recent several guidelines [13–15] as a practical modality to obtain out-of-office BP, which is less expensive, less complex, and more widely available than ambulatory blood pressure monitoring (ABPM) [16–19]. The adoption of telemonitoring strategy, an Internet-based transmission system, allows linking home blood pressure (HBP) records between multiple HBPM devices and a central computer at the clinic. The data can be monitored and analyzed by trained healthcare professionals remotely and can facilitate improvement in managing hypertensive patients [11, 20–22]. This technology overcomes the self-reporting bias which is a limitation of HBPM in a clinical practice [23] since the HBP data transferring is completed without manual data entry by the patient.

The telehealth-assisted instrument in home blood pressure monitoring (THAI HBPM) project was designed to be a proof-of-concept observational multicenter study implementing the web-based telemonitoring. We aimed to examine the prevalence and characteristics of HT subtypes defined by mean HBP and CBP in real-life clinical setting across Thailand.

2. Materials and Methods

2.1. Study Oversight. THAI HBPM is a nationwide prospective observational study involving 46 centers across all regions of Thailand (see Supplementary Material for the details of all participating sites). The Ministry of Public Health of Thailand promoted the nationwide project and approved the study protocol and the centralized institutional review board review process.

2.2. Patient Population. Eligible participants were consecutively enrolled from 46 centers throughout the country. Adult patients who were 18 years of age or older with known HT diagnosed for more than 3 months based on CBP without adoption of HBPM were enrolled. If the participants were taking antihypertensive agents, they must have been on a stable dose of medications for at least 3 months before the enrollment. Patients with incomplete clinical characteristics or BP data will be excluded.

2.3. Clinic and Home Blood Pressure Measurement. Clinic BP was measured by trained healthcare professionals using the validated sphygmomanometer, after the patient had been resting in a relaxed, seated position [24, 25]. We used the average of two consecutive readings at a 2-minute interval taken from the arm with the higher BP for the analysis. Clinical validation between CBP and HBP readings was performed at the clinic according to the standard recommendation [26] before starting the HBP recording (day 0). The device is validated if there are less than 5 mmHg differences of both SBP and DBP between sphygmomanometers and HBPM devices [26, 27] (see Supplementary Table 1).

Home BP data were obtained using the same validated automated, oscillometric devices (Uright model TD-3128, TaiDoc Technology Corporation, Taiwan, see Supplementary Figure 1). Trained healthcare providers instructed the participants to self-record HBP twice a day (1 hour after waking in the morning before taking antihypertensive medications or having breakfast and 30 minutes before going to bed) after 3 minutes of rest in a sitting position with two consecutive measurements, 1 minute apart for each recording. Blood pressure measurement continued for at least 7 days as recommended by standard guidelines [2, 28] during a 30-day period. In case there is a significantly different BP between both arms as determined at the enrollment visit, participants were instructed to use the arm with the greater BP. To avoid self-reporting bias, HBP values were automatically recorded in device memory. All participants were informed to bring the HBPM device along with them on the appointed clinic visit. At the 1st follow-up visit (day 30–45), all recorded HBP data were transferred from the devices via USB cable to the Windows-based computer at the participating clinics. The data will then be automatically forwarded to cloud storage through the Internet-based transmission system. When HBP data had been uploaded, they could be viewed and analyzed using a regular Internet Explorer program via Uright Telehealth website (Figure 1).
The device and Uright telehealth system were validated and approved by the US FDA [29]. A trained investigator at King Chulalongkorn Memorial Hospital who was blinded to the study demographic data independently interpreted the BP pattern. Patients who had at least 7-day HBP records will be included in the analysis. We discarded the measurements taken on the first day and used the mean value of all the remaining HBP records for the data analysis [16]. The CBP, demographic data, medical history, biochemistry laboratory results, and current antihypertensive medications were recorded on the web-based system.

