



Cost-effectiveness of Expanding Syphilis Screening and Diagnosis under Thailand's Universal Coverage Scheme

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Abstract

Objectives: The existing syphilis screening approach is insufficient in lowering the overall incidence of syphilis within the population. The current approach falls short of the World Health Organization 2030 elimination benchmarks (congenital syphilis <50 per 100,000 live births and a 90% reduction in incidence). This study aims to evaluate the cost-effectiveness of expanding syphilis screening and diagnosis in Thailand and its budget implications.

Methods: Decision tree models were developed to estimate the number of syphilis cases detected and determine associated healthcare costs. The analysis adopted the payer perspective (National Health Security Office), with the current Universal Coverage Scheme (UCS) targeted-screening practice as the base scenario. Inputs were drawn from national surveillance, program service data, published test-performance studies, and standard cost references. The evaluation compared Thailand's current UCS screening package with an enhanced strategy that encompasses a broader population and incorporates rapid diagnostic tests in addition to the current laboratory-based treponemal serological assessments. The primary outcomes included the number of syphilis cases detected and the incremental cost-effectiveness ratio, defined as the additional cost per case detected. A five-year budget impact analysis from the 2022 base year was also conducted.

Results: Expanding screening to all Thais with high-risk behaviors increased the total costs but improved the unit-cost efficiency and was more cost-effective than targeting specific groups. The cost per case detected was lowest for expanding to all high-risk Thais (19,870 Thai baht (THB); US\$567), compared to current practice (22,064 THB; US\$629) and prisoners-and-youth (20,549 THB; US\$586). Overall, annual budget expenditure is projected to increase from 149 million THB (US\$4.25 million) to 169 million THB (US\$4.82 million).

Public Health Recommendations: Extending screening to all high-risk Thais is more beneficial and cost-effective than restricting it to specific subgroups. We recommend integrating this strategy into existing routine disease-screening programs, such as HIV testing, to address HIV and syphilis together.

Keywords: syphilis, Universal Coverage Scheme, screening, diagnosis, health policy



Introduction

Syphilis, a sexually transmitted infection caused by the bacterium *Treponema pallidum*, remains a significant public health concern globally, with substantial morbidity and mortality if untreated. Untreated maternal syphilis can lead to stillbirth, premature birth, neonatal death, and congenital syphilis. In adults, syphilis can cause cardiovascular, neurological, and multi-organ complications.

In Thailand, the prevalence of syphilis among pregnant women was 0.9% in 2021.¹ Congenital syphilis cases surged from around 80 cases in 2015 to 438 cases in 2022.² From 2018 to 2022, the congenital syphilis rate increased from 25.6 to 98.2 per 100,000 live births.³ The number of reported syphilis cases rose from 7,658 in 2017 to 18,386 in 2021. This corresponds to a rise in the reported syphilis incidence rate, which increased from 11.6 per 100,000 population in 2017 to 27.8 per 100,000 population in 2021.⁴ Without expanded screening coverage and timely case-finding and treatment beyond the current targeted groups, the syphilis incidence rate is projected to continue increasing, potentially exceeding 50 cases per 100,000 population by 2030, based on the authors' linear extrapolation of the 2017–2021 trend.⁴

The highest incidence of syphilis in Thailand occurs among individuals aged 15–24 years. This group's share of new infections rose from 30% in 2014 to 46% in 2021, with the incidence climbing from 48.1 to 133.7 per 100,000, which is approximately four to five times higher than the national average.⁴ Contributing factors include increased sexual activity, low sexually transmitted infection awareness, and barriers to youth-friendly sexual health services.^{5–8}

Thailand's Universal Coverage Scheme (UCS), implemented in 2002, provides access to routine antenatal screening and treatment for syphilis. Under this scheme, syphilis treatment is provided free of charge to all UCS members, whereas free screening is offered to the specific population as part of the prevention and promotion benefits package. However, the coverage and utilization of this service have not yet reached the levels required to meet the World Health Organization (WHO) 2030 syphilis-elimination targets (90% incidence reduction; congenital syphilis <50 per 100,000 live births). Between 2016 and 2022, the UCS coverage was expanded to include high-risk human immunodeficiency virus (HIV) key populations; sex workers, men who have sex with men, transgender individuals, people who inject drugs, people living with HIV and those receiving HIV post-exposure prophylaxis

(PEP) or pre-exposure prophylaxis (PrEP). Since 2022, the UCS has expanded its coverage to include syphilis screening for pregnant couples and prisoners. However, gaps remain, mainly due to persistently high infection rates across all age groups.^{9–11}

Existing screening technologies, such as treponemal tests, e.g., *Treponema pallidum* hemagglutination assay (TPHA), *Treponema pallidum* particle agglutination, and chemiluminescence immunoassay (CLIA), and non-treponemal tests, e.g., rapid plasma reagin (RPR) and Venereal Disease Research Laboratory (VDRL) tests, are reliable and cost-effective. Both test types are recommended together to identify active infections. The traditional algorithm (TA) begins with non-treponemal testing, whereas the reverse algorithm (RA) begins with a treponemal test; RA detects more active and past infections but may require a second treponemal test for confirmation.^{12,13}

The utilization of point-of-care tests or rapid diagnostic tests (RDTs) (treponemal-based, lateral-flow immunochromatographic assays that detect antibodies to *Treponema pallidum* at the point of care within 15–20 minutes) for screening is sensitive, rapid, and easy to perform.^{12,14} RDTs are particularly useful in resource-limited settings and for reaching youth who face barriers to laboratory-based services. However, these RDTs have not yet been widely adopted nationwide by the Thai healthcare system. Under the current National Health Security Office (NHSO) reimbursement guideline (2022), only the TA is reimbursed for high-risk groups, and RDT use is limited to prisoners; the comparator strategies therefore model expansion to the methods recommended in the National Guideline for Syphilis Laboratory Diagnosis 2021.^{9,12}

To effectively address the rising syphilis burden in Thailand, further steps are needed to scale up screening coverage and target at-risk populations, including the youth and general population engaging in risky behaviors. Cost-effectiveness analyses can provide crucial insights to policymakers on the optimal strategies for expanding syphilis screening services and allocating limited healthcare resources efficiently.

Therefore, the objectives of this study were to (1) evaluate the cost-effectiveness (cost per case detected) of expanding syphilis screening and diagnosis by comparing current practice (CP) with two expanded policy strategies (policy I, expand to all Thais with high-risk behaviors; and policy II, scale-up of prisoner coverage with addition of youth aged 15–24 years); and (2) assess the budget impact of the expansion on the Thai healthcare system.

