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Costs of the HEARTS hypertension program in primary care in Lampang province, Thailand

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Abstract

Background In 2020, a pilot program for hypertension control was initiated in primary care facilities in Lampang Province, Thailand. The program followed the framework of the HEARTS program for standardized hypertension treatment, but the financial costs of the program are not well understood. This study evaluates the costs of the HEARTS approach compared to usual care to inform future scale-up efforts of the program.

Methods Cost data were collected and analyzed using the HEARTS costing tool, a Microsoft Excel-based tool that supports activity-based costing of the HEARTS program from the health system perspective. Three scenarios were considered: usual care, the HEARTS regimen using standardized hypertension treatment with single-agent pills, and a sub-scenario of the HEARTS regimen using single-pill dual-drug combination pills. Costs are estimated as annual costs from the health system perspective in all Lampang primary care facilities.

Results For the usual care scenario, the HEARTS single-pill scenario, and the HEARTS combination-pill sub-scenario, the average annual medication cost per treated patient was USD 14.0 (THB 485), USD 13.8 (THB 479), and USD 14.3 (THB 497), respectively. Total program cost per primary care user was USD 13.6 (THB 472.7), THB USD 14.3 (494.5), and USD 14.4 (THB 499.9) across the three scenarios, respectively. The largest program cost driver (45–47% across the examined scenarios) was attributed to a comprehensive package of laboratory tests applied to all hypertension patients. Hypothetically, reducing test coverage from all hypertension patients (27% of primary care users) to 15% of primary care users (corresponding to the proportion of patients aged 65+) would reduce program cost per user from USD 14.3 to USD 12.0 in the HEARTS combination-pill scenario.

Conclusions Compared to usual care, HEARTS implementation costs include additional costs for staff training, which are balanced by lower medication expenditures using the HEARTS standardized regimen with single-agent pills. The HEARTS regimen using dual-drug combination pills was estimated to be slightly more costly due to the higher price of combination pills. Optimizing coverage of diagnostic tests and lowering the purchasing prices of combination-pill medicines are key areas for cost reduction in future scale-up efforts.

Keywords Hypertension, HEARTS, Costing tool, Combination medicine, Primary care

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Background

Cardiovascular diseases (CVDs) are the leading cause of death globally with hypertension as the leading risk factor for CVDs [1]. In Thailand, about a quarter of all adults have hypertension [2, 3]. Despite the known effectiveness of hypertension treatment, it is estimated that the high blood pressure (HBP) control rate in Thailand is far from optimal. Among people diagnosed with hypertension in Thailand, about 56% are unable to achieve HBP control [2]. Suboptimal treatment outcomes have been attributed to therapeutic inertia (i.e., lack of intensification of therapy at high uncontrolled BP) and poor adherence by both the physicians to the updated guidelines as well the patients to anti-hypertensive medications prescribed [4–7].

The HEARTS technical package [8] aims to improve hypertension outcomes and prevent CVDs through a standardized clinical service protocol in primary care settings. The package consists of six elements: H - Healthy lifestyle counselling, E - Evidence-based treatment protocols, A - Access to essential medicines and technology, R– Risk-based CVD management, T - Team-based care, and S - Systems for monitoring [8]. The HEARTS package has been employed as an approach to hypertension control in primary care in several countries [9], and studies in other low-to-middle income countries (LMICs) have found it to be effective in hypertension control [10, 11]. Following the HEARTS approach, a research team from Chiang Mai University (CMU) in collaboration with the Thailand Hypertension Society and Lampang Provincial Health Office, developed a hypertension management program by adopting treatment and monitoring recommendations stated by the Thai Hypertension Society and HEARTS recommendations [8, 12–15]. A one-day workshop was held to train healthcare providers regarding the new treatment protocol. A session on providing behavioral change counseling and health promotion utilizing a patient-centered approach was also included in the workshop [16]. The HEARTS program pilot in Lampang province was initiated in October 2020, recommending the new treatment protocol to all primary care facilities in Lampang.

As cost is an important consideration for implementing the program at scale, better understanding of the costs required to implement the HEARTS program could assist decision-makers in plans to scale up the program's approach at the population level. The HEARTS costing tool is an Excel based template for assessing the costs of implementing the HEARTS program [17]. Prior studies in other LMICs utilizing the HEARTS costing tool have demonstrated the tool's ability to capture and estimate the various costs involved in the HEARTS program [18–20]. However, healthcare settings and program features can vary greatly across countries and evidence on costs of the HEARTS protocol that is specific to each country is essential to inform local health policy.

By assessing detailed activity-based cost estimates obtained from the HEARTS program in Lampang and current anti-hypertension practices using the HEARTS costing tool, we aim to provide insight into potential cost drivers of hypertension management in Thailand. To this end, this study provides a comparative cost description of hypertension care from the health system perspective, under three hypertension service delivery scenarios: usual care, the HEARTS program approach (referred in this study as the HEARTS scenario), and a sub-scenario of the HEARTS program approach using single-pill dual-drug combination medicine instead of the protocol drugs delivered as separate pills (referred in this study as the HEARTS sub-scenario). The combination-pill sub-scenario informs policy makers of the cost implications of prescribing anti-hypertensive combination pills in the Universal Coverage Scheme (UCS) setting, as these are not currently covered in UCS.