2.4. Data Analysis. Participants were categorized according to the treatment status, CBP (≥ or < 140/90 mmHg), and HBP data (≥ or < 135/85 mmHg) into the following 8 subtypes [2, 28, 30]. In nonmedicated patients, there were 4 subtypes: (1) normotension: nonhypertensive CBP and HBP levels; (2) white-coat HT: hypertensive CBP level and nonhypertensive HBP level; (3) masked HT: nonhypertensive CBP level and hypertensive HBP level; and (4) sustained HT: both hypertensive CBP and HBP levels. Treated participants were categorized into another 4 subtypes: (5) well-controlled HT: nonhypertensive CBP and HBP levels; (6) HT with white-coat effect: hypertensive CBP level and nonhypertensive HBP level; (7) masked uncontrolled HT: nonhypertensive CBP level and hypertensive HBP level; and (8) sustained HT: both hypertensive CBP and HBP levels.

Regarding the HBP control status in treated patients, the “controlled HBP group” consists of patients with well-controlled HT and HT with white-coat effect while the “uncontrolled HBP group” includes 2 other subtypes: masked uncontrolled HT and sustained HT. The white-coat effect (CBP and HBP difference) was calculated by mean CBP minus mean HBP (mmHg). Subgroup analyses were analyzed according to the country’s regions, gender, and age (<60 years and ≥60 years).

Categorical variables were described as numbers (n) and percentage of frequencies (%). Continuous variables were shown as mean values and SD. Chi-square test and ANOVA were used for the analysis of categorical and continuous variables, respectively. We used SPSS software, version 22.0 (IBM) for statistical analysis.

3. Results

3.1. Patient Characteristics. A total of 1,250 patients were consecutively enrolled between August 2016 and August 2017. Of these, 66 were excluded due to incomplete clinical characteristics or BP data. Thus, 1,184 patients from 46 hospitals (5 regions: North, Northeast, East, Center, and South) were included in the analysis (see patient enrollment flow chart in Supplementary Figure 2). Patient characteristics are summarized in Table 1. The mean (±SD) age of the patients was 58.2 ± 12.7 years; 59% were women. The majority of them were recruited from primary care hospitals (81%). The mean duration of the diagnosis of HT was 8.4 ± 3.1 months. There were 1,040 (87.8%) patients on antihypertensive medications. Most of them took one or two agents per day (39.0% and 36.1%, resp.). The most commonly used medications were dihydropyridine calcium channel blockers (62.3%), followed by angiotensin converting enzyme (ACE) inhibitors (45.6%), while the diuretics were used in 18.6%. The mean (±SD) BMI in the cohort was 26.5 ± 5.1 kg/m². The mean (±SD) clinic and home BP were 143.1 ± 18.0/84.8 ± 11.7 mmHg and 134.3 ± 13.9/80.6 ± 8.8 mmHg, respectively, with the overall white-coat effect (systolic BP/diastolic BP difference between CBP and HBP) of 8.9 ± 16.4/4.2 ± 9.8 mmHg.
white-coat effect of 21.2 patients, the prevalence of white-coat HT was 25.7% with the subtypes is presented in Table 2. Of 144 nonmedicated 3.2. Hypertension Subtypes. 

In comparison with the studies using ABPM, Omboni et al. [1] recently conducted a systematic review including studies using HBPM and found a wide range of prevalence of white-coat HT from 16% to 55%. Stergiou et al. [31] reported the International Database of Home blood pressure in relation to Cardiovascular Outcomes (IDHOCO) study involving 6,458 participants from 5 different populations. They found that 9.8% of the participants had masked HT. In comparison with the studies using ABPM, Piper et al. [5] included 14,143 patients from 27 countries and reported the prevalence of white-coat HT and masked HT of 22.6% and 11.1%, respectively. In the IDACO ABPM registry, white-coat HT was found in 35.7% while the prevalence of masked HT was 16.9% [6]. One possibility of a lower proportion of masked HT in our study is that we defined masked HT using the mean morning and evening HBP values. In contrast with ABPM method, we could not identify the elevated midday BP and high nocturnal BP during sleep, which are common phenotypes of masked HT [10, 32].

In treated hypertensives, the proportion of patients with HT with white-coat effect and masked uncontrolled HT in the present cohort was 23.3% and 9.6%, respectively. These
diseases, and laboratory results) between patients in each HT subtype as summarized in Tables 3 and 4.

