ASSESSING OF THAILAND HIV DATA QUALITY AND ITS IMPACT TO UNAIDS 90-90-90

by

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Abstract

Introduction

Despite having an effective Anti-Retroviral therapy regimen that improves the quality of life of HIV patients, HIV is still a major threat to public health and still is growing. To address this threat, UNAIDS has established the policy of the 90-90-90 indicators that needed to be achived. In 2018, Thailand's indicators have become unreasonably high excessing 100%. Therefore, this study aims to assess the current data quality using the Ministry of Public Health, exploring the causes, and providing recommendations.

Methods

Using a mix-methods approach this study analyzes and compares across two databases, the Ministry of Public Health (MOPH) and National AIDS Program (NAP) to describe the overall quality and the extent of the two data sources difference. The province with the highest difference was selected for a field visit and the deployment of the Data Quality Improvement Tools (DQI Tools), jointly developed by MOPH and Thai-MOPH-US-CDC Collaborator (TUC) for assessing the HIV data quality. Field interviews were conducted using the MEASURE Data Quality Audit (DQA) as a guide to identifying the drop-off in the workflow.

Results

Thailand's 90-90-90 indicators were calculated using NAP as a default data source giving 105%,72%, and 83% respectively. For MOPH, the first indicator was 104% and 52% for the second indicator. The third indicator for the MOPH was not available because of a lack of laboratory data.

NAP data quality gaps were identified including a legacy data migration problem and a difficult data correction process. MOPH gaps were related to the lacking of a single unified standard for both laboratory and medication, unclear regulation, and lack of incentives for data reporting. Bangkok, while having a similar reporting practices to the non-Bangkok province, it also suffers from having several hospital affiliations, technical problems, and limited data stewardship.

Conclusion

In this study, NAP suffers from complicated data correction processes, coverage of other health schemes, and disincentive, it was a suitable source for the 90-90-90 indicator calculation. MOPH is not suitable for indicator calculation from lacking national data standards, unclear regulation, and the database structure itself. Bangkok, Thailand's capital city is the area that needs special attention.

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Introduction

HIV or Human Immunodeficiency Virus is a virus that is transmitted through body fluids. As the name implies, the virus attacks and severely weakened the body's immune system. In the advanced stage, the patient progresses to Acquired Immune Deficiency Syndrome (AIDS). HIV has become one of the major health public health problems globally since its first report in 1981, as more than 77 million people have been infected by HIV and more than 10 million deaths from AIDS-related illnesses around the world (1). With significant global efforts to address the HIV problem, the treatment, the Antiretroviral Therapy (ARV or ARV) has become more and more affordable. As of 2017, 20.9 million infected patients have access to ARV, a significant increase from 7.5 million in 2010 (2).

However, there is still a long way to go. According to the UNAIDS report, there are approximately 1.8 million newly infected HIV each year. As a result, UNAIDS has established the 90-90-90 goals which stand for 90% of patients who know their status, receive Anti-retroviral therapy (ARV), and achieve viral suppression. The goals have to be achieved by the end of 2020 to prevent the HIV/AIDS epidemic to outrun the ARV intervention.

Thailand, despite having received international recognition as one of the HIV success stories in terms of leadership, financing, civil society, and research, is still facing a severe magnitude of HIV problem. According to the Asian Epidemic Model (AEM) estimation, there were 427,332 HIV infected patients in Thailand as of 2016. Only approximately 265,525 cases or half of the patients received antiviral treatment. There were 4,423 new HIV infected and 15,776 deaths. Thailand has slow progress toward UNAIDS 90-90-90 goals.

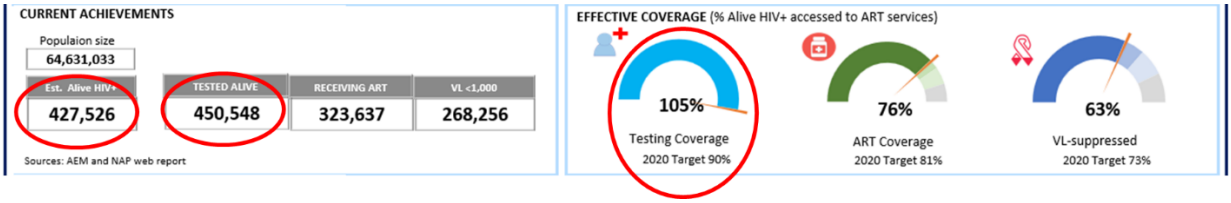


Figure 1 Thailand HIV Dashboard showing an AEM estimation of 427,526 while an actual reported HIV/AIDS is 450,548 resulted in 105% coverage, which is an illogical number (Source: AIDS Zero Portal Dashboard 2018).

However, we started to observe discrepancies between AEM estimation and the actual number from the HIV/AIDS reporting system (Figure 1). The first of the 90-90-90 indicators (Testing Coverage) was higher than 100% as the reported cases are higher than AEM estimation. This was important as the epidemiologic study, policy, strategic planning, and public communication are based on the AEM estimation and reported HIV cases. Having an illogical number can cause distrust and confusion among stakeholders and may fail HIV/AIDS planning and control.

Therefore, in this dissertation, we explored the reporting quality gaps of the HIV reporting system in Thailand, assess its impact on the 90-90-90 indicators, and provide data quality improvement recommendations to the Ministry of Public Health (MOPH).

Research questions

- What are the current quality gaps in Thailand's HIV data reporting?
- What are the possible key factors in data pipeline and reporting workflow that can cause gaps in HIV reporting quality?
- How would the 90-90-90 indicators improve if we correct the quality gaps?

Study Aims

- Aim 1. Determine the difference in the reporting quality between the two main reporting systems in Thailand, the National AIDS Program (NAP) and the Ministry of Public Health (MOPH)
- Aim 2. Assess and identify the causes of quality gaps in the reporting systems
    - Aim 2-1 Identify the facility and provincial level factors associated with reporting quality

    - Aim 2-2 Identify the loss in Thailand HIV reporting system quality
    - Aim 2-3 Identify the possible drop-off causes in the workflow
- Aim 3 Assess the impact of having better NAP data quality to 90-90-90 indicators compare to the current NAP data quality level.

Literature review

Thailand HIV history

The first AIDS patient in Thailand was reported in 1984. The epidemic at that time was mostly from HIV-1 subtype B. The epidemic spread rapidly to people who inject drugs (PWID) in 1998. The subtype E was detected among female sex workers (FSWs) and spread widely among them and their clients which reached its peaked in the mid-1990s before starting to decline (3, 4). At that time, most HIV-infected patients were from the Northern part of Thailand (5). During the same period, HIV prevalence among Ante-Natal Clinics (ANCs), male conscripts, and blood donors also raised and peaked in the early 1990s before continuously declining since then. At that time, the most common opportunistic infection was Tuberculosis, Pneumocystis carinii pneumonia (PCP), cryptococcosis, and candidiasis of the esophagus, trachea, or lung respectively.