Methods

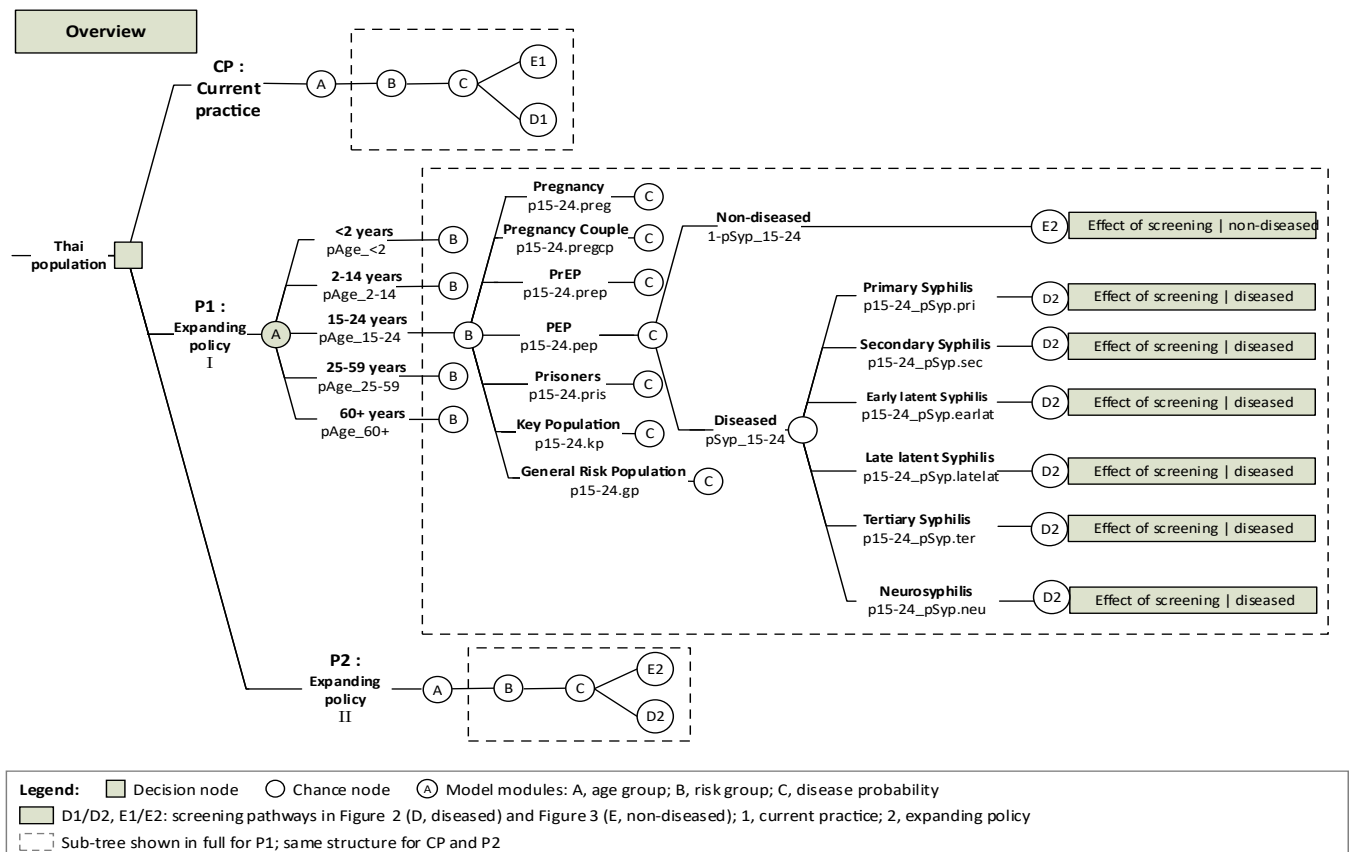
A cross-sectional, population-based deterministic decision-tree model was developed to evaluate the cost-effectiveness of expanding syphilis screening in Thailand. The model compared the current screening approach under the UCS to an expanded screening and diagnosis strategy that incorporates a broader target population and includes RDTs in addition to the existing laboratory-based treponemal and non-treponemal serological tests. The model population was all Thais aged two years and above. The analysis took a payer perspective (direct healthcare costs only). Cost components included consumables, equipment, and medication and the time horizon was one year.

The model examined three policy strategies: (i) current practice (CP): individuals receive syphilis screening through laboratory-based treponemal and non-treponemal testing under the UCS, with current levels of coverage and utilization. Targeted segments include pregnant women and couples, HIV key populations, and prisoners. Prisoner screening under the UCS had

just begun. Therefore, the input data on prisoners' current program performance belongs to the pilot scale situation; (ii) policy I (P1): expand screening to all Thais with high-risk behaviors across all age groups. High-risk behaviors refer to high-risk sexual behaviors, such as condomless sex or multiple sexual partners, in any member of the general population; this group is not limited to the HIV key populations. Screening would combine laboratory testing and RDTs with increased coverage; and (iii) policy II (P2): expand screening to prisoners (60% coverage) with addition of youth aged 15–24 years. As in P1, screening would combine laboratory tests and RDTs with enhanced coverage.