3.3. HT Subtypes by Age and Gender. HT subtypes stratified according to age and gender (≤60 years and >60 years) is shown in Table 5. In the treated older (>60 years old) subgroups (n = 499), uncontrolled HBP was more prevalent in male than female (53.7% vs. 42.4%, p = 0.013) but there was no significant difference between genders in younger subgroups (42.5% and 48.3%, p = 0.188). The older males had higher prevalence of uncontrolled HBP than younger males (p = 0.02) without significant difference in female groups (p = 0.151).

3.4. HT Subtype Analyzed by Hospital Regions. Table 6 shows the HT subtype categorized by hospital regions. Most of the patients were enrolled from the Northeast region (n = 276, 23.3%) followed by the Central region (n = 252, 21.3%). The prevalence of HT subtypes was not significantly different according to the hospital regions. Of all five regions, the East region tended to have the highest rate of uncontrolled HBP (53.3%) followed by the South (48.8%) without significant difference when compared with the rest of the country (p = 0.317).

4. Discussion

This is the first nationwide multicenter study to examine the prevalence of HT subtypes in Thai hypertensives using telemonitoring. We assessed patient characteristics and type of antihypertensive medications and further analyzed subgroup of patients according to gender, age, and geographical regions. In nonmedicated group of the present study, the proportion of patients with white-coat HT and masked HT was 25.7% and 7.0%, respectively, which was concordant with several published studies. Piper et al. [1] reported the International Database of Home blood pressure in relation to Cardiovascular Outcomes (IDHOCO) study involving 6,458 participants from 5 different populations. They found that 9.8% of the participants had masked HT. In comparison with the studies using ABPM, Omboni et al. [5] included 14,143 patients from 27 countries and reported the prevalence of white-coat HT and masked HT of 22.6% and 11.1%, respectively. In the IDACO ABPM registry, white-coat HT was found in 35.7% while the prevalence of masked HT was 16.9% [6]. One possibility of a lower proportion of masked HT in our study is that we defined masked HT using the mean morning and evening HBP values. In contrast with ABPM method, we could not identify the elevated midday BP and high nocturnal BP during sleep, which are common phenotypes of masked HT [10, 32].

In treated hypertensives, the proportion of patients with HT with white-coat effect and masked uncontrolled HT in the present cohort was 23.3% and 9.6%, respectively. These

| Characteristic | Value |
|---------------|-------|
| Age (years)   | 58.2 ± 12.7 |
| Female        | 695 (58.7%) |
| Diabetes      | 158 (13.3%) |
| Dyslipidemia  | 610 (51.5%) |
| Follow-up at primary care hospital | 960 (81.0%) |
| On antihypertensive therapy | 1,040 (87.8%) |

Number of antihypertensive medications

1: 406 (39.0%)
2: 375 (36.1%)
≥3: 259 (24.9%)

Type of antihypertensive medications

Dihydropyridine calcium channel blockers: 648 (62.3%)
Angiotensin converting enzyme inhibitors: 474 (45.6%)
Diuretics: 193 (18.6%)
Others: 636 (61.2%)

BMI (kg/m²): 26.5 ± 5.1

Clinical BP

Systolic BP (mmHg): 143.1 ± 18.0
Diastolic BP (mmHg): 84.8 ± 11.7
Pulse (beats/min): 79.2 ± 12.2

Home BP

Systolic BP (mmHg): 134.3 ± 13.9
Diastolic BP (mmHg): 80.6 ± 8.8
Pulse (beats/min): 74.6 ± 9.9

Laboratory results

Total cholesterol (mg/dL): 199.2 ± 41.2
Triglyceride (mg/dL): 152.3 ± 85.5
HDL (mg/dL): 53.4 ± 14.7
LDL; low-density lipoprotein, GFR; glomerular filtration rate. BMI; body mass index, BP; blood pressure, HDL; high-density lipoprotein.

There was no significant difference between nonmedicated and treated patients in all BP components except mean clinic diastolic BP and mean homodiastolic BP which were higher in uncontrolled HT and sustained HT. WY_here were no differences in baseline characteristics (age, gender, comorbid diseases, and laboratory results) between patients in each HT subtype as summarized in Tables 3 and 4.