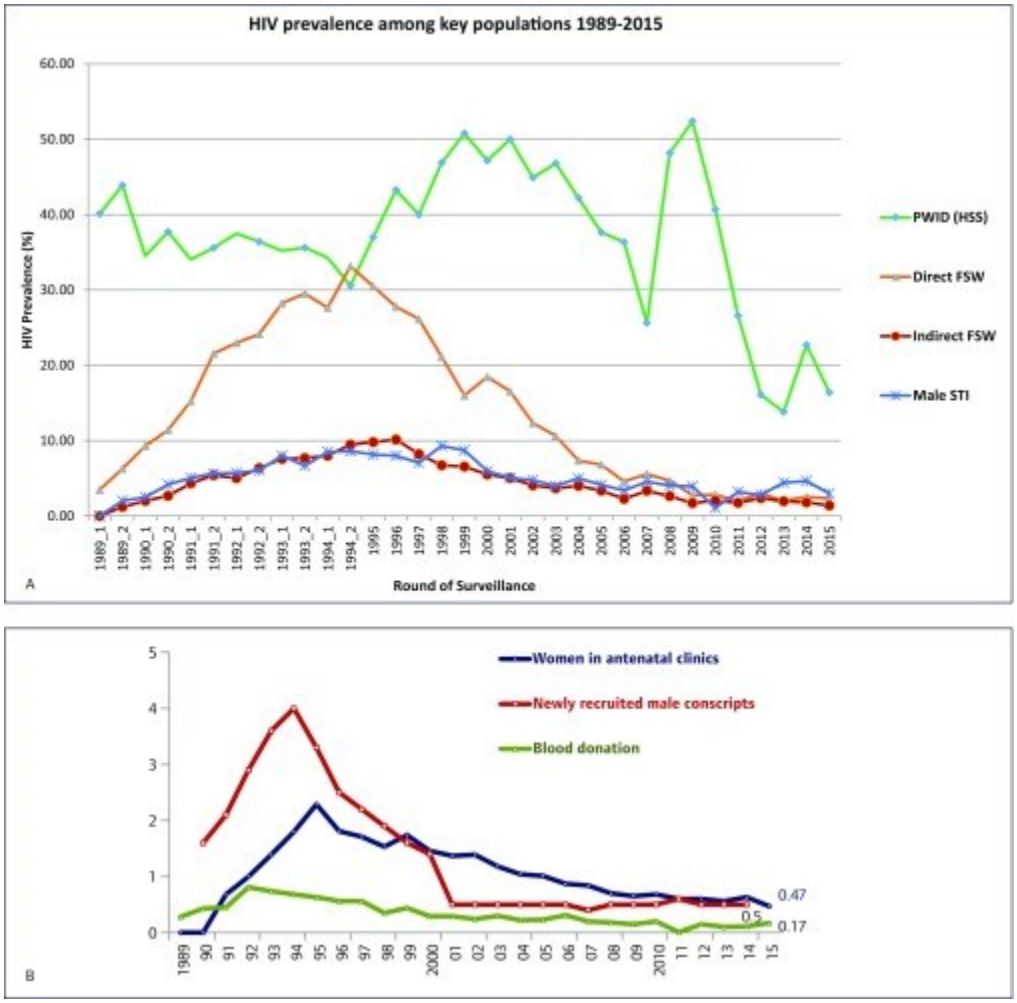


Figure 2 A. HIV prevalence in Thailand among the key population, 1989-2015 B. HIV prevalence among Thailand general population (6)

As described in Figure 2, the HIV prevalence among all key population groups was decreasing rapidly since the mid-1990s. However, there is a significant change in the HIV transmission pathway in Thailand as the prevalence among men who have sex with men (MSM) suddenly rising to 7.7% from 4.1% and have remained high since then. The serosurvey among this population has revealed an incidence of 12.2 per 100-person years which is nearly doubled to all-ages incidences of 6.3 per 100-person years (7). As a result, The Thai Red Cross Society has issued the policy of not receiving blood donation from MSM and LGBT since 2008 (8).

Overall, the annual new infection was declining since 2000 but at a slower rate. Although the new infection number largely reduced in 2010 by 65% compared to 2000, the 2014 number shows a 23% reduction from 2010 as shown in Table 1In 2015, according to an estimation from the AIDS Epidemic

Model (AEM) there were approximately 7,816 new infections, 20,492 AIDS-related deaths, and 445,504 HIV-infected patients. Among them, females contributed to 39% of adults and 47% of children. Among children, Thailand has been doing well since 2014 as there are only 121 children with newly HIV-infected or a 41% reduction from 2010**.**

Table 1 Key figures of AIDS Epidemic Model (AEM) estimation, Thailand 2000-2014 Source: 2015 THAILAND AIDS RESPONSE PROGRESS REPORT (9)

	2000	2005	2010	2012	2014
Annual new infection	29,619	16,014	10,215	8,877	7,816
Annual AIDS mortality	55,531	31,211	20,670	20,477	20,492
People living with HIV	683,841	555,808	493,932	471,811	445,504
Population (million)	60.6	63.1	63.9	64.5	65.1

However, AIDS-related deaths remained stable during the last 5 years despite achieving a dramatic reduction in new infections during 2000-2010. The AIDS deaths were 20,492 in 2014, nearly unchanged from 20,670 deaths in 2000. The reason was that after Thailand rapidly strengthening its ARV program in 2000 the AIDS-related death, and ARV coverage were both largely increased. However, several newly infected patients were brought to the care system for testing and starting ARV. Unfortunately, their treatment initiation was very late along with a lack of co-infection screening causing several HIV-infected patients to die within the first six months after diagnosis despite access to treatment.

Thailand HIV intervention, control, investment, and success stories

Thailand's public health action for HIV was initiated in 1984 by the Division of Epidemiology within the Ministry of Public Health in 1984, which was later promoted to the Bureau of Epidemiology, Department of Disease Control. They started reclassifying HIV as a high priority disease and developing the HIV surveillance system.

In 1987, the Ministry of Public Health (MOPH) launched the National AIDS Program (NAP) and established the Center of AIDS Prevention and Control which later become the Division of AIDS

under the Department of Communicable Disease, Ministry of Public Health. The surveillance system was established in 1989 providing information for strategic decision and resource allocation for the government and the MOPH (10). The government also played a critical role during that time by devoting a large amount of investment to the HIV control program. The investment went from $180,000 in 1988 to $81.96 million in 1996 for HIV control despite being a lower-middle-income country at that time (11). Thailand has relied on government funding as the main resource for the HIV program until today (Figure 3). The funding from the Global Fund for HIV, Tuberculosis, and Malaria (GFATM) has become available since 2003 and contributes 10-15% for the total response budget today. The majority of the fund was spent on treatment and prevention for children (< 5 years old) and other key populations.

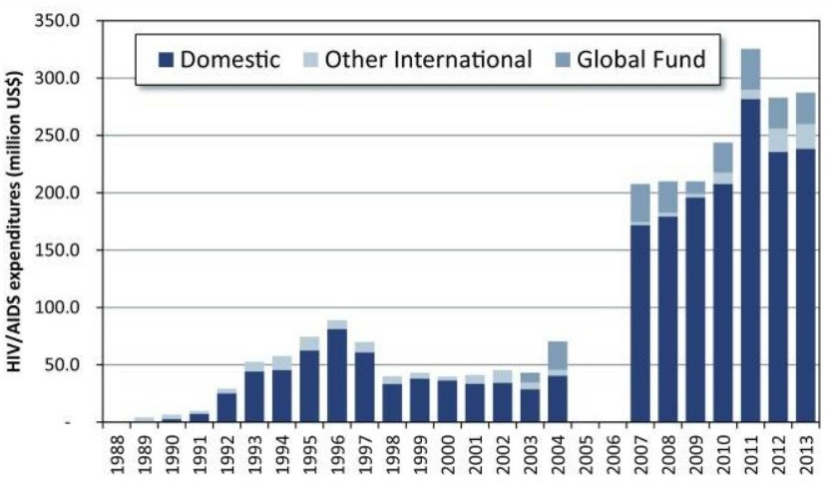


Figure 3 Thailand budget for HIV/AIDS program by funding sources during 1988-2013 (6). The government has doubled its budget for the HIV program since 2006 which remains as Thailand's main funding source since then.

One of the important HIV prevention programs is the campaign for 100% condom use which was initiated in 1991 and it has significantly raised condom use among sex-worker from 14 in 1989 to 94% in 1993 (12). This program plays a critical role in reducing HIV prevalence among other key populations especially among male conscripts which were reduced from 2.48 to 0.55 person-years during 1991-1995 (13).

According to the AEM projection, Thailand's intervention has reduced more than 2 million infections and the number reached 5.7 million in 2013. The model estimation during that period shows a

significant reduction from 168,485 to 28,241 during 1991- 2000 (Thai Working Group on HIV Estimation and Projection, 2015) as shown in Figure 4.

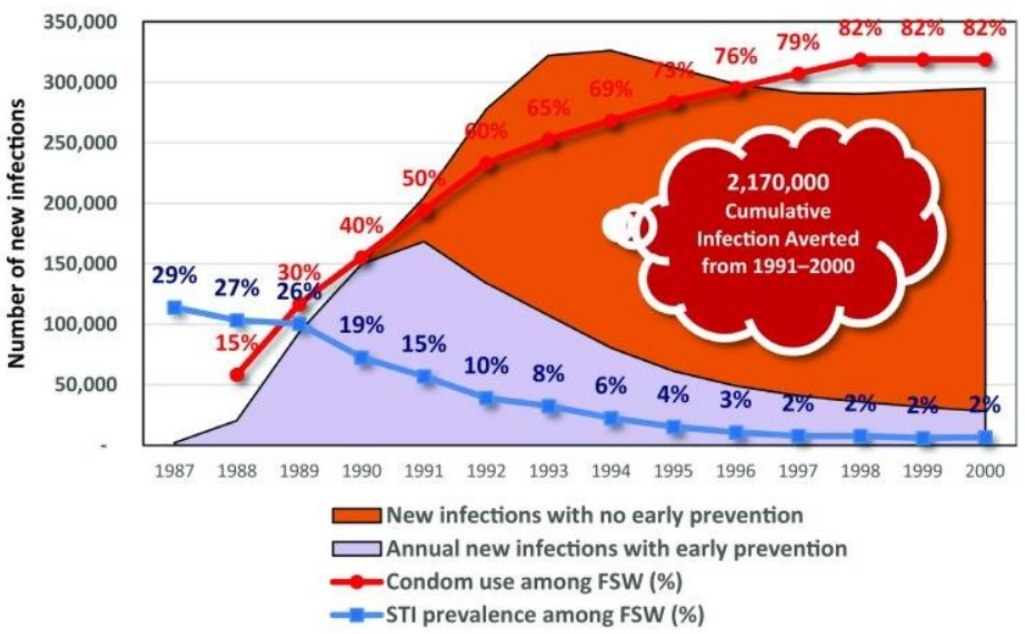


Figure 4 The AEM estimation for early prevention impact. The program has prevented approximately 2.1 million infections from 1991-2000. FSW stands for Female Sex Worker, STI stands for Sexually Transmitted Infection (6).