Methods

Study design

This is a cost analysis study utilizing the HEARTS costing tool to estimate and compare the annual costs of different hypertension management scenarios (usual care scenario versus HEARTS program scenario and HEARTS sub-scenario), using retrospective data from the HEARTS program pilot in Lampang since October 2020 and secondary data obtained from provincial electronic health records [21], dashboards, and surveys from the Ministry of Public Health (MoPH) and the Ministry of Finance in Thailand.

Setting

HEARTS program

The use of the HEARTS program treatment protocol during the pilot in Lampang was endorsed but not mandatory. Table S1 in Appendix 1 [see Additional file 1] compares the HEARTS program and the usual care approach, with the main differences introduced by the HEARTS approach being additional staff training and the HEARTS treatment protocol for hypertension.

Hypertension treatment protocols: usual care vs. HEARTS program

For both protocols, individuals aged 35 years and older are eligible for hypertension screening, including assessment of CVD risks. Patients diagnosed with hypertension (defined as systolic blood pressure [SBP] of ≥ 140 mmHg or diastolic blood pressure [DBP] of ≥ 90 mmHg) are then assessed for signs of end-organ damage and receive additional diagnostics.

In the usual care treatment protocol, the initiation and intensification of anti-hypertensive medications are up to the attending physician based on the national guidelines [13, 22]. The national guidelines contain six groups of antihypertensive medications (diuretics, angiotensin receptor blockers [ARBs], calcium channel blockers [CCBs], angiotensin converting enzyme inhibitors [ACEIs], alpha-blockers, and beta-blockers [BBs]).

By contrast, the HEARTS program treatment protocol is a stepwise initiation and titration protocol for specific anti-hypertensive medications and doses. The protocol consists of five steps of treatment, which move up one step at a time during follow-up visits if blood pressure control is not achieved, as shown in Fig. 1. The HEARTS sub-scenario protocol follow the same treatment regimen as the HEARTS program protocol but uses a dual-drug single-pill combination of amlodipine and losartan.