### Table 1: Demographics and clinical characteristics of the patient population (n = 1,184). Values are number (%) or mean ± SD.
numbers are quite similar to 23% and 9% reported from the recent Asia BPHome study that included the patients from 11 countries across Asia [33]. Comparing with the western study, Stergiou [34, 35] et al. reported the prevalence of HT with white-coat effect and masked uncontrolled HT of 22% and 11.9%, respectively, by using average 2-visit CBP value and 4-day HBPM value. We further investigated the white-coat effect across the cohort and found the effect of 8.7 ± 16.9/3.8 ± 10.0 mmHg in patients receiving antihypertensive medications, while the effect was 10.2 ± 12.9/7.2 ± 7.8 mmHg in the nonmedicated patients. These ranges of white-coat effect found in our study are comparable to the previous reports using HBPM [36, 37].

In the present study, the controlled HBPM was achieved in 53.3% of treated patients, which is comparable to 51% from the cross-sectional survey over 25 provinces across Thailand in 2011 [38]. However, this rate is lower than the result from the 2014 Thai National Health Examination Survey V showing that 60% of hypertensive participants had controlled BP using field BP target of <140/90 mmHg taken by the community health volunteer home visit [39]. The differences in the patient demographic and BP measurement method could account for the higher BP control rate.

Subgroup analysis of patients according to sex and age found that older males had the least HBP controlled (only 38.2%) in one year, compared with usual care (from 81.8% to 38.2% in one year, compared with usual care (from 81.8% to 54.5%) [40]. These findings could emphasize the role of HBPM for long-term BP control in the older population, especially in the males.

Regarding the BP control of each geographical region across Thailand, the East region tended to have the greatest rate of uncontrolled HBP whereas the Northeast tended to have the lowest (57.2% and 46.7%). The interregional difference may be attributed to the fact that the Northeast region has the lowest prevalence of HT compared with other regions.

| Table 2: Prevalence of eight hypertension (HT) subtypes categorized according to the treatment status, clinic blood pressure, and mean home blood pressure. |
|---|---|---|---|
| Clinic blood pressure | SBP <140 and DBP <90 mmHg | SBP ≥140 and/or DB ≥90 mmHg | Normotension 14 (9.7%) | White-coat HT 37 (25.7%) | Masked HT 10 (7.0%) | Sustained HT 83 (57.6%) |
| Treated patients (n = 1,040) | Home blood pressure | SBP <140 and DBP <90 mmHg | SBP ≥140 and/or DB ≥90 mmHg | SBP ≥135 and/or DBP ≥85 mmHg | SBP <140 and DBP <90 mmHg | SBP ≥140 and/or DB ≥90 mmHg |
| Clinic blood pressure | SBP <140 and DBP <90 mmHg | SBP ≥140 and/or DB ≥90 mmHg | Normotension 312 (30.0%) | Masked uncontrolled HT 100 (9.6%) | Well-controlled HT 312 (30.0%) | Masked uncontrolled HT 100 (9.6%) |
| Nonmedicated patients (n = 144) | Home blood pressure | SBP <140 and DBP <90 mmHg | SBP ≥140 and/or DB ≥90 mmHg | SBP ≥135 and/or DBP ≥85 mmHg | SBP <140 and DBP <90 mmHg | SBP ≥140 and/or DB ≥90 mmHg |
| Clinic blood pressure | SBP <140 and DBP <90 mmHg | SBP ≥140 and/or DB ≥90 mmHg | Normotension 14 (9.7%) | White-coat HT 37 (25.7%) | Masked HT 10 (7.0%) | Sustained HT 83 (57.6%) |
| Nonmedicated patients (n = 144) | Home blood pressure | SBP <140 and DBP <90 mmHg | SBP ≥140 and/or DB ≥90 mmHg | SBP ≥135 and/or DBP ≥85 mmHg | SBP <140 and DBP <90 mmHg | SBP ≥140 and/or DB ≥90 mmHg |
| Clinic blood pressure | SBP <140 and DBP <90 mmHg | SBP ≥140 and/or DB ≥90 mmHg | Normotension 14 (9.7%) | White-coat HT 37 (25.7%) | Masked HT 10 (7.0%) | Sustained HT 83 (57.6%) |

Values are number (%) or mean ± SD. The P values reflect comparison between 4 subtypes. p values <0.05 are in bold.
regions [39], the difference in healthcare systems, and high salt intake in the East region. More importantly, this data should prompt local healthcare authorities for further evaluation and action to improve HT care.