In the 2000s, the idea of providing ARV without charge was initiated and was made possible and rapidly scaled-up as the Government Pharmaceutical Organization (GPO) begun to locally produce its ARV, a combination of stavudine, lamivudine, and nevirapine (NVP). The program was receiving large support from the government who doubled its budget for ARV along with the GFATM from the Global Fund in 2004 (14). The program was later renamed to National Access to Antiretrovirals Program for People Living with HIV/AIDS (NAPHA) manufacturing ARV for adults and children (15). The program was completely incorporated into Thailand's main health coverage (Universal Health Coverage) in 2006. In 2014, the AEM estimation showed that the NAPHA program already averted 196,000 deaths as shown in Figure 4. NAPHA was later renamed to National AIDS Program (NAP) in 2008 (Figure 5).

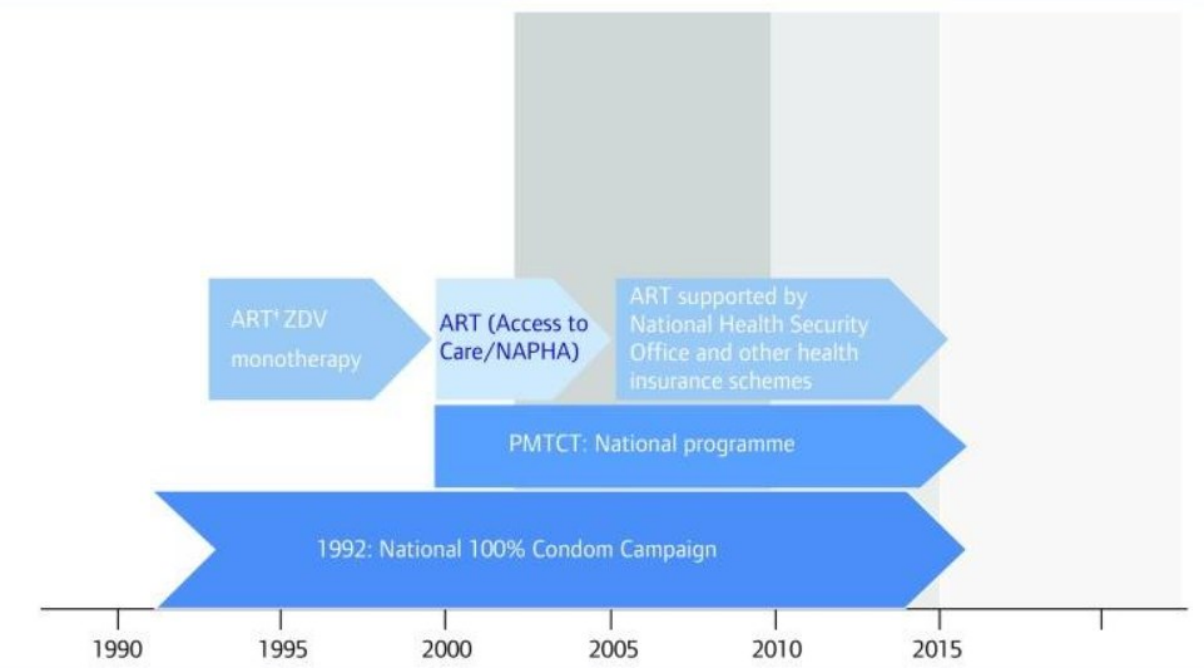


Figure 5 HIV intervention in Thailand during 1990-2015. PMTCT stands for Prevention of mother-to-child transmission, NAPHA stands for National access for people living with HIV/AIDS to ARV. The NAPHA was funding by the Ministry of Public Health and the Global Fund (6)

Asian Epidemic Model (AEM)

As we reviewed in the previous section, Thailand has been using the Asian Epidemic Model (AEM) for strategic planning and evaluation regarding the HIV/AIDS program, its interventions, and investment for several years. The AEM is a mathematical model that mimics HIV transmission and spreading in Asia which can provide an insight into whether the interventions induce behavior change. The AEM model was developed based on Chin *et al* research (16) on three main contributions factors to HIV spreading in Asia, heterosexual risk behavior patterns, percentage of men visiting female sex workers, and the partner exchange among female sex workers. The model received support from the United States Agency for International Development (USAID). The AEM only estimates the HIV transmission among two age groups: adults (15 years old and older) and children (younger than 15 years old) infection. The infection occurs through sexual behavior in both homo and heterosexual transmission or by needle sharing. The overall transmission dynamic was described in Figure 6.

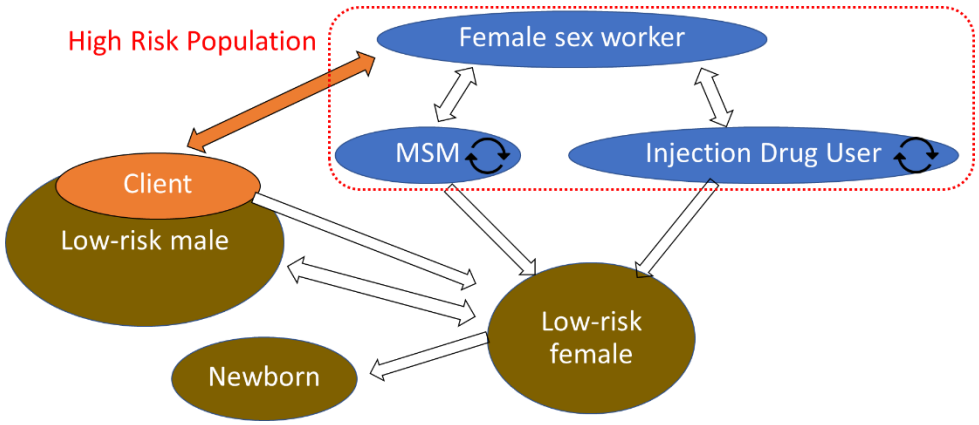


Figure 6 HIV transmission dynamic in Asia. MSM stands for Men who have Sex with Men. The transmission circulates within the high-risk population before transmitting to other low-risk populations and newborn.

The model aims to capture HIV spreading in Asia from existing data sources. Initially, the model was deployed in Cambodia and Thailand. There are two important key designs in the AEM. First, the model is semi-empirical. Second, the input parameters could be input on an annual basis. The design allows the user to create an alternative outcome or "what if?" scenario for the decision-makers to evaluate the impact of each intervention retrospectively. For example, the AEM estimated that Thailand might face another HIV epidemic if condom use falls from 85% to 60% in 1998 as shown in Figure 7.

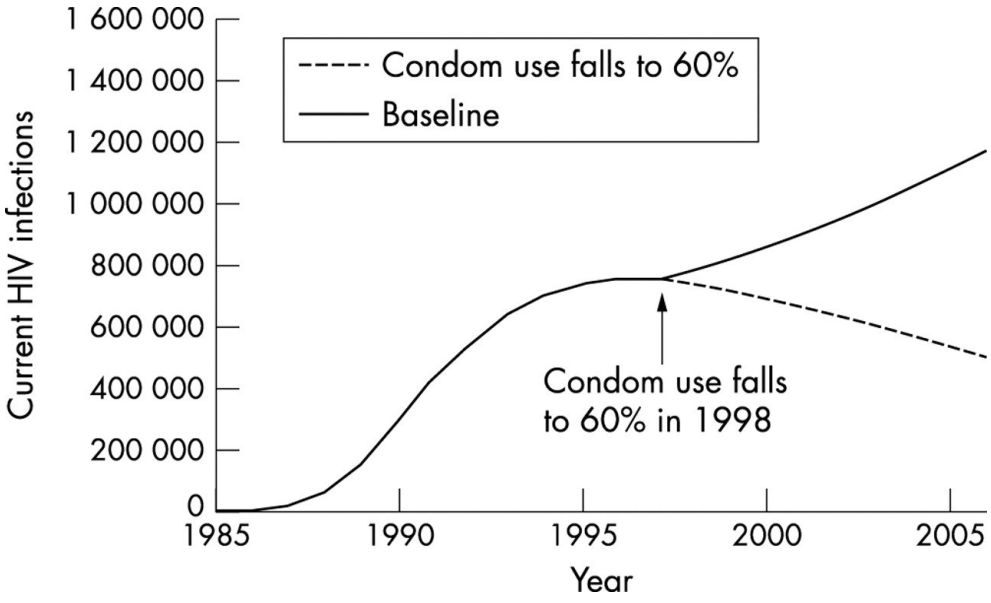


Figure 7 The alternative estimation generated from AEM in which the condom use drops to 60% in 1999 will lead to an HIV epidemic (Thai Working Group on HIV/AIDS Projection)

Overview of Thailand health system

The majority of the Thailand Health services were provided by the primary health clinic which serves under a community hospital. Each health center services cover approximately 3,000-5,000 population. Typical health center personnel consisted of nurses and paramedics of 3-5 people in total. Health center provides basic treatment, health prevention, and promotion from nurses and public health personnel (17).