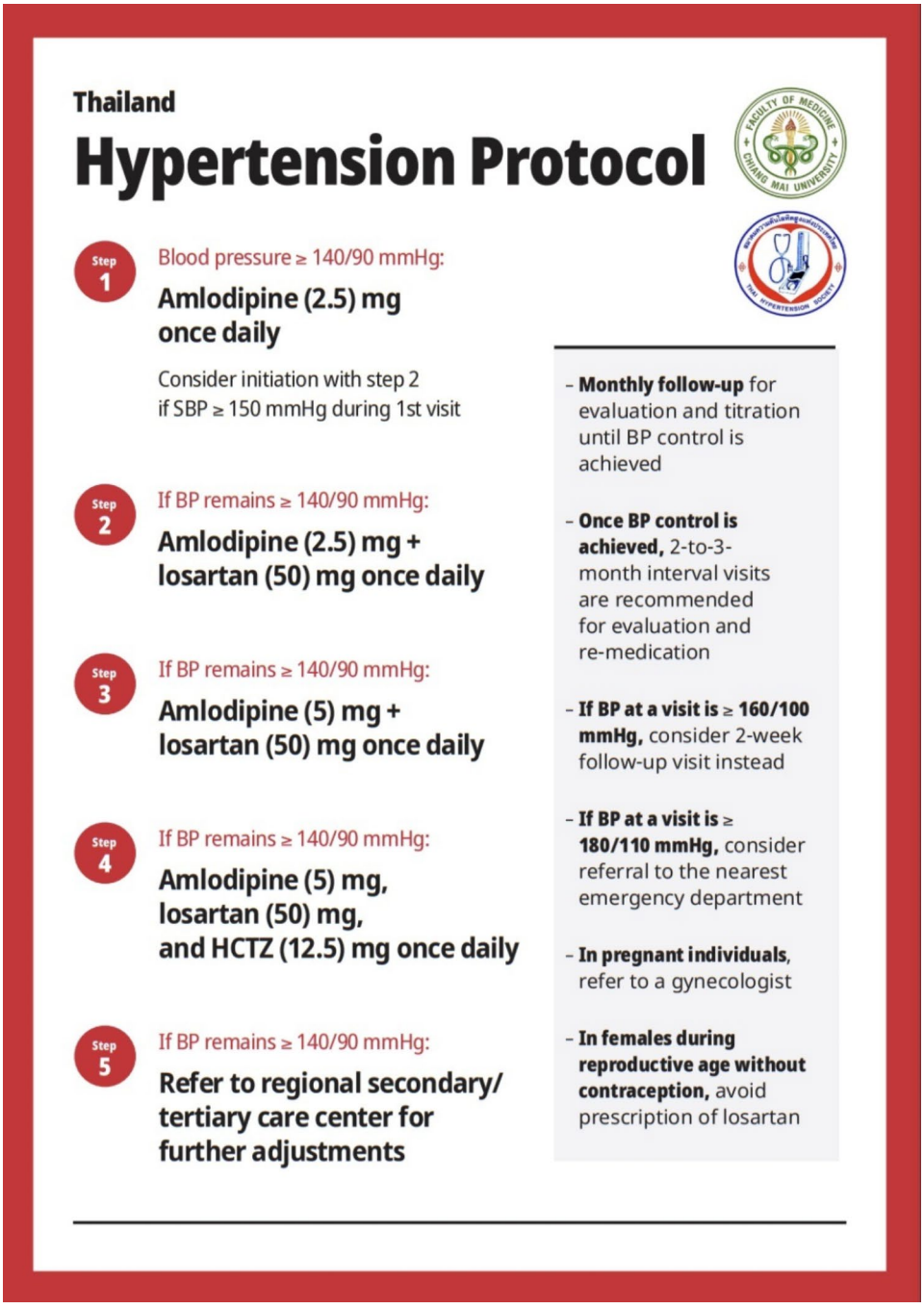

Fig. 1 HEARTS treatment protocol for hypertension

The usual care approach for patient monitoring involves collecting routine medical records through the MoPH health system [21]. Parameters related to hypertension management are aggregated from the routine collected data. As a result, only area-stratified aggregated statistics are reported back to health providers, such as overall hypertension control rates. For the HEARTS program, the monitoring system is also set up to collect routine patient outcome data and to store these as electronic medical records. Data related to hypertension management from the entire province are stored at the Lampang Provincial Health Office computer server. This allows information technology personnel to summarize outcomes of hypertension management such as blood pressure control rate in a population subgroup.

Outcomes

The primary objective of the study is to estimate and compare the annual costs of provincial implementation of different hypertension management programs in Lampang (the two HEARTS scenarios vs. usual hypertension care). The cost outcomes that are used to accomplish this objective are: total annual cost per primary care user, total annual medication cost per patient treated for hypertension, estimated full-time equivalent (FTE) staff for program delivery, and sensitivity cost analysis of diagnostic test coverage.

Data collection and analysis

The HEARTS costing tool is an Excel data collection form for assessing the costs of implementing the HEARTS program based on program activity [17]. Using the HEARTS costing tool version 5.1, we examined costs under the three different hypertension program scenarios (the usual care approach and the two HEARTS program scenarios). A list of input values required for the cost estimation is presented in Table 1. Retrospective primary and secondary data were used to populate the required input variables for the cost estimations. The HEARTS costing tool allows point estimates as inputs and also reports point estimates as outputs, which was then used to estimate differences in costs across the three program scenarios. This tool has been used in other publications and allows comparisons with other studies [15, 17]. The estimates produced across the three scenarios are considered as total eligible population estimates for the entire Lampang population of adults aged 35 years and above in 2020 ($n = 261{,}445$).

Estimations of medication use in both the usual care and the two HEARTS program scenarios are based on actual medication prescribed to the patients after the initiation of the HEARTS pilot program, extracted from the provincial electronic health records [21]. For the two HEARTS program scenarios, we identified 631 patients prescribed with amlodipine 2.5 mg daily (step 1 of the HEARTS treatment protocol) from the 1st October 2020 to the 30th September 2021. A review of routine electronic heath records revealed no prescriptions of 2.5 mg daily of Amlodipine prior to the HEARTS pilot program in October 2020. Their medication prescription records during the 12 months after the first prescription of 2.5 mg of Amlodipine were extracted. For the usual care scenario, a random sample of 1,000 hypertensive patient not receiving the HEARTS regimen during the 1st of October 2020 to the 30th September 2021 were selected and their 12-month medication prescription records were also extracted. Following intention to treat analysis, for both the usual care and the two HEARTS program scenarios, their prescription records were reviewed to determine the percentages of patients receiving different treatment regimens within each scenario (see Table 1). Appendix 2 (see Additional file 2) provides a more detailed explanation of the program elements and data used for the cost assessments. All identifiable data involved in the analysis are either excluded or anonymized by Lampang Provincial Office prior to data extraction.

This study received ethical approval from the Faculty of Medicine, Chiang Mai University (No 426/2020 and No. 077/2022). The research protocol was reviewed, and concerns were addressed before data collection. Informed consents were obtained from healthcare personnels before they were interviewed for data on health services provided in their respective PCUs.

There are several broad types of cost that the HEARTS costing tool estimates using the inputs introduced in Table 1. The first is the cost of provider time and the FTEs required. The cost of provider time is measured by multiplying the number of target patients, provider salary per minute, and per patient minutes for each healthcare service such as counseling, testing, screening and assessing CVD risk, and follow-up visits. The FTEs required are measured by multiplying the number of target patients with per patient minutes for each healthcare service then divide by 1 FTE (260 working days per year and 8 work hours per day are assumed for FTE estimation = 124,800 min per FTE). The second is medication cost. This is the sum of medication expenditures across all treatment protocol steps. The medication cost for each step is the product of the number of hypertensive patients, tablets per day, days per year, unit price, and percentage of patients receiving that regimen. Third is the cost of diagnostic tests. This is estimated by multiplying the number of target patients, unit price, and percentage receiving the diagnostic test. Lastly, we have other program costs such as training, program support staff, technologies, and supplies. For these, we manually input the annual cost. Costs were converted from Thai Baht to USD using the exchange rate of 37.92 from the

Table 1 Input parameters, costs, and cost assumptions (in Thailand THB and USD)