Telehealth technology has been strongly recommended in the recent guidelines for the prevention, detection, and management of high BP in adults [11, 15]. It can be implemented with adjunct active interventions from healthcare providers such as the titration of medication or giving feedback to the patients or it can be used as only passive telemetering [41, 42] as demonstrated in our study. A recent meta-analysis of randomized controlled studies showed that the effect of home telemetering on BP control was greater than that of BP self-monitoring without transmission of HBP data [21]. This emphasizes an incremental value of the teletransmission approach to minimize self-reporting bias [23]. The present study shows that implementing telehealth-assisted HBPM technology in Thailand was feasible. We constructed a network of hypertensive care across all regions and provided Internet-based online database. Achieving target BP control required technological advances for BP control in Thailand. Thus, our study could be the first step to enhance the role of technological advances for BP control in Thailand. The ongoing 1-year follow-up study of THAI HBPM to examine the BP control rate after implementing the HBPM-facilitated medication titration could further highlight the role of telemetering in the management of HT.

Table 4: Patient characteristics categorized by hypertension subtypes in the treated group.

| Characteristic | All (n = 1,040) | Well-controlled HTa (n = 312) | HT with white-coat effectb (n = 242) | Masked uncontrolled HTc (n = 100) | Sustained HTd (n = 386) | p value |
|---------------|----------------|-------------------------------|-----------------------------------|-------------------------------|-----------------------|--------|
| Age (years)   | 59.0 ± 12.5    | 58.9 ± 12.5                   | 58.5 ± 12.3                       | 59.3 ± 12.5                   | 59.2 ± 12.6           | 0.907  |
| Female        | 618 (59%)      | 195 (62.5%)                   | 140 (57.9%)                       | 54 (54.0%)                    | 229 (59.3%)           | 0.441  |
| Diabetes      | 157 (15.1%)    | 37 (11.8%)                    | 38 (15.7%)                        | 14 (14.0%)                    | 68 (17.6%)            | 0.362  |
| Dyslipidemia  | 558 (53.7%)    | 169 (54.2%)                   | 131 (54.1%)                       | 52 (52%)                      | 206 (53.4%)           | 0.854  |
| BMI (kg/m2)   | 26.6 ± 5.2     | 26.3 ± 4.5                    | 26.7 ± 4.9                        | 26.7 ± 4.7                    | 26.8 ± 5.9            | 0.717  |

Clinic BP

- Systolic BP (mmHg): 143.1 ± 18.1 vs. 125.7 ± 9.0, p < 0.001
- Diastolic BP (mmHg): 84.1 ± 11.7 vs. 76.45 ± 7.6, p < 0.001
- Pulse (beats/min): 79.2 ± 12.2 vs. 77.61 ± 10.3, p = 0.012

Home BP

- Systolic BP (mmHg): 134.4 ± 14.2 vs. 122.9 ± 6.9, p < 0.001
- Diastolic BP (mmHg): 80.4 ± 8.8 vs. 74.6 ± 5.6, p < 0.001
- Pulse (beats/min): 74.4 ± 10.1 vs. 73.9 ± 8.9, p = 0.599

Laboratory results

- Total cholesterol (mg/dL): 198.2 ± 40.2 vs. 196.3 ± 36.9, p = 0.678
- Triglyceride (mg/dL): 153.8 ± 86.2 vs. 148.0 ± 86.4, p = 0.603
- HDL (mg/dL): 53.3 ± 14.8 vs. 54.0 ± 13.2, p = 0.731
- Calculated LDL (mg/dL): 113.9 ± 37.8 vs. 112.3 ± 33.9, p = 0.687
- Creatinine (mg/dL): 0.94 ± 0.50 vs. 0.89 ± 0.28, p = 0.007
- GFR <60 mL/min/1.73 m²: 256 (28.2%) vs. 76 (27.3%), p = 0.802

Values are number (%) or mean ± SD. The p values reflect comparison between 4 subtypes. p values <0.05 are in bold. Abbreviations as Table 1.