District or Community hospital, typically with 30-150 beds capacity serves approximately 30,000-50,000 population. Community hospital personnel minimally consisted of 3-4 general practices physicians, 30 nurses, 2-3 pharmacists, 2 dentists, and 20 paramedics. The Community hospital provides a more complicated treatment service that is still under the primary health practice scope. When specialties' services such as surgery, internal medicine, pediatrics are needed, patients will be referred to a general hospital. Each province has at least one general or tertiary care hospital. This arrangement was named the "district health system", a backbone of the Thailand health system.

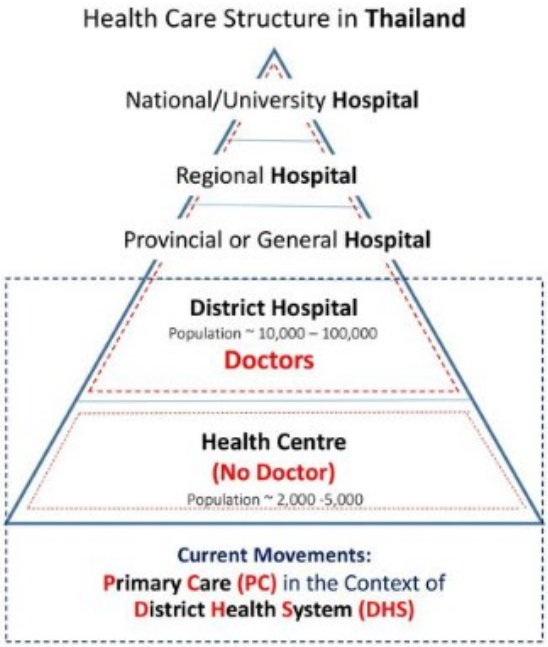


Figure 8 Overall of Healthcare structure facility in Thailand. Primary care services were provided by the District or Community hospital and Health center. Source; Pongsupap,

Another hospital classification is by care level (18). There are three main care level facilities in Thailand: Primary, secondary, and tertiary.

Primary care includes all public and private facilities that provide out-patient (OPD) services only. Specialists providing services at this level includes family medicine, preventive medicine, occupational medicine, and epidemiologist.

The secondary health care level hospital is a facility of 120-500 bed capacity. Secondary care level was broken down further into three subtypes: basic, medium, and advanced level. Basic secondary care means all government or private facilities that provide in-patient service in addition to those of primary care facilities. The facility can provide services for common health problems. Medium secondary care can provide services for more complicated health problems that require several additional specialties include obstetrics gynecologist, surgeon, internal medicine, pediatrics, orthopedist, and anesthesiologist. Advance secondary care provides further complex health problem that requires minor specialty including an ophthalmologist, Ear-Nose-Throat (ENT), psychiatry, rehabilitation, and critical care.

Tertiary care is a hospital with a bed capacity of 500 and over, including large general hospital, regional hospital and teaching hospital that provides more service to overly complex health problem and require sub-specialists (e.g. dermatologist, pediatric surgeon) (17).

While Thailand's private hospital is famous and has attracted many foreign patients for medical tourists, the private sector still has a small contribution to overall Thailand health service capacity. In 2015, the private sector contributes 14% of total outpatient visits (OPD) and 11.3% of total admission in Thailand.

There is another hospital class, MOPH- specialized hospital. The term represents the hospitals affiliated to MOPH but under a different authority. MOPH- specialized hospitals are designed to focus on more specialized services. For example, hospitals specially designed for proving health promotion,

occupational services, the hospital specialized for quarantine and treatment of high priority diseases (e.g. Ebola, SARS, MERS), and hospital specialized for Sexually Transmitted Diseases treatment. While the hospitals are still under MOPH authority, they are considered another department within the MOPH to achieve efficient processes necessary for specialized service.

Thailand Health coverage

Thailand has established three health care coverage schemes to cover each specific population group. The Civil Servant Medical Benefit (CSMBS) was introduced in 1980 specifically for government officers. The program covers 4.4 million government officers and their families. The benefit includes fee-for-service reimbursement for health care. Other benefits include pension, housing benefit, and child allowance are also available. The program is currently managed by Comptroller General's Department, Ministry of Finance. The CSMBS program budget is "Open-ended" which has the highest reimbursement per population among the three health coverage programs in Thailand.

In 1990, the Social Health Insurance (SSO) for private-sector employees was introduced. Social health insurance is an important program to address social security problems including pension, disability, and funeral grants. Unlike other health coverage program, the funding relies on triparty payment contribution (employer, employee, and the government), the budget is managed by Social Security Office, Ministry of Labor to purchase health services from both government and private providers. The program utilizes the capitation payment model which later was also adopted by Universal Health Coverage The program currently covers approximately 10.6 million population.

In the early 2000s, despite having several health coverages institutions, Thailand's healthcare system faced inefficiency and inequity as approximately 30% of the Thai population was uninsured. To address this challenge, the last and the most important program is the Universal Health Coverage (UC) program which covers the majority of the Thai population of 48 million, and it was established in 2001. The program aims to cover the uninsured low-income population as the program slogan describes "30 Baht (approximately $1) treat all diseases". As the slogan implies, a fixed amount of 30 Baht or approximately $1 was charged as a co-payment from patients for each service from a public

hospital. The program was managed by the National Health Security Office (NHSO), an organization that was established in 2002 especially to manage the UC program.

The system also allows for seamless transfer between the three systems. For example, when the employees were unemployed, they will be automatically transferred to UC and vice versa. Summary and comparison among three health coverage in Thailand were described in Table 2.

Table 2 Characteristics of the three main health coverage in Thailand. Sources: Thai National Health Accounts, 2013, International Health Policy Program (IHPP) and Ministry of Public Health

	Civil Servant Medical Benefit (CSMBS)	Social Health Insurance (SSO)	Universal Health Coverage (UC)
Legislation	Royal decree 1980	Social Security Act of 1990	National Health Security Act 2002
Purchaser	Comptroller General's Department, Ministry of Finance	Social Security Office, Ministry of Labor	National Health Security Office
Population	4.4 million	10.6 million	48 million
Funding	Tax-based, non-contributory	Triparty contributions (employee, employers, government)	Tax-based, non-contributory
Budgeting type	Open-ended	Closed-ended	Closed-ended
Expenditure in 2016 (Thai Baht)	71.02 billion	37.7 billion	109.3 billion
Payment method	Outpatient, fee-for-service, in-patient; diagnostic-related groups (DRG) with multiple cost bands	Out-patient: Capitation In-patient: DRG within the global budget	Out-patient, health promotion and prevention: Capitation In-patient: DRG within the global budget A fee schedule for specific high-cost procedures

For HIV, there are two reimbursement components: ARV and the laboratory. Each health coverage scheme has its pathway of data submission for reimbursement. UC is mandated to submit ARV and laboratory requests to NAP for reimbursement under NHSO. For SSO, the only laboratory was submitted to NAP while the ARV was submitted to the SSO's Vendor Managed Inventory (VMI) system. CSMBS has a separate system for both submissions (19).

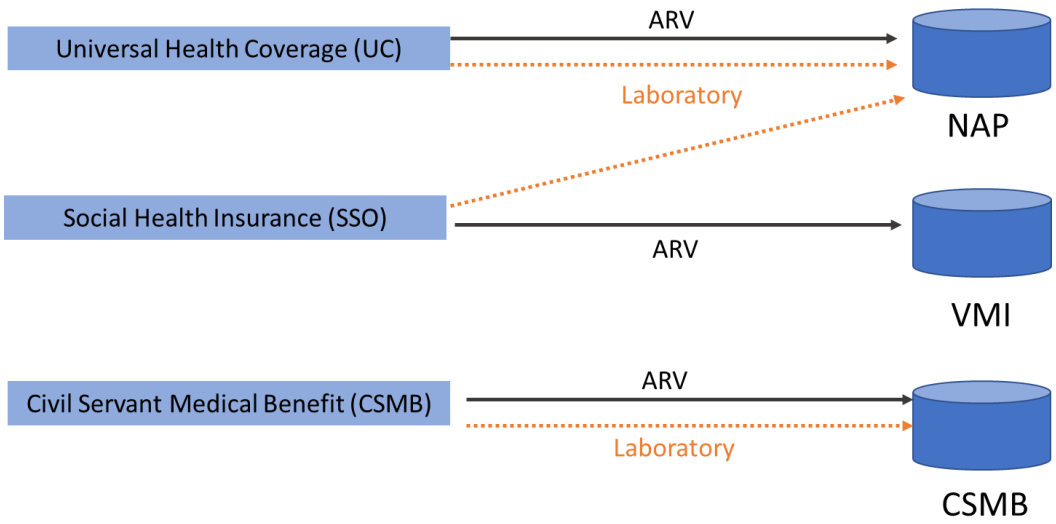


Figure 9 Reimbursement data submission pathway for each health coverage schemes. Noted that SSO and UC share laboratory reimbursement data from NAP. VMI= Vendor Managed Inventory

HIV reporting system in Thailand

There are two main reporting in Thailand related to HIV: The MOPH reporting system and the National Program on Prevention and Control of HIV/AIDS and STI (NAP) under the NHSO reporting system.