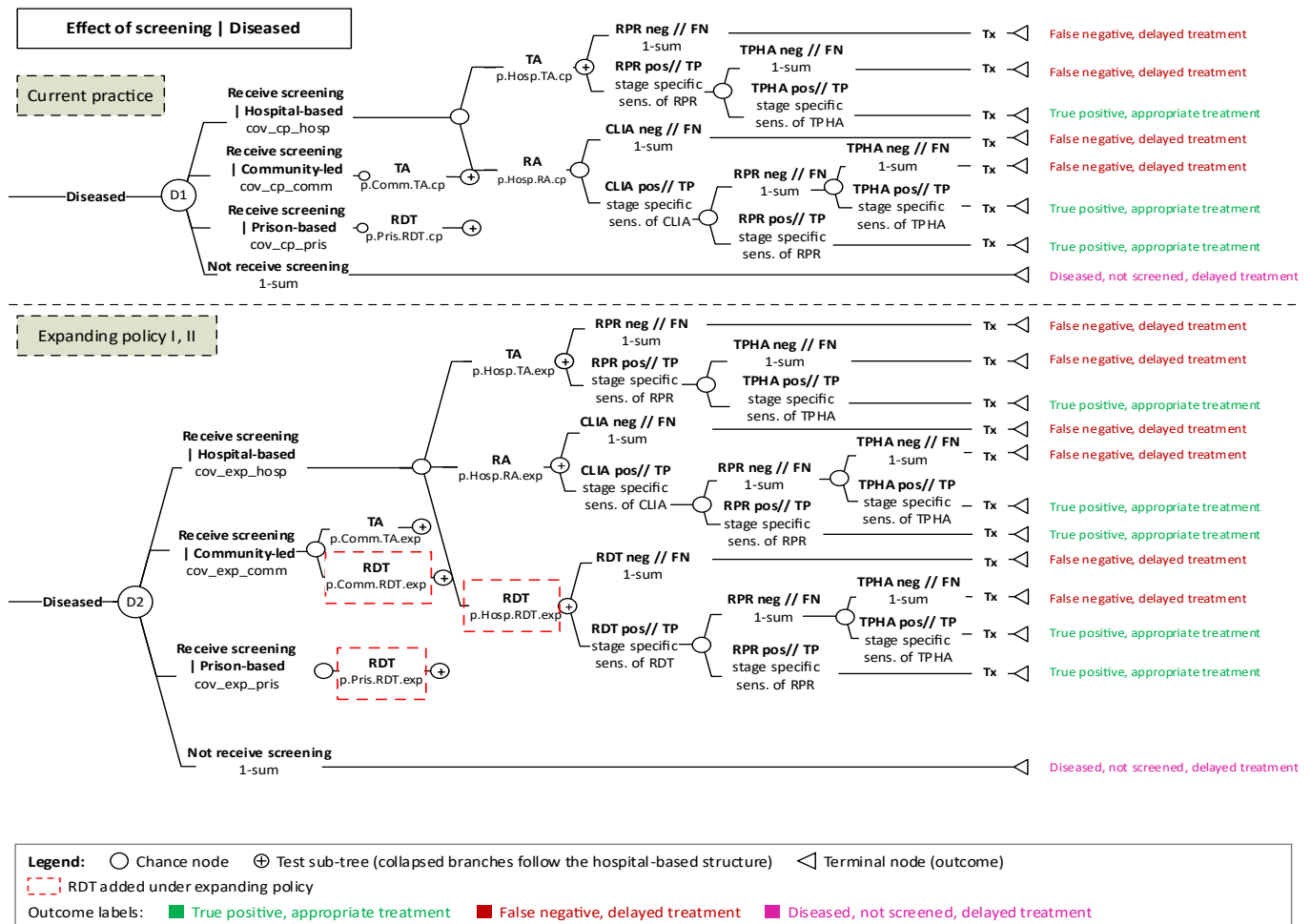
Model Structure

The decision tree model represents the Thai population distributed by age groups (module A) followed by risk groups (module B). For each risk group, probability of disease was applied (module C, see Figure 1). The effect of screening on diseased and non-diseased groups are illustrated in Figures 2 and 3 (modules D and E), respectively.



pAge: population proportion by age group. *pSyp_15-24*: probability of syphilis among persons aged 15–24 years. *p15-24.preg*, *p15-24.pregcp*, *p15-24.prep*, *p15-24.pep*, *p15-24.pris*, *p15-24.kp*, and *p15-24.gp*: proportions of the following risk groups among persons aged 15–24 years: pregnant women, pregnant couples (partners of pregnant women), HIV PrEP recipients, HIV PEP recipients, prisoners, HIV key populations, and the general risk population, respectively. *p15-24_pSyp.pri*, *p15-24_pSyp.sec*, *p15-24_pSyp.earlat*, *p15-24_pSyp.latelat*, *p15-24_pSyp.ter*, and *p15-24_pSyp.neu*: proportions of syphilis by disease stage: primary, secondary, early latent, late latent, tertiary, and neurosyphilis, respectively. Parameters for persons aged 15–24 years are shown as an example. CP: current practice; P1: policy I, expansion to all Thais with high-risk behaviors; P2: policy II, scale-up of prisoner screening coverage with the addition of youth aged 15–24 years; PrEP: pre-exposure prophylaxis; PEP: post-exposure prophylaxis.

Figure 1. Overview of decision tree diagram.



cov_cp_hosp, *cov_cp_comm*, and *cov_cp_pris*: screening coverage under current practice in hospital-based, community-led, and prison-based settings, respectively. *cov_exp_hosp*, *cov_exp_comm*, and *cov_exp_pris*: screening coverage under the expanding policies in the same settings. *p.Hosp.TA.cp*, *p.Hosp.RA.cp*, *p.Comm.TA.cp*, and *p.Pris.RDT.cp*: proportions of persons screened with each testing method in each setting under current practice; *p.Hosp.TA.exp*, *p.Hosp.RA.exp*, *p.Hosp.RDT.exp*, *p.Comm.TA.exp*, *p.Comm.RDT.exp*, and *p.Pris.RDT.exp*: the corresponding proportions under the expanding policies. *sens.*: stage-specific sensitivity of each test. *1-sum*: complement of the other branches. *CLIA*: chemiluminescence immunoassay; *FN*: false negative; *neg*: negative. *pos*: positive. *RA*: reverse algorithm. *RDT*: rapid diagnostic test. *RPR*: rapid plasma regain. *TA*: traditional algorithm. *TP*: true positive. *TPHA*: *Treponema pallidum* hemagglutination assay. *Tx*: treatment.

Figure 2. Screening pathway for the diseased population (module D).

Models A–E constitute a single decision tree presented as linked modules for clarity. Strategy-specific parameters (service coverage rate and the proportion of testing methods [TA/RA-CLIA/RA-RDT] by population group) differ between strategies, whereas all other input parameters are common to all strategies.

Module A: four age groups (2–14, 15–24, 25–59, ≥60 years).

Module B: each age group was stratified into risk groups by service program (pregnant women; pregnant couples, i.e., the partners of pregnant women; HIV key populations; HIV PEP/PrEP; prisoners; general risk population).

Module C: stage-specific infection probability was applied to each risk group.

Module D: simulated screening of the diseased population using screening probability, algorithm mix, and test sensitivity. These parameters classified diseased individuals into true positives (TP, identified and treated), false negatives (FN, missed), and those not screened.

Module E: simulated screening among non-diseased individuals. The specificity of the screening tests was applied, resulting in three groups: true negative cases (TN) that were correctly identified as not having syphilis through the screening process, false positive cases (FP) that were incorrectly identified as having syphilis and received unnecessary treatment, and individuals without syphilis who did not receive screening.