Table 5: Prevalence of hypertension (HT) subtypes and BP control patterns further classified according to gender and age (≤60 years and >60 years).

| Characteristic | Male | Female |
|---------------|------|--------|
|                | Age ≥60 years | Age >60 years | p value | Age ≤60 years | Age >60 years | p value |
| Nonmedicated patient (n = 144) | 53 (100%) | 16 (100%) | 0.604 | 55 (100%) | 20 (100%) | 0.565 |
| Normotension | 4 (7.5%) | 3 (18.7%) | | 5 (9.1%) | 2 (10.0%) | |
| White-coat HT | 10 (18.9%) | 5 (31.2%) | | 18 (32.7%) | 4 (20.0%) | 0.565 |
| Masked HT | 3 (5.7%) | 1 (6.3%) | | 5 (9.1%) | 1 (5.0%) | |
| Sustained HT | 36 (67.9%) | 7 (43.8%) | | 27 (49.1%) | 13 (65.0%) | |

| Characteristic | Treated patient (n = 1,040) | p value |
|---------------|----------------------------|--------|
|                | Age ≥60 years | Age >60 years | | Age ≥60 years | Age >60 years | |
| Well-controlled HT | 212 (100%) | 216 (100%) | | 329 (100%) | 283 (100%) | |
| HT with white-coat effect | 64 (30.1%) | 55 (25.5%) | 0.138 | 95 (28.8%) | 101 (35.7%) | |
| Masked uncontrolled HT | 58 (27.4%) | 45 (20.8%) | | 75 (22.8%) | 62 (21.9%) | 0.230 |
| Sustained HT | 19 (9.0%) | 27 (12.5%) | | 27 (8.2%) | 27 (9.5%) | |

| Characteristic | Controlled HBP* | Uncontrolled HBPb | p value |
|---------------|-----------------|-------------------|--------|
|                | Age ≥60 years | Age >60 years | | Age ≥60 years | Age >60 years | |
| Controlled HBP* | 122 (57.5%) | 100 (46.3%) | 0.020 | 170 (51.7%) | 163 (57.6%) | 0.151 |
| Uncontrolled HBPb | 90 (42.5%) | 116 (53.7%) | | 159 (48.3%) | 120 (42.4%) | |

Values are number. aControlled HBP included well-controlled HT and HT with white-coat effect. bUncontrolled HBP included masked uncontrolled HT and sustained HT in treated patients. p value between male age >60 years and female age >60 years = 0.013.
The present study has some limitations. Firstly, the majority of the participants were enrolled from primary care hospitals and managed by general practitioners; thus the results may not be generalizable to the larger scale hospitals. However, our finding can still represent the characteristic of HT subtypes in real-life practice since the vast majority of Thai hypertensives have been followed at primary care centers [40]. Secondly, the proportion of patients with white-coat and masked HT may not be accurate since the number of patients in the nonmedicated group was small. Moreover, this study enrolled the participants solely based on high CBP; thus the majority of patients with masked HT who have normal or borderline CBP may have not been included. Thirdly, since the data on current smoking status is not available, this could affect the characteristic of masked HT. The out-of-clinic smoking potentially affects the raising of BP at home [32]. Lastly, due to the fact that this study was conducted in various clinics across the country, thus CBP data were obtained from different sphygmomanometers’ models. However, we minimized intraobserver and interobserver variations by training the staff to perform CBP and models. However, we minimized intraobserver and inter-

## 5. Conclusions

This is the first nationwide study in Thailand to demonstrate the prevalence and characteristics of HT subtypes in Thai hypertensives using telemonitoring. Almost one-fourth had white-coat HT or HT with white-coat effect. Approximately half of the treated hypertensives, especially in the older males, had uncontrolled HBP which requires more intensive interventions. The cost-effectiveness of utilizing THAI HBPM for long-term BP control in routine practice needs to be examined in the future study.

## Data Availability

The related data used to support the results of this study are available from the corresponding author upon request.

## Conflicts of Interest

All authors declare no conflicts of interest.

## Acknowledgments

The authors gratefully acknowledge investigators, staff, and participants of all 46 sites for their contribution to this study. They are thankful to Naiyana Kanjanapibul RN and Sawangchit Kongpibarn RN who are the nurse coordinators. In addition, they would like to thank the Ministry of Public Health of Thailand, the Heart Association of Thailand, and the Thai Hypertension Society for their promotion and support of this Nationwide project. The major source of funding was from the charity concert as a fundraising event held by the Division of Cardiovascular Medicine, Department of Medicine, Faculty of Medicine, Chulalongkorn University to commemorate Her Majesty the Queen’s 84th Birthday Anniversary Celebrations on the 12th of August 2016. This study was also supported in part by the Heart Association of Thailand and the Thai Hypertension Society.