The MOPH Reporting system

In 2007, Thailand MOPH established its electronic health information standard and health data centers for nationwide data exchange for strategic planning and epidemiology studies as EHR 12 or 12 File system. The reporting system applies a relational database design to store and exchange health service data. As the Thailand system was progressing, a new table was added to the system. The current version contains 43 tables in total and it was deployed in August 2010. The system consisted of 43 database tables organized in 11 sections as shown in Figure 10, each line represents one database table.

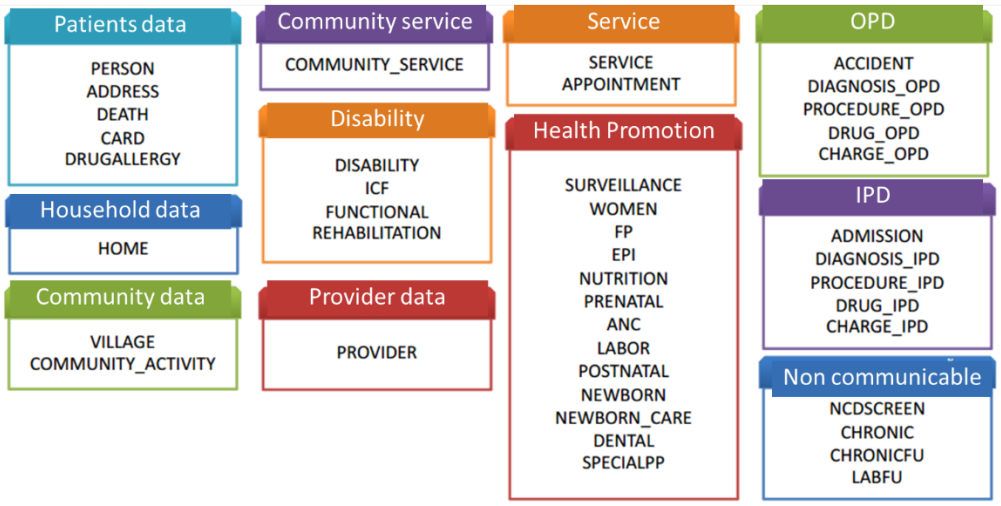


Figure 10 The overall Structure of the 43-File system. Tables are grouped into 11 sections; each line represents one table.

At the end of the month, each hospital extracts the information from its EHR database, converts, and submits to the MOPH server maintained by the Center for Information Technology and Communications (ICT), MOPH as shown in Figure 11.

The server operates on the MOPH's Cloud infrastructure. Each of the 77 provincial health offices was allocated one instance of the MOPH cloud where the entire dataset resides in the main centralized database server that is running on Linux Operating System with Apache Hadoop and Hewlett Packard (HP) Vertica.

At the end of 2016, 11,187 of 11,218 (99.7%) hospitals under the MOPH and 346 other hospitals (university teaching hospital, private hospitals, the public hospital not under MOPH) have transferred the data through the MOPH reporting system.

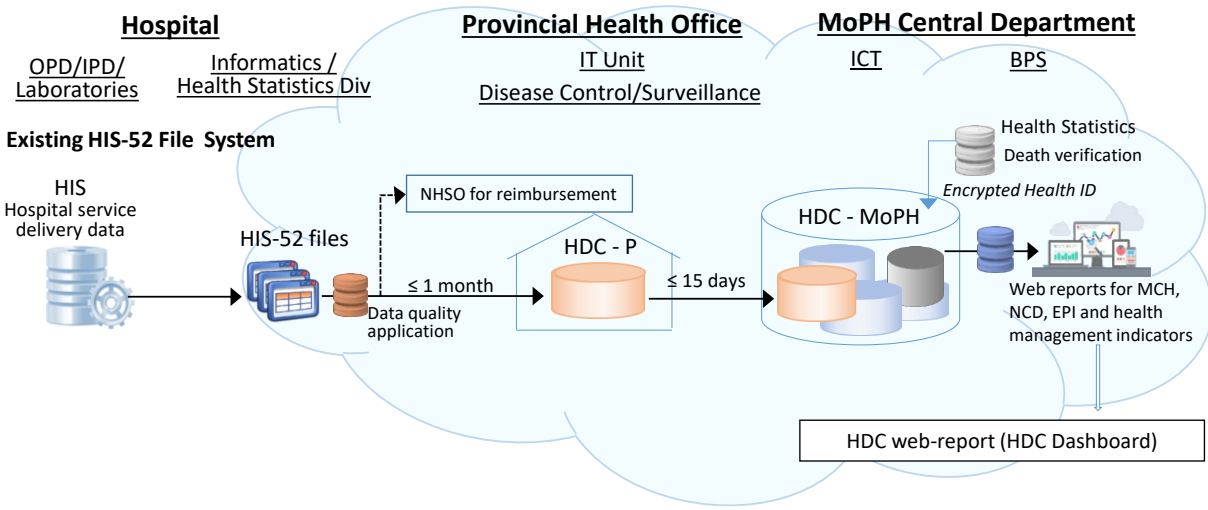


Figure 11 The current MOPH reporting system dataflow. OPD = Out-Patient Department; IPD = In-Patient Department; NHSO = National Health Security Office; HDC = Health Data Center; P = Province, ICT = Institute of Communicable and Information Technology, MOPH; BPS = Bureau of Policy and Strategic Plan, MOPH; ID = Personal Identification Code; MCH = Maternal and Child Health Department; NCD = Non-Communicable Disease Control Department; EPI = Expanded Program in Immunization. Source: https://hdcservice.moph.go.th

MOPH Dashboard system

The MOPH dashboard components describe the current Thailand health services situation and MOPH Key Performance Index (KPIs) as shown in Figure 12. It has been used for program monitoring at national, regional, and provincial levels. Several data visualization platforms including Power BI, Tableau, and KNIME are also available.

It is important to emphasize that the dashboard component application is still limited to non-communicable disease (NCD) monitoring, the expanded program for immunization (EPI), and maternal and child health (MCH). The dashboard component section for communicable disease and HIV/AIDS is still under development.

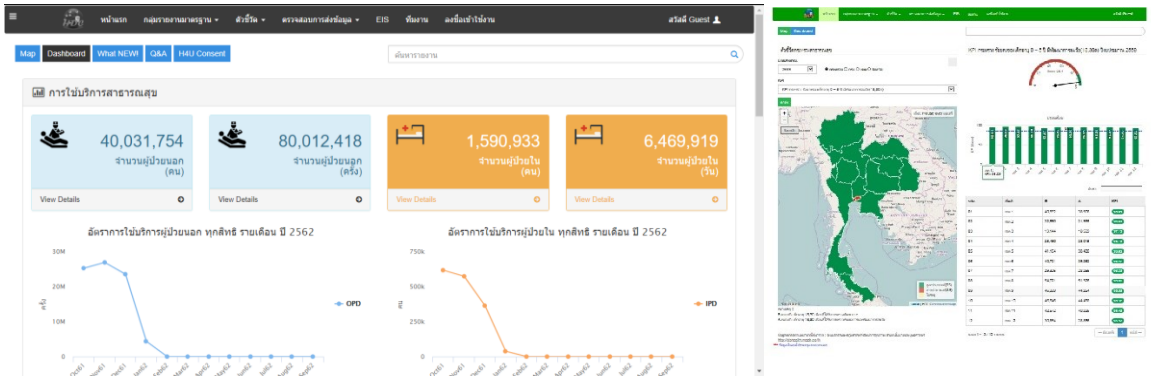


Figure 12 MOPH Dashboard system. (Left) The overall situation of Thailand Health services, the number is updated monthly. (Right) Choropleth map of Health Key Performance Index (KPIs) allows comparison between provincial at the national level at a glance. Source: https://hdcservice.moph.go.th

National Program on Prevention and Control of HIV/AIDS and STI (NAP)

When Thailand's national access to the ARV program was initiated, several data infrastructures were deployed to support program logistics, supply chain management, laboratory, including monitoring and evaluation. To monitor the program effectively, the National Access to Antiretroviral Program for People Living with HIV/AIDS (NAPHA is a Thai word means “Sky”) was developed and deployed in 2001.

Later, as Thailand's HIV/AIDS program developed and become freely available under the UC program, NAP was established to address the limitations of NAPHA. The NAP system is now under NHSO authority since 2008 for the ARV and HIV laboratory reimbursement purpose. However, database migration from NAPHA to NAP did not succeed. The personnel decided to directly re-enter all paper-based data from the NAPHA program into NAP manually which resulted in several data quality problems among the historical data before 2008 (Source; Thailand MOPH-US CDC collaboration).