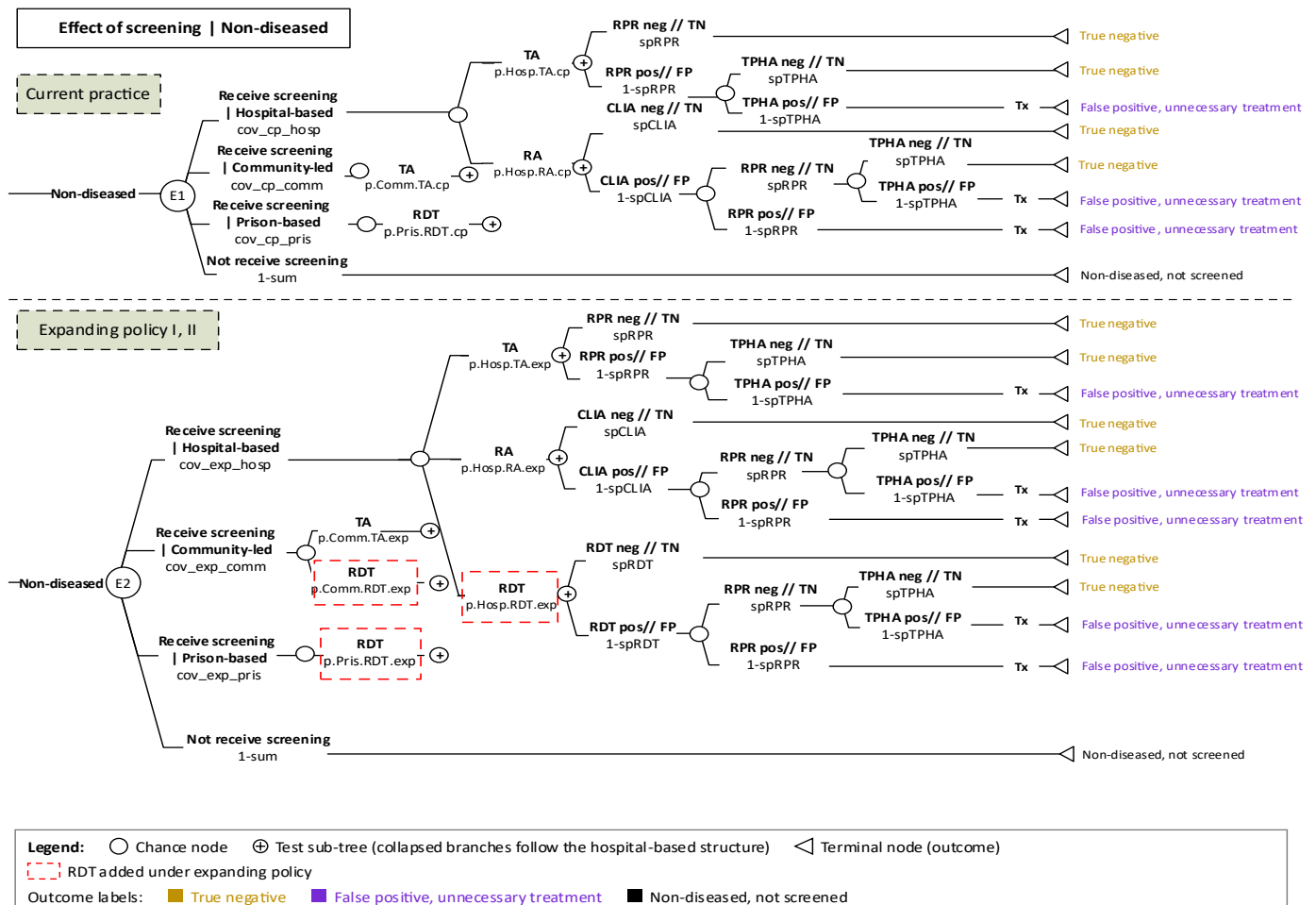


Figure 3. Screening pathway for the non-diseased population (module E).

Input Parameters

Model parameters (coverage, positive rates, test performance, clinical/epidemiological inputs, and costs) were obtained from published and unpublished literature and national data (2018–2021); current screening coverage and positive rates are shown in Table 1, general input parameters in Table 2 and strategy-specific coverage and test mix in Table 3.

Screening Coverage and Syphilis-positive Rates, Current Practice

Table 1 systematically details the annual screening coverage and syphilis-positive rates across various populations in Bangkok, Thailand, as utilized in a cost-

effectiveness analysis model. Coverage and syphilis-positive rates differed by benefit category.^{1–4,12,14–26}

The HIV key population consists of 897,706 individuals in the target population¹⁹, of whom 11,534 were screened through hospitals and public health centers financially supported by the Bangkok Metropolitan Administration (BMA), with an average positive rate of 11.4%.²⁰ Prisoner screening via RDTs had a coverage of 18.8% (1.9% positive)²¹; BMA facilities screened 5,214 general risk individuals (1.8% positive).²⁰

General risk populations without support accessed services out of pocket (127,210 individuals screened).¹⁸ Where positive rates were unavailable, assumptions from similar-risk groups were used.

Table 1. Annual screening coverage and syphilis-positive rate of current situation used in the model.

Benefit Support	Population	Setting	Screening Availability	Number of target population	Number of people screened (%)	Positive rate (%)
Universal Coverage Scheme	Pregnant women	Hospital	TA, RA	379,278 ²	377,674 (99.6%) ²	0.9% ²
	Pregnant couples		TA, RA	379,278 ^a	226,605 (59.8%) ^a	0.9% ^a
	HIV PrEP service recipients	Hospital, HIV clinic,	TA, RA	NA	1,968 ¹⁷	8.2% ¹⁷
	HIV PEP service recipients	Community-led organization	TA, RA	NA	1,045 ¹⁸	8.2% ^a
	HIV key population	Hospital and public health center managed by BMA	TA, RA	897,706 ¹⁹	11,534 (1.3%) ²⁰	11.4% ²⁰
		Hospital, HIV clinic	TA, RA		117,606 (13.1%) ¹⁸	11.4% ^a
		Community-led organization	TA		20,470 (2.3%) ¹⁸	11.4% ^a
Other Government Support	Prisoners	Prison	RDT	285,755 ²¹	53,716 (18.8%) ²¹	1.9% ²¹
	General risk population (BMA)	Hospital and public health center managed by BMA	TA, RA	NA	5,214 ²⁰	1.8% ²⁰
No Support (Out of pocket)	General risk population	Hospital, HIV clinic, Community-led organization	TA, RA	NA	127,210 instances ¹⁸	1.8% ^a

a: assumption used in cost-effectiveness analysis. BMA: Bangkok Metropolitan Administration. NA: not applicable. PEP: Post-exposure prophylaxis. PrEP: Pre-exposure prophylaxis. RA: reverse algorithm. RDT: rapid diagnostic test. TA: traditional algorithm.