Input Description	Units	Usual-care approach	HEARTS program scenario*	HEARTS sub-scenario**
Adult population (35+)	Persons	261,445	261,445	261,445
Primary healthcare attendance rate (annual)	Percent	77.20%	77.20%	77.20%
Adult population with risk factors				
Use of tobacco products	Percent	18.70%	18.70%	18.70%
Hazardous or harmful use of alcohol	Percent	6.00%	6.00%	6.00%
Physical inactivity	Percent	30.90%	30.90%	30.90%
Hypertension (≥ 140/90mmHg)	Percent	27.40%	27.40%	27.40%
Low CVD risk (0 to < 10%)	Percent	83.67%	83.67%	83.67%
Medium CVD risk (10 to < 20%)	Percent	14.78%	14.78%	14.78%
High CVD risk (≥ 20%)	Percent	1.54%	1.54%	1.54%
Number of Healthcare Providers in Lampang				
Doctors		732	732	732
Nurses		1,594	1,594	1,594
CHWs (Community Health Workers)		18,200	18,200	18,200
Annual wage (including benefits)				
Doctors	THB (USD)/year	287,160 (8,280)	287,160 (8,280)	287,160 (8,280)
Nurses	THB (USD)/year	215,760 (6,221)	215,760 (6,221)	215,760 (6,221)
CHWs	THB (USD)/year	7,200 (207)	7,200 (207)	7,200 (207)
Training to counsel patients to change behavior (5 A's)				
Classroom size	Persons	0	96	96
Hours of training needed	Persons	0	8	8
Number of Trainers				
Professional trainer(s)	Persons	0	7	7
Administrative staff	Persons	0	5	5
Input costs for training				
Hourly wage				
Professional trainer	THB (USD)/hour	0	131.25 (3.78)	131.25 (3.78)
Administrative staff	THB (USD)/hour	0	31.25 (0.90)	31.25 (0.90)
Per unit cost of materials				
Guideline book	THB (USD)/book	0	75 (2.16)	75 (2.16)
Treatment flow chart	THB (USD)/day	0	2.5 (0.07)	2.5 (0.07)
Additional costs				
Facility rental for training (one day)	THB (USD)/day	0	18,125 (522.64)	18,125 (522.64)
Per diem for staff	THB (USD)/day	0	647 (18.66)	647 (18.66)
Per diem and/or salary of trainees	THB (USD)/day	0	300 (8.65)	300 (8.65)
Transportation stipend for staff	THB (USD)/day	0	623 (17.97)	623 (17.97)
CVD Risk Screening and Diagnosis				
Approximately how much time (in minutes) does a health provider spend to:				
Screen patients for total CVD risk (ask about patients' health history)	Minutes	4	4	4
Counsel patients with behavioral risk factors to change their behavior (e.g., quit tobacco, cease using alcohol harmfully, increase physical activity)	Minutes	5	5	5
Provide a physical exam (including relevant metabolic screenings) to assess patients' total CVD risk	Minutes	3	3	3
Assess patient risk using a CVD risk chart, counsel patient, and document results	Minutes	2	2	2
What other resources are provided to individuals who receive brief interventions for behavioral risk factors?				

Table 1 (continued)

Input Description	Units	Usual-care approach	HEARTS program scenario*	HEARTS sub-scenario**
# of 'How to quit' informational materials disseminated per person annually (print)		0	0	0
Cost (in LCU) of 'How to quit' informational materials, per unit (print materials)		12	12	12
# of 'How to quit' informational materials disseminated per person annually (digital)		0	0	0
Cost (in LCU) of 'How to quit' informational materials, per unit (digital materials)		0	0	0
Treatment for High CVD Risk				
How many follow-up visits should a person with the following levels of CVD risk undertake annually?				
Low CVD risk (≥ 0% to < 10%)		1	1	1
Medium CVD risk (≥ 10% to < 20%)		2	2	2
High CVD risk (≥ 20%)		4	4	4
Approximately how much time will the following health providers spend with a patient during a visit?				
Generalists/primary care doctors	Minutes	5	5	5
Nurses	Minutes	15	15	15
Purchasing price of diagnostic tests				
Fasting blood glucose (FPG)	THB (USD)/test	40.94 (1.18)	40.94 (1.18)	40.94 (1.18)
Cholesterol	THB (USD)/test	40.94 (1.18)	40.94 (1.18)	40.94 (1.18)
Triglyceride	THB (USD)/test	68.24 (1.97)	68.24 (1.97)	68.24 (1.97)
High-Density Lipoprotein (HDL)	THB (USD)/test	75.06 (2.16)	75.06 (2.16)	75.06 (2.16)
Low-density lipoprotein (LDL)	THB (USD)/test	177.41 (5.12)	177.41 (5.12)	177.41 (5.12)
Complete blood count (CBC)	THB (USD)/test	88.71 (2.56)	88.71 (2.56)	88.71 (2.56)
BUN + Creatinine + Urine microalbumin	THB (USD)/test	266.12 (7.67)	266.12 (7.67)	266.12 (7.67)
Electrocardiogram (ECG) ***	THB (USD)/test	204.71 (5.90)	204.71 (5.90)	204.71 (5.90)
Purchasing price of pharmaceutical drugs				
Amlodipine 2.5 mg	THB (USD)/tablet	0.45 (0.01)	0.45 (0.01)	0.45 (0.01)
Amlodipine 5 mg	THB (USD)/tablet	0.9 (0.03)	0.9 (0.03)	
Amlodipine 10 mg	THB (USD)/tablet	1.31 (0.04)		
Losartan 50 mg	THB (USD)/tablet	1.1 (0.03)	1.1 (0.03)	
hydrochlorothiazide 12.5 mg	THB (USD)/tablet	0.09 (0.003)	0.09 (0.003)	
Enalapril 2.5 mg	THB (USD)/tablet	0.25 (0.01)		
Enalapril 5 mg	THB (USD)/tablet	0.5 (0.01)		
Amlodipine 2.5 mg + Losartan 50 mg	THB (USD)/tablet			1.61 (0.05)
Amlodipine 5 mg + Losartan 50 mg	THB (USD)/tablet			2.11 (0.06)
Amlodipine 5 mg + Losartan 50mg & hydrochlorothiazide 12.5 mg	THB (USD)/tablet			2.11 + 0.09 (0.063)
Pharmacological treatment for hypertension (1 per day, 365 days)				
Hypertension Protocol Step #1	Medicine (mg)	Amlodipine 5 mg	Amlodipine 2.5 mg	Amlodipine 2.5 mg
% of all individuals with HBP with this regimen	Percent	20%	40%	40%
Hypertension Protocol Step #2	Medicine (mg)	Amlodipine 10 mg	Amlodipine 2.5 mg Losartan 50 mg	Amlodipine 2.5 mg + Losartan 50 mg
% of all individuals with HBP with this regimen	Percent	8%	38%	38%
Hypertension Protocol Step #3	Medicine (mg)	Enalapril 2.5 mg	Amlodipine 5 mg Losartan 50 mg	Amlodipine 5 mg + Losartan 50 mg
% of all individuals with HBP with this regimen	Percent	6%	23%	23%