Currently, NAP is being utilized by NHSO for HIV/AIDS-related care reimbursement for all UC beneficiaries. However, Civil Servant Medical Benefit (CSMBS), and Social Health Insurance (SSO) data entry are not mandated and were not be reimbursed.

Designated users at hospitals have received a username and password to enter data into NAP using the web-based data entry platform available on the website which was updated monthly. Currently, the users need to enter data into the NAP system manually, there are no automatic tools to connect the EHR database to NAP (Figure 13 and Figure 14).

Users can use the NAP dashboard to see an overall summary of the HIV/AIDS situation from NAP data and download an Excel file of de-identified individual records on the user's affiliated province. Users could not see or download data outside of their affiliated hospitals.

NAP data entry workflow

When a patient visits a hospital or was requested to be tested for HIV, the patient received a special generated NAP ID and is registered in the NAP database using a NAP Web-based application on NHSO Website (Figure 13). NAP ID is used as an identifier for all patients in the NAP system. NAP ID does not link to the patient SSN for security reasons. While the user can search through the NAP database using the NAP ID, the NAP system does not return the patient SSN (CID).

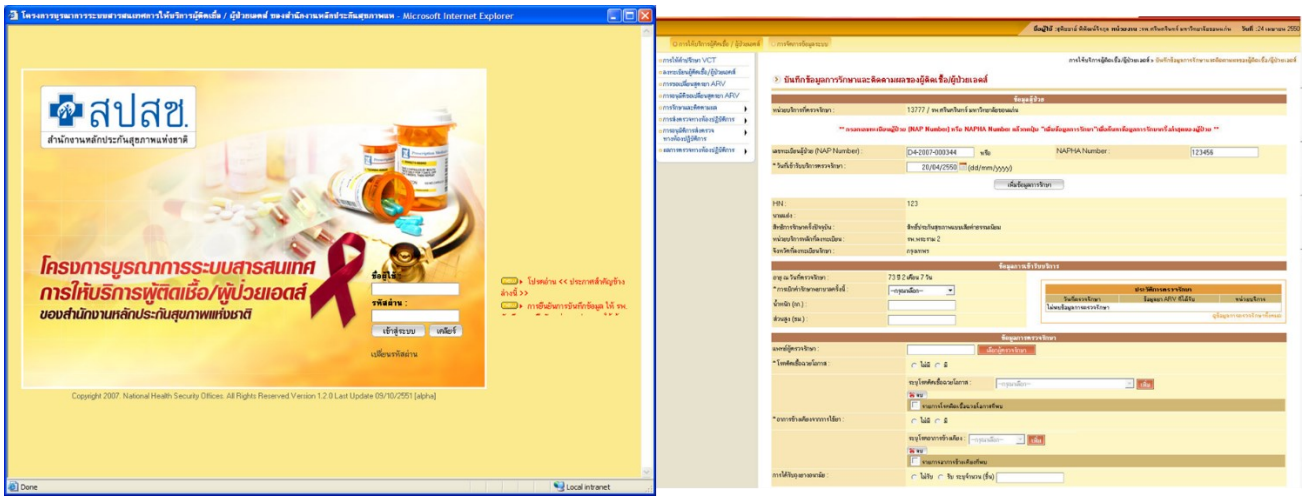


Figure 13 NAP Data entry application. The application is web-based and available on the NHSO website. Source: http://napdl.nhso.go.th/NAPWebReport/main_care.jsp

There are four main activities in the NAP web-based system. Data entry (Figure 14), data viewer (Figure 15), patient referral, and the dashboard (Figure 17). The third activity, the referral process is

the most complicated and require the HIV clinic personnel's attention. HIV clinic personnel need to select the "Refer" option (1), (2) specify the referral hospital, and (3) save to complete the referral process as shown in Figure 16. Any missing steps could result in the referral failure causing destination hospital personnel unable access or modify the NAP patient record. Patients, despite being follow-up at the destination hospital they remain in the original hospital in NAP.

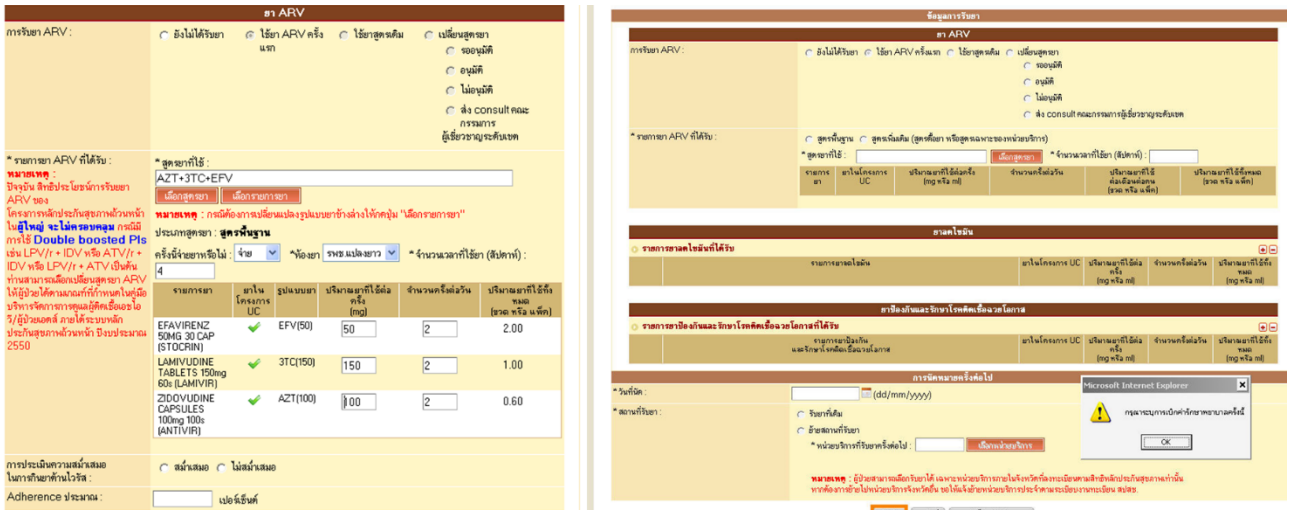


Figure 14 NAP Data entry system. Both figures show the data entry mainly for ARV and treatment-related information (including laboratory results).

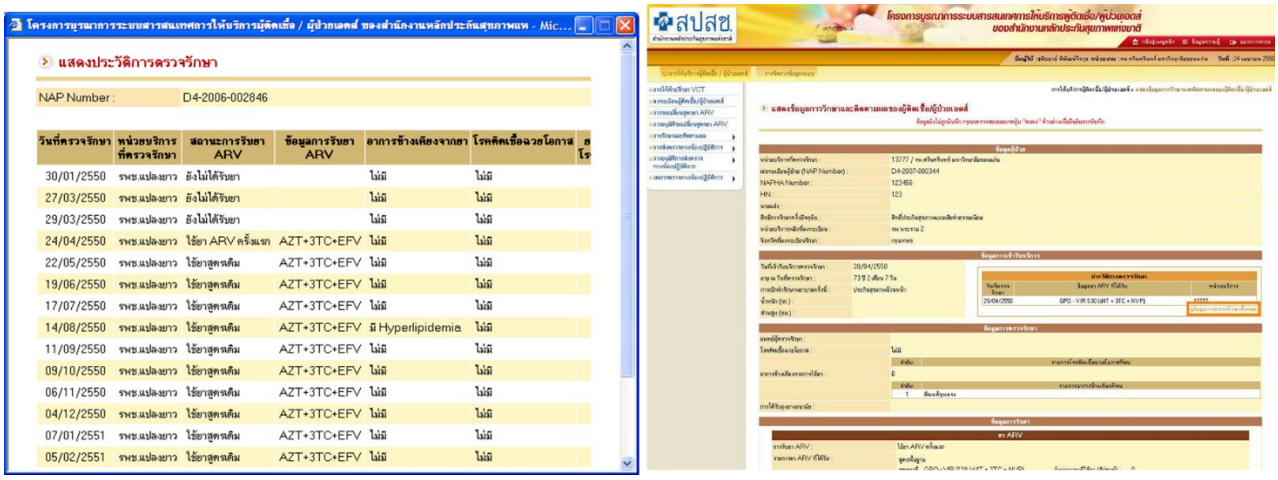


Figure 15 NAP Data viewer. The figure shows a historical visit, ARV regimen, and treatment details including complications and adverse effects. Unfortunately, the system does not show a complete medical record nor SSN for that visit.