Test Performance

The performance of syphilis diagnostic tests varied by test type and stage of the disease as shown in Table 2. Non-treponemal tests (VDRL, RPR) had sensitivities of 78-86% in primary, 100% in secondary, 95-96% in latent, 71-73% in late syphilis, with 98% specificity. TPHA had a sensitivity of 86% in primary, 100% in secondary and latent, and 99% in late syphilis, with 96% specificity. CLIA had a sensitivity of 98-100% and a specificity of 99%, while RDTs had a sensitivity of 94% and a specificity of 99% (meta-analysis of Thai data).^{12,14,15}

Cost Parameters

Costs were estimated using a prevalence-based, normative approach over a single year (no reinfection assumed). The normative cost assessment, guided by the standard treatment protocol outlined in the National Guideline for Syphilis Laboratory Diagnosis

2021¹², was employed to estimate resource allocation and associated costs (Table 2).

Direct medical costs were assigned according to each individual's screening and disease status. True-positive individuals incurred both screening and treatment costs within the study year, and false-positive individuals were assigned the same cost profile. True-negative individuals incurred screening costs only, whereas false-negative individuals incurred screening costs within the study year and treatment costs accrued over the subsequent five years. Time adjustment of future costs were adjusted by a 3% yearly discount per the Thai Health Technology Assessment Guideline; cost inputs from earlier years were adjusted to 2022 values using the Consumer Price Index of Thailand.²⁷⁻²⁹ Costs are reported in 2022 Thai baht (THB); where US dollar (US\$) equivalents are given, they were calculated at the 2022 average official exchange rate of 35.06 THB per US\$.³⁰

Table 2. Input parameters.

Test	Sensitivity for each stage of infection, % (range)				Specificity, % (range)	Reference
	Primary	Secondary	Latent	Late		
VDRL	78 (74–87)	100	96 (88–100)	71 (37–94)	98 (96–99)	12,14
RPR	86 (77–99)	100	95 (95–100)	73	98 (93–99)	
TPHA	86	100	100	99	96	
CLIA	98	100	100	100	99	
RDT	94 (92–96)				99 (98–99)	15*

Table 2. Input parameters (cont.).

Clinical and epidemiological parameters								
Age-specific proportion of risk group (years)								
	Preg	Pregcp	PrEP	PEP	Pris	KP	GP	Reference
2–14	2.37e ⁻⁴	2.37e ⁻⁴	5.09e ⁻⁶	3.47e ⁻⁵	2.25e ⁻⁴	8.12e ⁻⁴	9.98e ⁻¹	2,4,17-19,22-24
15–24	2.54e ⁻²	2.54e ⁻²	5.77e ⁻⁵	5.40e ⁻⁵	6.01e ⁻³	3.22e ⁻²	9.11e ⁻¹	
25–59	9.73e ⁻³	9.73e ⁻³	4.09e ⁻⁵	1.46e ⁻⁵	7.11e ⁻³	1.58e ⁻²	9.58e ⁻¹	
60+	NA	NA	3.89e ⁻⁶	1.33e ⁻⁶	3.95e ⁻⁴	6.92e ⁻³	9.93e ⁻¹	
Age-specific probability of syphilis infection, classified by staging (years)								
	Pri	Sec	EL	LL	Ter	Neu		Reference
2–14	11.49e ⁻²	25.68e ⁻²	22.30e ⁻²	36.49e ⁻²	0.68e ⁻²	3.38e ⁻²		22-24
15–24	8.06e ⁻²	17.30e ⁻²	23.19e ⁻²	49.85e ⁻²	0.43e ⁻²	1.17e ⁻²		
25–59	6.93e ⁻²	18.20e ⁻²	17.76e ⁻²	51.82e ⁻²	1.38e ⁻²	3.92e ⁻²		
60+	5.48e ⁻²	4.98e ⁻²	7.64e ⁻²	49.83e ⁻²	2.82e ⁻²	29.24e ⁻²		
Description							Value	Reference
Number in cohort, aged 2 years and above							63,869,724	23
Proportion of age group (years)								
2–14							0.1471	23
15–24							0.1298	
25–59							0.5345	
60+							0.1886	
Total number of reported cases, annually, by age (years)							15,841	
2–14							253	24
15–24							8,394	
25–59							6,325	
60+							869	
Proportion of reported cases of syphilis by age group (years)								
2–14							0.0160	24
15–24							0.5299	
25–59							0.3993	
60+							0.0549	
Prevalence rate of syphilis								
Pregnant women							0.0130	Calibrating parameters, calculated by authors
Pregnant couples							0.0130	
HIV Pre-exposure prophylaxis (PrEP)							0.1334	
HIV Post-exposure prophylaxis (PEP)							0.1334	
Prisoners							0.0288	
HIV key population							0.1734	
General risk population							0.0275	
Cost and resource utilization parameters								
Resource utilization of screening (THB/service)								
Cost of RPR							100.00	9
Cost of TPHA							100.00	9
Cost of CLIA							200.00	25
Cost of RDT							50.00	Assumption
Number of screening visits/year							1.19	18
Resource utilization of treatment								
Cost of penicillin G vial dry 1–1.2 million units/vial (THB/vial)							60.00	26
Cost of ceftriaxone vial dry 1 g/vial (THB/vial)							9.45	26
Cost of erythromycin film-coated tablet 250 mg (THB/tablet)							2.24	26
Number of penicillin G, primary and secondary, vial/episode							2.00	12
Number of ceftriaxone, early latent, vial/episode							28.00	12
Number of erythromycin, early latent, tab/episode							112.00	12
Number of penicillin G, late latent and tertiary, vial/episode							6.00	12
Number of penicillin G, neurosyphilis, vial/episode							63.00	12

Table 2. Input parameters (cont.).

Total cost of treatment (THB/episode)	Diagnosed	Undiagnosed	
Primary and secondary syphilis	120.00	103.51	
Early latent syphilis	211.83	182.72	Calculated
Late latent / tertiary syphilis	360.00	310.54	by authors
Neurosyphilis	3,780.00	3,260.66	

**Meta-analysis conducted by the authors. Pri: primary syphilis. Sec: secondary syphilis. EL: early latent syphilis. LL: late latent syphilis. Ter: tertiary syphilis. Neu: neurosyphilis. KP: key populations. RPR: rapid plasma reagin. TPHA: Treponema pallidum hemagglutination assay. CLIA: chemiluminescence immunoassay. RDT: rapid diagnostic test. VDRL: Venereal Disease Research Laboratory. Preg: pregnant women. Pregcp: pregnant couples (partners of pregnant women). Pris: prisoners. GP: general risk population. NA: not applicable. HIV: human immunodeficiency virus. Costs are reported in 2022 Thai baht (THB) at the exchange rate of US\$1=35.06 THB.*

Cost-effectiveness Analysis

The assessment of model validation included face validation along with internal and predictive model validation. Internal and predictive validation verified model inputs and outputs, evaluated by data-source stakeholders and organizational representatives (see Acknowledgements). Inputs and assumptions were reviewed by 28 experts and stakeholders, including policymakers from the NHSO and Ministry of Public Health (MoPH), medical experts from royal colleges and professional associations, STI specialists, civil-society representatives, and service providers under the MoPH, the BMA, and community-led organizations. As the cost and resource-utilization parameters were fixed, single-valued inputs were derived by a normative approach, and a probabilistic sensitivity analysis was not performed; uncertainty was explored through scenario analyses. The model was calibrated against the 15,841 reported incidence cases in 2021 (24.8 per 100,000) from the Health Data Center.²⁴ The calibrated at-risk prevalence (Table 2) was 1.52 times the observed value (Table 1). The main outcome was the incremental cost-effectiveness ratio, determined as the extra cost per case identified.