## Supplementary Materials

Supplementary list of all 46 participating sites. Supplementary Figure 1: specification of the oscillometric home blood pressure monitoring device used in the study (Uright model TD-3128, TaiDoc Technology Corporation, Taiwan). Supplementary Figure 2: patient enrollment flow chart of the study. Supplementary Table 1: clinical validation of home blood pressure device according to British Hypertension Society grading criteria. (Supplementary Materials)

## References

[1] M. A. Piper, C. V. Evans, B. U. Burda, K. L. Margolis, E. O’Connor, and E. P. Whitlock, “Diagnostic and predictive
[30] K. Kario, N. Tomitani, P. Buranakitjaroen et al., “Rationale and design for the Asia BP@Home study on home blood pressure control status in 12 Asian countries and regions,” The Journal of Clinical Hypertension, vol. 20, no. 1, pp. 33–38, 2018.

[31] G. S. Stergiou, K. Asayama, L. Thijs et al., “Prognosis of white-coat and masked hypertension,” Hypertension, vol. 63, no. 4, pp. 675–682, 2014.

[32] S. S. Franklin, E. O’Brien, and J. A. Staessen, “Masked hypertension: understanding its complexity,” European Heart Journal, vol. 38, no. 15, pp. 1112–1118, 2017.

[33] K. Kario, N. Tomitani, P. Buranakitjaroen et al., “Home blood pressure control status in 2017-2018 for hypertension specialist centers in Asia: results of the Asia BP@Home study,” The Journal of Clinical Hypertension, vol. 20, no. 12, pp. 1686–1695, 2018.

[34] G. Stergiou, S. P. Efstathiou, C. K. Argyraki, L. G. Roussias, and T. D. Mountokalakis, “White coat effect in treated versus untreated hypertensive individuals: a case-control study using ambulatory and home blood pressure monitoring,” American Journal of Hypertension, vol. 17, no. 2, pp. 124–128, 2004.

[35] G. Stergiou, E. Salgami, D. Tzamouranis, and L. Roussias, “Masked hypertension assessed by ambulatory blood pressure versus home blood pressure monitoring: is it the same phenomenon?” American Journal of Hypertension, vol. 18, no. 6, pp. 772–778, 2005.

[36] A. R. Feinstein, “On white-coat effects and the electronic monitoring of compliance,” Archives of Internal Medicine, vol. 150, no. 7, pp. 1377-1378, 1990.

[37] P. Verdecchia, “White-coat hypertension in adults and children,” Blood Pressure Monitoring, vol. 4, no. 3-4, pp. 175–179, 1999.

[38] P. Buranakitjaroen, “Hypertension audit in clinical practice based in Thailand (HABIT),” Journal of the Medical Association of Thailand, vol. 94, no. Suppl 1, pp. S57–S65, 2011.

[39] Y.-C. Chia, P. Buranakitjaroen, C.-H. Chen et al., “Current status of home blood pressure monitoring in Asia: statement from the HOPE Asia network,” The Journal of Clinical Hypertension, vol. 19, no. 11, pp. 1192–1201, 2017.

[40] W. Aekplakorn, P. Suriyawongpaisal, R. Tansirisithikul, T. Sakulpipat, and P. Charoensuk, “Effectiveness of self-monitoring blood pressure in primary care,” Journal of Primary Care & Community Health, vol. 7, no. 2, pp. 58–64, 2016.

[41] C. J. Lee and S. Park, “The role of home blood pressure telemonitoring for blood pressure control,” Pulse, vol. 4, no. 2-3, pp. 78–84, 2016.

[42] R. J. McManus, J. Mant, M. Franssen et al., “Efficacy of self-monitored blood pressure, with or without telemonitoring, for titration of antihypertensive medication (TASMINH4): an unmasked randomised controlled trial,” The Lancet, vol. 391, no. 10124, pp. 949–959, 2018.