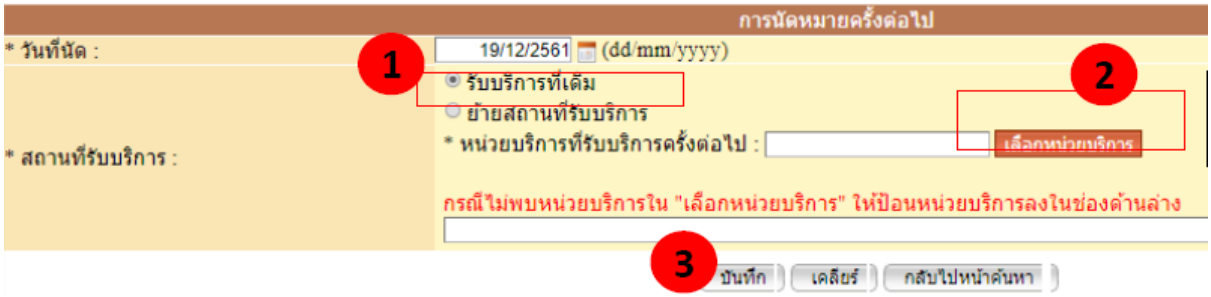


Figure 16 NAP Patient-refer-out system. HIV clinic personnel need to select "Refer" option (1), (2) Select destination for referral, and (3) Save.

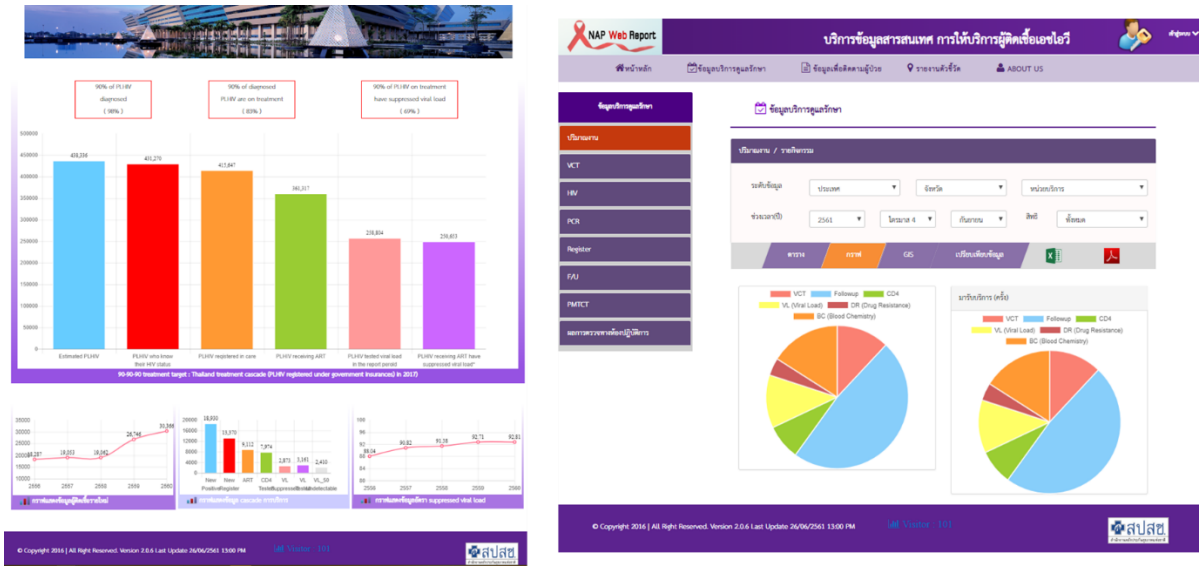


Figure 17 NAP Web-based online dashboard. The figure shows an overall statistic for the national level. Source: http://napdl.nhso.go.th/NAPWebReport/main_care.jsp

Important consideration between NAP and MOPH

While both NAP and MOPH Reporting systems store HIV/AIDS patient data, there are several different aspects of their deployment. First, NAP covers both public and non-public hospitals (e.g. teaching hospitals, private hospitals, and clinics) which are not covered by the MOPH reporting system. Second, NAP contains HIV related information that they are not included in the MOPH reporting system. Key Population identified, Voluntary Counselling and Testing (VCT), and historical data before 2008 (Figure 18).

The MOPH reporting system has a couple of advantages over the NAP. NAP suffers a couple of drawbacks, first, the MOPH system covers all health coverage scheme databases including CSMBS, SSO, private insurance, and migrant workers which NAP did not cover. Second, the MOPH allows data linkage with HIV coinfection (e.g. Tuberculosis and Hepatitis) while NAP does not.

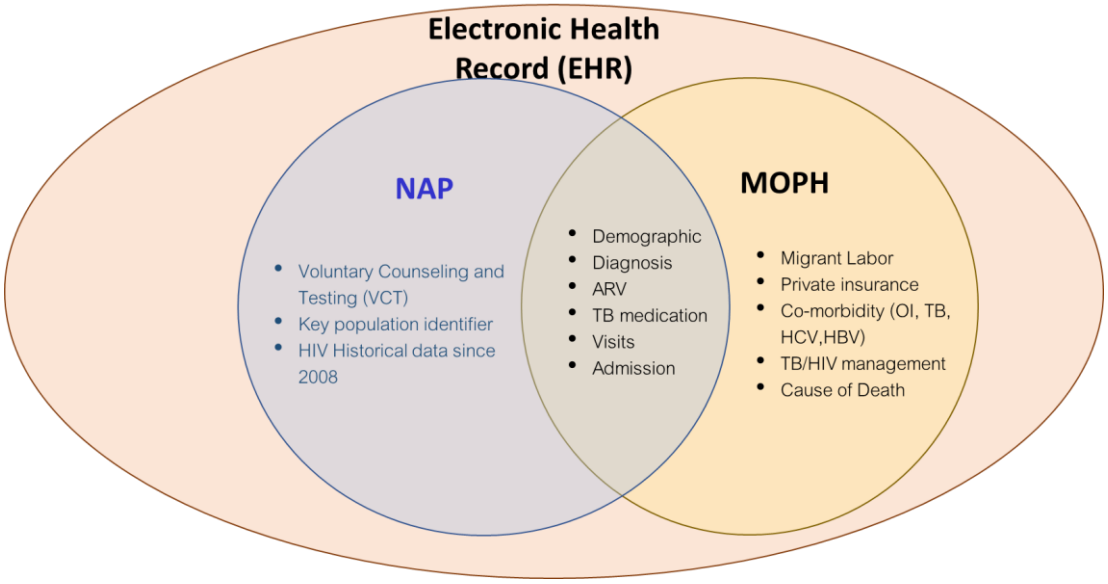


Figure 18 Current overlapping of MOPH and NAP database. While both NAP and MOPH data also reside from hospital EHR, NAP contains specific HIV/AIDS-related data (e.g. Voluntary Counselling and Testing Key Population) that do not exist in the MOPH database.

Thailand data standard

Thailand does not have a single unified standard. Each health coverage scheme defined and deploy its standard for reimbursement and data submission. There is two health coverage scheme using data standard for laboratory and medication: UC and CSMBS. UC use DRGs through ICD-10TM as the main reimbursement pathway and NAP manual data entry for HIV related reimbursement. SSO use manual data entry for both HIV medication and laboratory.

MOPH data standard

For MOPH submission, there are two main data standards besides ICD-10TM, 24-digits medication system, and 7 digits ICD-10TM laboratory coding. The laboratory database was stored in a seven characters long format.

Table 3 MOPH 7-digits HIV-related laboratory coding (20)

Laboratory test	MOPH ICD-10TM 7-digits laboratory code	Possible results	Remark
Anti-HIV	0743299	0=Negative 1= Positive 2=Inconclusive	
HIV DNA PCR	0749100	0= Negative 1= Positive	
CD4	0703001	Actual value	Exclude "<" and">"
Viral Load (VL)	0749300	Actual value	Use Log10 value Exclude "<" and ">" Input 0 for "Undetectable"

The 24 digits structures consisted of the following components.

1. Medication category (1st digit)
2. Medication identifier (2-11th digits)
3. Dosage (12-16th digits)
4. Form (17-19th digits)
5. Manufacture (20-24th digits)

An example of 24 digits among ARV (See Appendix). Normally only 2-11th digit is required to identify the medication. For example, Lamivudine's full 24 digits are '124884000004121121781336' but practically, 24884000000 (2-11th digits) were used for drug identifier.

Table 4 An example of 24-Digits system among ARV

No	Class	Drug Name	24 Digits ID (2-11th digit)	Drug abbreviation
1	NRTIs	Lamivudine	2488400000	3TC
2	NRTIs	Tenofovir	4433449300	TDF

However, the 24 digits system suffers the ambiguity problem that unable to determine the package, prescribing, and dispensing which are particularly important for CSMBS, a fee for service scheme needs to have a more rigorous treatment cost monitoring. For example, the 24 digits code

10180400005016024158162O means any of Alcohol 70% 1000 ml, Alcohol 70% 240 mL, Alcohol 70% 60ml, and Alcohol 70% (ear drop) 60 mL. Therefore, they jointly developed their data standard, Thai Medical Terminology (TMT) based on SNOMED CT.