Budget Impact Analysis

The budget expense projection for the five-year horizon following the analytic base year (2022) was conducted from the viewpoint of the NHSO, incorporating expenses related to fees for screening services, without any discount based on Thai Health Technology Assessment Guideline.^{27,28}

Under CP, coverage was held at 1.72% (past performance) and the alternatives grew 0.09% annually, reflecting 2015–2020 HIV Voluntary Counseling and Testing service coverage growth, at 1.19 visits per person.¹⁸ The reimbursement prices for RDT, RPR, TPHA, and CLIA examination were set at 50, 100, 100, and 200 THB per test, respectively.^{9,25}

Sensitivity Analysis

A one-way sensitivity analysis was conducted on the screening utilization rate, comparing the base case scenario (1.19 visits per person per year) with a high-utilization scenario (two visits per person per year) to illustrate the upper bound of the budget impact.

Results

Clinical outcomes and cost-effectiveness ratios derived from the model for the three syphilis screening strategies are summarized in Table 3 and Table 4, respectively.

Two coverage metrics were reported: screening coverage, defined as the number of individuals screened as a proportion of the total population, and effective coverage, defined as the number of true-positive cases detected as a proportion of all prevalent cases (Table 3). Under CP, 1,095,524 individuals were screened (screening coverage 1.72%; effective coverage 2.51%). Under P1, 1,304,721 individuals would be screened (2.04%; 2.82%), and under P2, 1,224,326 individuals would be screened (1.92%; 2.73%). Under CP, there were 15,076 true positives and 632 false negatives. Under P1, there were 16,970 true positives and 860 false negatives, while under P2, there were 16,428 true positives and 835 false negatives. Syphilis cases rose from 15,841 under CP to 17,853 for P1 and 17,261 for P2.

The true prevalence of syphilis remained steady at 0.94% throughout all three strategies, suggesting that the model assessed all three strategies based on an identical underlying prevalence.

Total costs, in million THB, were 332.63 under CP, 337.19 under P1, and 337.58 under P2, with unit costs of 304, 258, and 276 THB per person and cost-effectiveness ratios of 22,064, 19,870, and 20,549 THB per case for CP, P1 and P2, respectively. Under P1, the incremental cost-effectiveness ratio was 2,409 THB per

case detected compared to CP, while P2 was dominated by P1, being more costly (337.58 vs 337.19 million THB and less effective (16,428 vs 16,970 true-positive cases). Thus, P1 was the most cost-effective strategy.

Over five years, the budget, in million THB, was fixed at 149 per year under CP, while under P1, the amount

rose from 156 in Year 1 to 182 in Year 5, averaging 169 million THB (Figure 4). Over five years, the cumulative budget impact under P1 was an additional 98 million THB compared to CP. A high-utilization scenario (two visits per person-year) raised the cumulative impact to 672 million THB.

Table 3. Strategy descriptions and screening results derived from the model.

	CP: Current practice	P1: Policy I, Expand to all Thais with high-risk behaviors	P2: Policy II, Scale-up prisoner coverage with addition of youth aged 15–24
Strategy description			
Rationale	Status quo (UCS 2022 reimbursement)	Universal coverage of high-risk behaviors	Targeted addition of high-burden groups
Target population	Pregnant women & couples, HIV KP, and prisoners (pilot 18.8%, age 25+) ²¹	CP groups + all Thais with high-risk behaviors	CP groups + prisoners scaled to 60% + youth 15–24
Testing algorithm/method	TA only (VDRL, TPFA); RDT for prisoners	TA + RA (CLIA or RDT)	TA + RA (CLIA or RDT)
Service coverage (within-group, %) and test mix proportion (%)			
Pregnant women	Cov 99.58% ² TA (61.65)/ RA-CLIA (38.35) ^{22,†}	=CP	=CP
Pregnant couples	Cov 59.75% [§] TA (61.65)/ RA-CLIA (38.35) ^{22,†}	=CP	=CP
Pre-exposure prophylaxis (PrEP)	Cov 100.00% ¹⁷ TA (58.04)/ RA-CLIA (41.96) ^{22,†}	=CP	=CP
Post-exposure prophylaxis (PEP)	Cov 100.00% [§] TA (58.04)/ RA-CLIA (41.96) ^{22,†}	=CP	=CP
Prisoners, age 15–24	Cov 14.25% [§] RA-RDT (100) ²¹	Cov 45.48% [§] RA-RDT (100) ^a	=P1
Prisoners, age 25+	Cov 18.80% ²¹ RA-RDT (100) ²¹	Cov 60.00% [§] RA-RDT(100) [§]	=P1
HIV key population	Cov 8.84% ^{18,20,†} TA (56.47)/ RA-CLIA (43.53) ^{22,†}	Cov 8.84% (= CP) TA (28.24)/ RA-CLIA (21.76)/ RA-RDT (50.00) [§]	=P1
General risk population	Cov 0.15% [†] TA(34.22)/ RA-CLIA (65.78) ^{22,†}	Cov 0.30% all ages [§] TA (17.11)/ RA-CLIA (32.89)/ RA-RDT (50.00) [§]	Cov 0.30% (15-24); 0.15% (other) [§] Test=P1
Screening results			
Not received screening (persons)	Non-diseased	62,189,051	61,981,976
	Diseased	585,149	583,027
Received screening (persons)	TP	15,076	16,970
	FN	632	860
	TN	1,079,051	1,286,009
	FP	765	883

Table 3. Strategy descriptions and screening results derived from the model (cont.).