Table 1 (continued)

Input Description	Units	Usual-care approach	HEARTS program scenario*	HEARTS sub-scenario**
Hypertension Protocol Step #4	Medicine (mg)	Losartan 50 mg	Amlodipine 5 mg Losartan 50 mg Hydrochlorothiazide 12.5 mg	Amlodipine 5 mg + Losartan 50 mg & Hydrochlorothiazide 12.5 mg
% of all individuals with HBP with this regimen	Percent	5%	0%	0%
Hypertension Protocol Step #5	Medicine (mg)	Enalapril 5 mg		
% of all individuals with HBP with this regimen	Percent	3%		
Hypertension Protocol Step #6	Medicine (mg)	Other regimen		
% of all individuals with HBP with this regimen	Percent	59%		
LCU to USD exchange rate	THB/USD	37.92	37.92	37.92
"Safety stock" required to be on hand for medicines	Percent	8.3	8.3	8.3

*HEARTS program treatment protocols using single-agent pills

**The HEARTS sub-scenario follows the same treatment protocols as the HEARTS program, but multiple medications are delivered in the form of combination pills

***ECG costs are not included as an input in the program cost analysis but are included for reference because they may be offered to newly diagnosed hypertension patients

October 2022 Federal Reserve Economic Data (FRED) Spot Exchange Rate repository.

Results

Total annual costs of implementation

The total implementation cost estimated across the three scenarios were USD 2.75 million under usual care, USD 2.88 million under the HEARTS scenario, and USD 2.91 million under HEARTS sub-scenario (see Table 2). Cost estimations broken down by activity category are described in detail in Appendix 3 (see additional file 3).

The cost difference between usual care and the HEARTS program scenario was 126.90 thousand USD (THB 4.41 million), a 4.61% increase from the total annual cost of usual care. Extra costs were primarily accrued from additional training, with an additional USD 156.28 thousand (THB 5.42 million) compared to usual care. Relative savings occurred from medication costs, supply chain costs, and reduced labor costs due to the task-sharing aspect of HEARTS, with savings of USD 8.57 thousand (THB 297 thousand), USD 0.86 thousand (THB 30 thousand), and USD 15.91 thousand (THB 552 thousand) respectively (or 0.31%, 0.03%, and 0.58% relative difference).

The cost difference between usual care and the HEARTS combined-pill sub-scenario was 158.55 thousand USD (THB 5.50 million), a 5.77% increase from the total annual cost of usual care and 1.16% increase from the main HEARTS scenario, driven by the relatively higher cost of combination pills.

Total cost per primary care user

Table 3 presents the total annual program cost per primary care user where primary care users are defined as adults 35 years and older who are estimated to attend the primary care facilities in the catchment area, regardless of hypertension status. For the usual care scenario, the HEARTS program scenario, and the combination-pill HEARTS sub-scenario, the program cost per primary care user was USD 13.6, USD 14.3, and USD 14.4 respectively. Compared to the usual care approach, the two HEARTS program scenarios reflect the added costs of HEARTS program training, balanced by lower medication expenditure under the HEARTS program scenario.