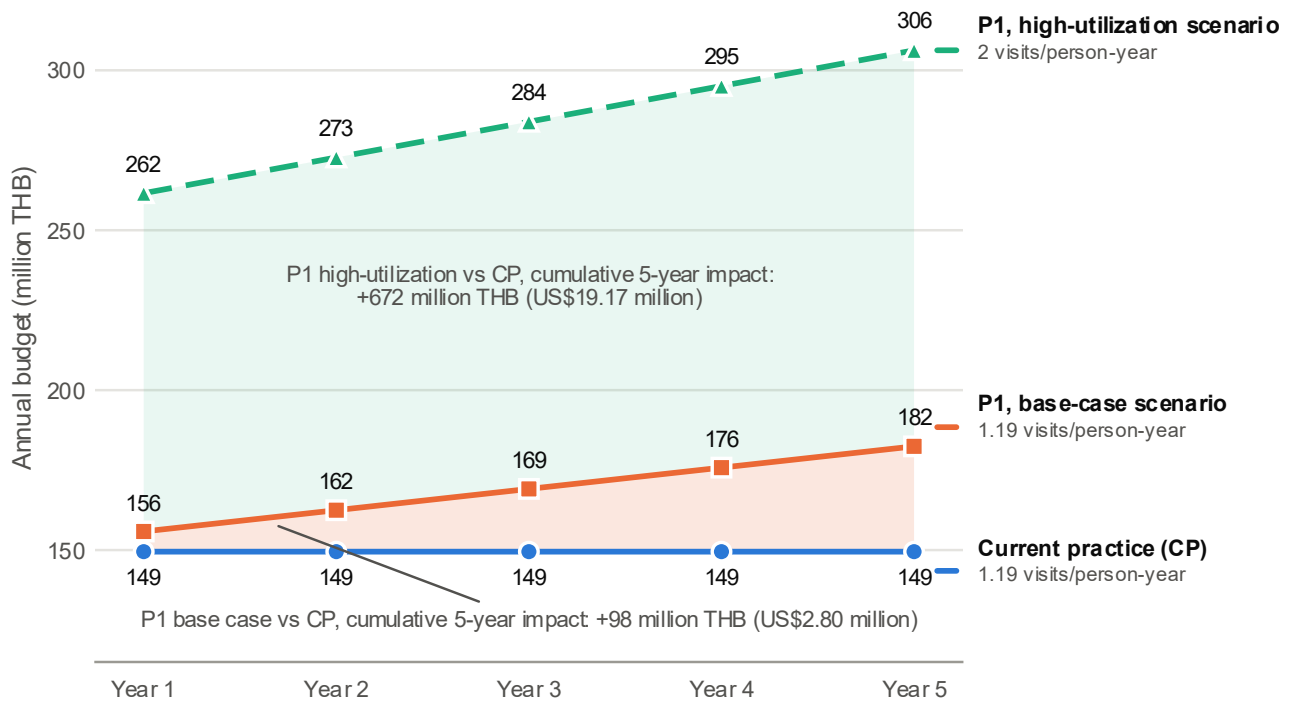
		CP: Current practice	P1: Policy I, Expand to all Thais with high-risk behaviors	P2: Policy II, Scale-up prisoner coverage with addition of youth aged 15–24
Total population (persons)	(a)	63,869,724	63,869,724*	63,869,724
Total diseased (persons)	(b)	600,856*	600,856	600,856
Total non-diseased (persons)	(c)	63,268,868	63,268,868	63,268,868
True Prevalence (%)	=b/a	0.94%	0.94%	0.94%
Total screening (persons)	(d)	1,095,524	1,304,721	1,224,326
Screening coverage (%)	=d/a	1.72%	2.04%	1.92%
Reported incidence (cases)	(e)	15,841	17,853	17,261
Effective coverage (%)	=TP/b	2.51%	2.82%	2.73%

*Components may not sum exactly to the total owing to rounding of expected values. †Calculated. §Assumption. CLIA: chemiluminescence immunoassay. Cov: service coverage rate. FN: false negative. FP: false positive. KP: key population. RA: reverse algorithm. RA-CLIA/RA-RDT: reverse algorithm with CLIA/RDT as initial treponemal test. RDT: rapid diagnostic test. TA: traditional algorithm. TN: true negative. TP: true positive. TPHA: Treponema pallidum hemagglutination assay. UCS: Universal Coverage Scheme. VDRL: Venereal Disease Research Laboratory. TPHA: Treponema pallidum hemagglutination assay. RDT: rapid diagnostic test.

Table 4. Cost-effectiveness results derived from the model

Comparators	By screening status	By screening results (persons)	Total cost, THB	Summary per strategy, THB
CP	Not received screening 62,774,200 persons	Non-diseased	62,189,051	-
		Diseased	585,149	205,355,460
	Received screening 1,095,524 persons (1.72%)	Non-diseased-TN	1,079,051	124,006,822
		Non-diseased-FP	765	163
		Diseased-TP	15,076	3,248,387
		Diseased-FN	632	20,739
P1	Not received screening 62,565,003 persons	Non-diseased	61,981,976	-
		Diseased	583,027	204,248,492
	Received screening 1,304,721 persons (2.04%)	Non-diseased-TN	1,286,009	129,174,299
		Non-diseased-FP	883	174
		Diseased-TP	16,970	3,748,373
		Diseased-FN	860	21,096
P2	Not received screening 62,645,398 persons	Non-diseased	62,061,804	-
		Diseased	583,594	204,687,514
	Received screening 1,224,326 persons (1.92%)	Non-diseased-TN	1,206,230	129,127,753
		Non-diseased-FP	833	174
		Diseased-TP	16,428	3,746,769
		Diseased-FN	835	21,092

CP: current practice. P1: policy I, expand to all Thais with high-risk behaviors. P2: policy II, scale-up prisoner coverage with addition of youth aged 15–24. TN: true negative. FP: false positive. TP: true positive. FN: false negative. Unit cost: per person screened. CE ratio: cost-effectiveness ratio, per case detected. ICER: Incremental cost-effectiveness ratio, per additional case detected vs CP. Costs are reported in 2022 Thai baht (THB) at the exchange rate of US\$1=35.06 THB.



Years 1–5 are counted from the 2022 analytic base year. The base case assumes 1.19 screening visits per person-year and the high-utilization scenario 2 visits per person-year. Shaded areas show the additional annual budget of P1 relative to CP. CP: current practice. P1: expand to all Thais with high-risk behaviors. THB: Thai baht. Costs are reported in 2022 Thai baht (THB) at the exchange rate of US\$1=35.06 THB.

Figure 4. Annual budget impact of P1 compared with current practice over five years (million THB).

Discussion

The findings of this study underscore that expanding syphilis screening to all Thais with high-risk behaviors (Policy I) was the most economically efficient strategy for addressing the country's escalating syphilis incidence. By identifying more true-positive cases while achieving a lower unit cost per person screened than current targeted practices, universal testing within this population would leverage economies of scale, providing greater public-health benefit than narrowly targeted policies.

From a managerial perspective, Policy I appears operationally feasible because it can leverage the existing HIV-testing platform under the same provider, and RDTs enable same-visit treatment without laboratory infrastructure. Key operational considerations include provider training, RDT procurement and supply, strengthening of recording and reporting systems, demand generation among youth, and ensuring linkage to treatment.

When comparing these findings with international literature, there is a notable divergence in recommendation strategies. The U.S. Preventive Services Task Force recommends risk-based rather than universal screening in low-prevalence settings.⁵ In contrast, Thailand's incidence increased from 11.6

to 27.8 per 100,000 (2017–2021), with projections exceeding 50 per 100,000 by 2030 (versus 11.9 in the U.S. in 2019), justifying a more universal approach. This high baseline prevalence necessitates a more aggressive, universal approach whereas targeted approaches may be more appropriate in lower-prevalence countries.

The significance of these findings lies in providing a robust evidence base for the NHSO and policymakers to revise the UCS benefits package. By transitioning from targeted to universal screening for high-risk behaviors, Thailand can more effectively address the rising infection rates among the general population and youth, who currently face barriers in accessing sexual health services. Ultimately, this strategy offers a viable roadmap for meeting WHO elimination targets and preventing long-term morbidity associated with untreated syphilis.

Because the budget impact was projected from the 2022 base year, these figures represent expected rather than realized expenditure. This study's evidence subsequently informed a national policy decision: on 5 Jun 2024 the National Health Security Board approved expanding the benefit to youth, adolescents and people with high-risk behaviors, drawing on the study's projected gains in screening

coverage (from 1.72% to 2.04%), effective coverage (from 2.51% to 2.82%) and annual case detection (from 15,841 to 17,853 cases), and allocating an additional 6.76 million THB for the initial roll-out over the last two months of the 2024 fiscal year.³¹ This allocation is of the same order of magnitude as our projected incremental first-year budget of approximately seven million THB (an increase from 149 to 156 million THB), supporting the credibility of the projection. While policy decisions necessarily rest on many considerations, it is encouraging that the cost-effectiveness and budget-impact evidence generated here proved timely and decision-relevant. The benefit was implemented nationwide in 2025, and a full comparison of the projection against realized multi-year program expenditure remains an important real-world evaluation for future work.

Limitations

This study used a cost-effectiveness analysis with a decision-tree model owing to limited epidemiological data; a Markov or dynamic model was not used, limiting assessment of long-term outcomes. As the study was a rapid health technology assessment to inform a timely decision, a full cost-utility analysis with quality-adjusted life-years and long-term projection was not undertaken. Other limitations include the undescribed distributional nature of the data (precluding probabilistic sensitivity analysis), and the short one-year horizon. Moreover, cost-effectiveness is only one dimension of a decision-making policy; however, a comprehensive operational feasibility assessment was also conducted and is being prepared for publication elsewhere, with the findings presented to policymakers alongside the results of this study.

The data obtained from surveillance systems and healthcare services originates from various sources and contains incomplete details, which require a separate analysis and integration of the data. It is crucial to categorize the population and merge the information, along with employing hypotheses to fill in the gaps in order to develop a comprehensive model of the entire Thai population. Finally, this study did not include the screening of syphilis among foreign workers, as this subgroup is not included in Thailand's UCS.

Public Health Recommendations

These findings provide an evidence base for revising the UCS benefits package. We recommend that the NHSO, as the purchaser and benefit-package

authority, in collaboration with the MoPH and the Department of Disease Control (DDC), incorporate expanded screening for all Thais with high-risk behaviors into the UCS benefit package. A companion feasibility study (reported separately) confirms readiness across the technical, organizational and operational dimensions, and that the standard protocols (TA, RA, or RDT) are appropriate and reliable for routine use. Delivering this within the established "free HIV testing biannually for all Thais" program is organizationally and practically viable, since both services share the same agencies and platforms and offer convenience for providers and users. This co-delivery has since been adopted and announced in the Royal Gazette.³²

Nevertheless, screening represents secondary prevention only; primary prevention through condom use remains important and is a cost-effective complementary measure in the Thai setting.^{33,34} Relevant agencies including the MoPH, the Ministry of Education and the Thai Health Promotion Foundation should strengthen youth-focused education alongside early screening, diagnosis and treatment, and reinforce data-management, monitoring-and-evaluation (National AIDS Program; voluntary counseling and testing) and reporting systems to track outcomes.

Ultimately, expanding screening offers a viable roadmap toward the WHO elimination targets and the prevention of long-term morbidity from untreated syphilis.

Conclusion

Expanding syphilis screening and diagnosis to all Thais with high-risk behaviors was the most cost-effective strategy, providing a lower unit cost per screened person and a favorable budget expense and cost-effectiveness ratio per case detected.

Specifically, this strategy achieved the lowest unit cost per person screened (258 THB) and the most favorable cost-effectiveness ratio (19,870 THB per case detected; incremental cost-effectiveness ratio 2,409 THB per additional case versus current practice) while detecting more true-positive cases. The five-year average budget requirement was approximately 169 million THB per year. Integrating screening with the existing free HIV-testing platform is recommended for organizational and practical feasibility, and the findings informed the subsequent national decision to expand the benefit. Future research should employ a cost-utility analysis with quality-adjusted life-years,

dynamic transmission modeling to capture long-term and secondary-prevention effects, a probabilistic uncertainty analysis, and real-world evaluation of the operational feasibility and equity of implementation.

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Author Contributions

Naiyana Praditsitthikorn: Conceptualization, methodology, project administration, writing—original draft, writing—review & editing. **Suppachok Kongtian:** Conceptualization, methodology, writing—original draft, writing—review & editing. **Jitrada Jantasila:** Writing—review & editing. **Pratpathom Saipruek:** Writing—review & editing. **Yosita Thitiwatthana:** Writing—review & editing. **Somjit Buaban:** Writing—review & editing. **Jirawan Sawangsuk:** Writing—review & editing.

Ethical Approval

This evaluation was conducted with authorization from the DDC, MoPH. The formal ethical approval was waived. Nevertheless, the study was executed under the guidance of experts in the high-impact research support program of the DDC, and in compliance with the ethical standards outlined in the Declaration of Helsinki.

Informed Consent

Informed consent was obtained, either verbally or in writing, from all participants involved in the study.

Data Availability

The data of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest related to this work.

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Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this work, the authors used Grammarly and SciSpace to enhance clarity and correct grammatical errors. The content produced by this tool was reviewed and edited by the authors, who accept full responsibility for the final text.

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