Medication cost per patient treated for hypertension

Table 4 presents the estimated average medication cost per patient, which was calculated by dividing the estimated annual expenditure on hypertension medications by the number of patients treated with hypertension medications. The average medication cost per patient for usual care, the HEARTS program scenario, and the HEARTS sub-scenario were USD 14.0, USD 13.8, and USD 14.3, respectively. The HEARTS program scenario treatment approach with separate pills showed the lowest medication cost per patient. The slightly higher price for the HEARTS combination-pill sub-scenario reflected the higher price of dual-drug combination pills relative to the same treatment regimen delivered via single pills.

Estimated full-time equivalent (FTE) staff for program scale-up

The FTE provider time approximates how many of each type of personnel would be needed to run the

Table 2 Total annual implementation costs

	Usual-care approach		HEARTS program scenario		HEARTS–Sub-scenario	
	THB	USD	THB	USD	THB	USD
H: Healthy Lifestyles	**565,124**	**16,295**	**3,207,621**	**92,492**	**3,207,621**	**92,492**
H1: Training costs	0	0	2,709,839	78,138	2,709,839	78,138
H2: Brief counseling costs	565,124	16,295	497,782	14,354	497,782	14,354
H2.1: Tobacco	190,069	5,481	167,420	4,828	167,420	4,828
H2.2: Alcohol	60,985	1,758	53,718	1,549	53,718	1,549
H2.3: Physical inactivity	314,071	9,056	276,645	7,977	276,645	7,977
H3: Other program costs	0	0	0	0	0	0
E: Evidence-based Treatment Protocols	**13,022,745**	**375,512**	**12,538,312**	**361,543**	**12,538,312**	**361,543**
E1: Ask about patient history - provider time	2,217,593	63,944	1,953,339	56,325	1,953,339	56,325
E2: Assess via physical exam and diagnostic tests - provider time	1,847,714	53,279	1,627,535	46,930	1,627,535	46,930
E3: Return visits - Counsel and treat per protocol - provider time	8,957,438	258,288	8,957,438	258,288	8,957,438	258,288
E4: Other program costs	0	0	0	0	0	0
A: Access to Essential Medicines and Technologies	**80,630,079**	**2,324,973**	**80,303,178**	**2,315,547**	**81,395,662**	**2,347,049**
A1: Hypertension medications	26,798,593	772,739	26,501,410	764,170	27,494,577	792,808
A2: Diagnostic test	45,300,007	1,306,229	45,300,007	1,306,229	45,300,007	1,306,229
A3: Diagnostic tech., machines & supplies	1,201,472	34,645	1,201,472	34,645	1,201,472	34,645
A4: Supply chain (on-cost)	7,330,007	211,361	7,300,289	210,504	7,399,606	213,368
R: Risk-based Management	**1,175,797**	**33,904**	**3,745,525**	**108,002**	**3,745,525**	**108,002**
R1: Training costs	0	0	2,709,839	78,138	2,709,839	78,138
R2: Estimate risk using risk charts	1,175,797	33,904	1,035,686	29,864	1,035,686	29,864
R3: Other program costs	0	0	0	0	0	0
T: Team-based care (Savings from training nurses and CHEs to do Doctors' work)	**0**	**0**	**(551,775)**	**(15,910)**	**(551,775)**	**(15,910)**
T1: Savings from training nurses	0	0	(551,775)	(15,910)	(551,775)	(15,910)
T2: Savings from training CHWs	0	0	0	0	0	0
S: Systems for monitoring	**0**	**0**	**5,000**	**144**	**5,000**	**144**
S1: Human resources	0	0	5,000	144	5,000	144
S2: Technology	0	0	0	0	0	0
S3: Supplies	0	0	0	0	0	0
S4: Training	0	0	0	0	0	0
Total Program Cost (H + E + A + R + S)	**95,393,745**	**2,750,685**	**99,799,635**	**2,877,729**	**100,892,119**	**2,909,231**

Table 3 Annual implementation program costs per primary care user* ($n = 201,809$)

	Usual-care approach		HEARTS program scenario		HEARTS–Sub-scenario	
	THB	USD	THB	USD	THB	USD
H: Healthy Lifestyles	**2.8**	**0.1**	**15.9**	**0.5**	**15.9**	**0.5**
E: Evidence-based Treatment Protocols	**64.5**	**1.9**	**62.1**	**1.8**	**62.1**	**1.8**
A: Access to Essential Medicines and Technologies	**399.5**	**11.5**	**397.9**	**11.5**	**403.3**	**11.6**
A1: Hypertension medications	**132.8**	**3.8**	**131.3**	**3.8**	**136.2**	**3.9**
A2: Diagnostic test	**224.5**	**6.5**	**224.5**	**6.5**	**224.5**	**6.5**
A3: Diagnostic tech., machines & supplies	**6.0**	**0.2**	**6.0**	**0.2**	**6.0**	**0.2**
A4: Supply chain (on-cost)	**36.3**	**1.0**	**36.2**	**1.0**	**36.7**	**1.1**
R: Risk-based Management	**5.8**	**0.2**	**18.6**	**0.5**	**18.6**	**0.5**
S: Systems for monitoring	**0**	**0**	**0.025**	**0.001**	**0.025**	**0.001**
Total Program Cost (H + E + A + R + S)	**472.7**	**13.6**	**494.5**	**14.3**	**499.9**	**14.4**

* Primary care users = adults 35 years and older who are estimated to attend the primary care facilities in the catchment area, regardless of hypertension status

hypertension program, assuming full-time program engagement. Due to the task-sharing feature of the HEARTS program, counseling, and CVD risk assessment services are shared between doctors and nurses but are conducted solely by doctors in the usual care scenario. As shown in Table 5, more full-time nurses but fewer full-time doctors would be needed in the HEARTS program and its sub-scenario compared to usual care.

Table 4 Annual medication cost per patient ($n = 55,296$)

	Usual-care approach		HEARTS program scenario		HEARTS–Sub-scenario	
	THB	USD	THB	USD	THB	USD
Medication cost per patient treated with medications for hypertension	485	14.0	479	13.8	497	14.3

Table 5 Estimates of total FTEs (full-time equivalent) staff

	Usual-care approach		HEARTS program scenario		HEARTS–Sub-scenario	
	Minutes	Converted to FTE	Minutes	Converted to FTE	Minutes	Converted to FTE
Health Personnel						
Doctor	3,641,597	29	2,430,312	19	2,430,312	19
Nurse	3,706,605	30	4,917,890	39	4,917,890	39
Non-health Personnel						
Statistician	124,800	1	124,800	1	124,800	1

Table 6 Annual total program costs per primary care user* ($n = 201,809$) using different assumptions on diagnostic test coverage and range

	Usual care approach		HEARTS program scenario		HEARTS–Sub-scenario	
	THB	USD	THB	USD	THB	USD
Original estimate	472.7	13.6	494.5	14.3	499.9	14.4
Reduced test coverage: only 15% of primary care users receive test package	394.8	11.4	416.7	12.0	422.1	12.2

* Primary care users = adults 35 years and older who are estimated to attend the primary care facilities in the catchment area, regardless of hypertension status

Sensitivity of program costs to diagnostic test coverage

This analysis assumes that, across all scenarios, all hypertension patients (approximately 27% of primary care users) receive a comprehensive package of laboratory diagnostic tests. Because of the high cost of this package and its universal application, expenditure on diagnostic tests comprises nearly half of total program costs across all scenarios– approximately 45-47% of the overall program cost per primary care user (Appendix 3 Figure). To assess the sensitivity of overall program costs to test coverage, we replicated the main analysis assuming reduced diagnostic test coverage of only 15% of primary care users, which corresponds to the elderly population only (age 65+). In all scenarios, this hypothetical reduction in the coverage of diagnostic tests would correspond to a reduction of approximately USD 2 or 14% of the overall program cost per primary care user (Table 6).

Discussion

We estimated the annual implementation cost of a hypertension control program in Lampang's primary care facilities, comparing three scenarios– usual care, the HEARTS program approach for hypertension treatment and monitoring, and a HEARTS program sub-scenario which follows the same treatment protocols as HEARTS but uses dual-drug single-pill combinations instead of multiple pills. The HEARTS program approach was estimated to result in a lower average medication cost per patient treated for hypertension compared to the usual-care approach (USD 13.8 vs. 14.0). The largest proportion of the total annual cost in all scenarios was attributed to the cost of diagnostic tests, which was 48% in the usual care scenario and 45% in the two HEARTS scenarios. Although local hypertension guidelines recommend offering electrocardiograms to patients diagnosed with hypertension, these costs were not included in the cost analysis due to their non-recurring nature. However, adding ECGs at an estimated cost of THB 204.71 (USD 5.90) per patient would raise the share of diagnostic tests to an even higher level.

Techakehakij (2016) estimated the average annual anti-hypertensive medication cost in Universal Coverage Scheme (UCS), the largest public health insurance scheme, from the provider's perspective in Thailand to be USD 19.1 (668.5 THB) [23], which is more expensive when compared to the estimation in this study of USD 14.0 (485 THB). Although it is difficult to determine the exact reasons for the difference observed as details on both the name and the number of medications used were not published and the study was based on a different year and region, one possible reason could be the broad decrease in central drug prices of anti-hypertensive medications in 2021.

Sensitivity analysis indicated that program cost could be reduced by limiting coverage for diagnostic tests, for example, by prioritizing coverage of diagnostic tests to higher-risk hypertension patients such as the elderly, instead of all hypertension patients. The

second largest cost component was the cost of medications (28.1%, 26.6%, and 27.3% in each scenario, respectively). Thus, finding more competitive purchasing prices of diagnostic tests and medicines can be an area for exploring future cost reductions.

The total annual program cost from implementing the HEARTS program was slightly (about 4%) higher than the estimated total cost of the usual care approach, reflecting the added expense of training providers in the HEARTS approach. However, training costs will likely be substantially lower in subsequent years as most of the workforce will have already undergone training. Further studies on the optimization of training expenses and estimations of possible training costs in subsequent years could help provide a clearer picture of the monetary impact of implementing the modified HEARTS protocol across extended periods.

In this analysis, medication-specific cost savings from applying the HEARTS treatment protocols can occur when using separate pills for different medications in the protocols but not when using single-pill dual-medicine combinations. Medication costs per patient were slightly higher at USD 14.3 in the HEARTS combination-pill sub-scenario vs. USD 13.8 in the HEARTS single-pill scenario due to the relatively higher cost of combination pills. However, many aspects of combination pills are not reflected in this study, including possible benefits of simplified procurement, storage, and supply chain factors, as well as possibility of improved medication adherence and hypertension control [24] which also ties to the patients' perspectives and their circumstances [25]. Future studies on the cost-effectiveness, budget impact analysis, and patient perspectives of single-pill combination treatment that account for these aspects can help determine the most appropriate use of combination pills in regards to the HEARTS regimen and better inform the HEARTS program evaluations.

Compared to other HEARTS costing studies conducted in Bangladesh and Mexico [18–20], the estimated HEARTS medication cost per patient treated for hypertension in Lampang was lower (USD 13.8 vs. USD 18 in Bangladesh and USD 15–17 in two Mexico states). The overall HEARTS program cost per primary care user in Lampang (USD 14.3) was also lower than the respective estimates from Mexico (USD 31– USD 42), yet it was higher than the cost estimate for Bangladesh (USD 9). This difference could be explained by the fact that Lampang's program approach employed a comprehensive diagnostic test package for those diagnosed with hypertension during a screening visit, which accounted for the majority of the program cost, while other studies did not include costs of additional diagnostic tests.

Although studies on the effects of the HEARTS approach conducted in other LMICs showed improvements in hypertension control [10, 11], this study does not explore the clinical effects and benefits of the HEARTS program in Thailand. Additional studies on the clinical outcomes of the HEARTS program in Thailand are needed to determine the health impact of the program in the country. A process evaluation study manuscript of the HEARTS program implemented in Lampang is being prepared. The paper will consist of detailed explanation and evaluation of the program implementation including the health benefits of the program. However, from a cost perspective, our findings indicate a potential for savings in expenditure on hypertension medications using the HEARTS standardized treatment approach, particularly when using single-agent pills for standardized treatment. Although using combination pills in the HEARTS approach was estimated to be more costly at the current pricing schedule, they might offer benefits such as improved adherence; future studies can assess the relative cost-effectiveness of prescription practices.

This study has several limitations. The HEARTS Costing Tool used to calculate the relevant costs in this study takes a deterministic, not a statistical, approach and provides results as point estimates, not reflecting uncertainties. The estimations also include scaling-ups of parameters derived from relatively small sample sizes (e.g., data derived from health provider interviews) introducing the possibility of reporting error; however, as the population was kept constant across all comparator scenarios, the implications from estimated differences remain valid as any over/underestimations should be of similar proportions across scenarios. The costs of medication were estimations based on actual medication use during the 12 months. The estimated costs proposed in this study might not reflect true costs as some have deviated from the HEARTS regimen. However, the aim was to give estimates of the supposed costs that would have incurred if the government can implement the HEARTS program and to compare them to the total annual cost of usual care, as well as comparing different sub-costs within different categories.

Conclusions

Our study suggests that the HEARTS program can lower per-patient medication costs when single-agent medications are used and promote lower costs through task shifting/sharing aspect of the program. Combination-drug medications are estimated to result in slightly higher per-patient treatment costs; however, they might offer logistical and clinical advantages in terms of patient adherence; thus, further economic evaluation would be needed to inform the relative cost-effectiveness of combination-drug regimens. While a comprehensive set of diagnostic tests for all hypertension are recommended,

our study reflects that it accounts for nearly half of the annual program costs. Total HEARTS program costs may be reduced by limiting coverage that prioritizes diagnostic laboratory testing to only select higher-risk patients, such as the elderly, instead of all patients.

Abbreviations

HBP	High blood pressure
CVD	Cardiovascular disease
CMU	Chiang Mai university
UCS	Universal coverage scheme
SBP	Systolic blood pressure
DBP	Diastolic blood pressure
ARBs	Angiotensin receptor blockers
CCBs	Calcium channel blockers
ACEIs	Angiotensin converting enzyme inhibitors
BBs	Beta-blockers
MoPH	Ministry of public health
FTE	Full-time equivalent

Supplementary Information

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Supplementary Material 1: **Additional file 1**: **Appendix 1**: Table S1.

Supplementary Material 2: **Additional file 2**: **Appendix 2**: Program inputs description.

Supplementary Material 3: **Additional file 3**: **Appendix 3**: Total annual implementation costs.

Supplementary Material 4: **Additional file 4**: **Appendix 3**, Figure: Total program cost of each scenario classified by elements of HEARTS (million USD).

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Author contributions

The authors confirm contribution to the paper as follows: conceptualization: PA, CA, NW, AS, ChaiA, DK, AM, data collection: PA, CA, SD, WI, AM, data analysis: PA, CA, TK, MH, SB, DK, data validation: PA, CA, SD, WI, NW, AS, ChaiA, draft manuscript: PA, CA, NW, TK, MH, SB, DK, revise manuscript: PA, TK, MH, SB, SD, WI, AS, ChaiA, DK, AM. All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki, and received ethical approval from the Faculty of Medicine, Chiang Mai University (No 426/2020 and No. 077/2022). The research protocol was reviewed, and concerns were addressed before data collection. Informed consent was obtained from participants.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the U.S. Centers for Disease Control and Prevention.

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