Thai Medical Terminology (TMT)

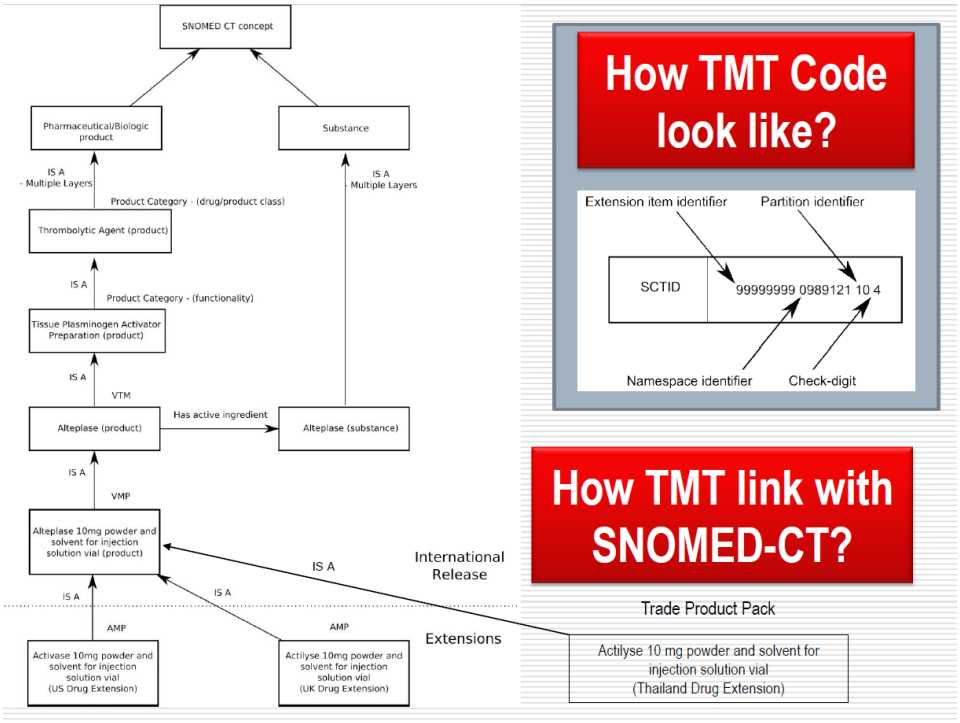


Figure 19 Thai Medical Terminology (TMT) and its linkage to SNOMED CT (Source: http://www.this.or.th/tmt.php)

The following table shows a comparison between the 7 digits system and TMT for Alcohol 70%. Noted that both were Alcohol 70% with a different package, while their 24 digits codes are similar, their TMT codes were different allowing packaging to differentiate and more specific than the 24 digits system. TMT codes are the current medication data standard for the CSMBS reimbursement submission.

Table- 5 Comparison of TMT and 23 Digits coding for Alcohol 70%

Medication	24 Digits	TMT
Alcohol 70% 60 mL	10180400005016024158162O	766081
Alcohol 70% 240 mL	10180400005016024158162O	824949

CSMBS currently deployed in-house developed a 5-digits laboratory coding for their laboratory expense reimbursement (21). To receive reimbursement, hospitals have to convert their laboratory code to CSMBS' before submission.

Table 6 An example of CSBM Laboratory code for HIV

Laboratory	CSMBS Lab code
CD4 Count	30509
HIV Viral Load	36362

In summary, as Thailand did not have a single unified standard, several standards were deployed by each health coverage scheme. There were two codings for the medication (TMT and 24 digit system) and another two (CSMBS 5 digits and ICD-10TM) for the laboratory involved in the HIV reporting system.

Thailand health data system IT infrastructure, Electronic Health Record (EHR)

Up until now, there is no official survey or research project on the extent of the implementation of the EHR in Thailand. The only information available so far is the Thai Medical Informatics Association's annual meeting report (22) and the results of one Thai student's Ph.D. Dissertation (23). In overall, the EHR market share was dominated by HOSxP, an EHR developed by Bangkok Medical Service company higher than 50%, only 15.87% still using their own developed EHR. Like EHR in the United States, the vendor does offer several modules and components to be added-on including data warehouse, preventive medicine, and epidemiology service, etc. However, the majority of the public hospital in Thailand is still using EHR only for Out-patient department (OPD) services, while In-patient department (IPD) remains a paper-based chart.

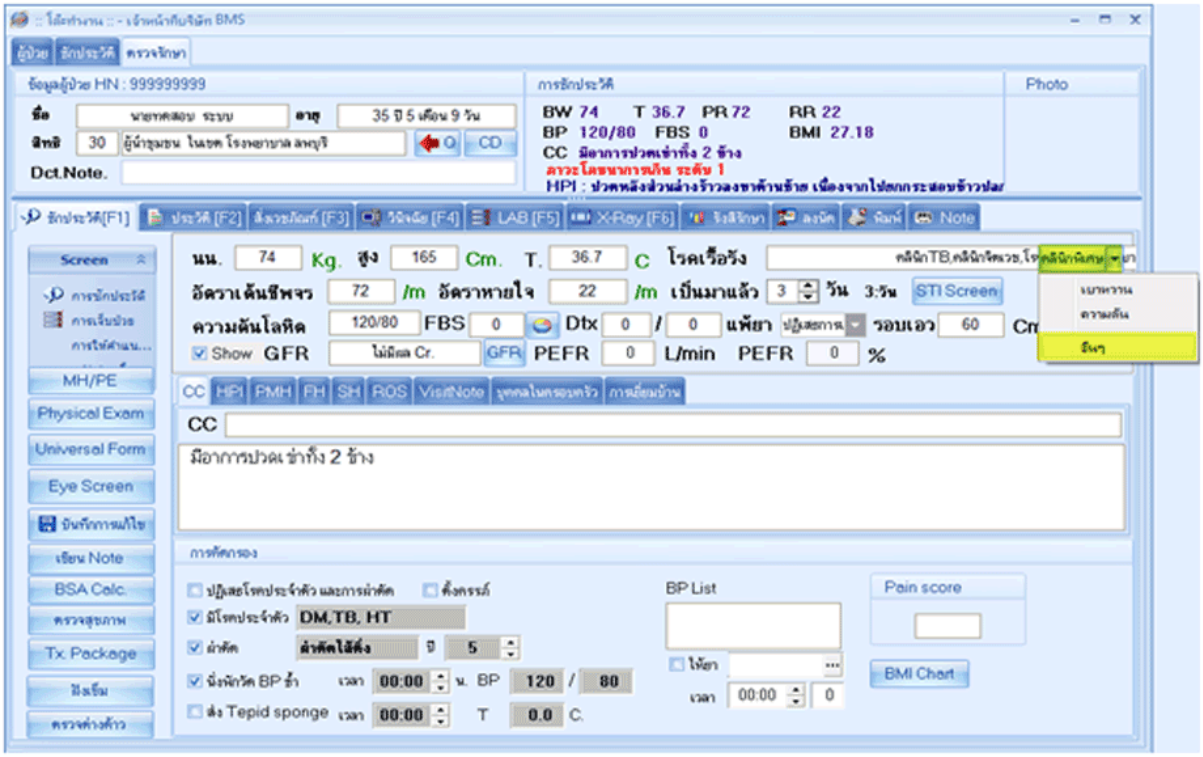


Figure 20 Thailand's most popular EHR, "HosXP'. The image shows the physician working screen for the Out-patient Department (OPD) Source: https://hosxp.net/joomla25/

HIV/AIDS Goals and Performance indicators.

UNAIDS indicators assessing the '90-90-90'

In 2015, the new Sustainable Development Goals (SDGs) was initiated and replace the 2015 Millennium Development Goals (MDGs). One important goal is SDG 3 which aims to end the AIDS epidemic as a public health threat by 2030. To be able to achieve the goal, UNAIDS has initiated a Fast-Track strategy, that aims to help low- and middle-income countries to meet SDG 3 target by 2030. The reason is, without any rapid scaling up, the HIV epidemic is going to progress faster than intervention and the epidemic ไวรส continue to progress (24).

Several experts and stakeholders were gathered to set up the new goal for the post-2015 era to ending the AIDS epidemic, and the "90-90-90" goals target was established (25).

1. By 2030, 90% of all people living with HIV know their HIV status.

2. By 2030, 90% of all people with diagnosed HIV infection receive sustained antiretroviral therapy.
3. By 2030, 90% of all people receiving antiretroviral therapy achieved have viral suppression.

While several countries have already achieved these targets and the newly infected HIV patient are dramatically decreasing during the last decade, there is still a long way to achieve a global 90-90-90 target (26). As of 2017, 75% of people living with HIV knew their status, 79% of people who know their status have access to treatment (24). And only 81% among those who have access to treatment were virally suppressed. Despite some regions, especially the Middle East and North Africa which are lagging far behind the target due to their continuously involved in a war (27). Europe also faces a challenge in reaching the target as there are wide disparities in the HIV continuum of care as Western subregions are closing to achieve the 90-90-90 target while the rest are far behind (28). The most common challenges in achieving targets are limitation of data reporting due to the absence of focal data sources, lacking funding, personnel, stigmatization, and lack of expertise (28, 29).

Methods

Study design

In aligning with the study the aims, this study uses a mix-method design and it was organized into three parts; The first part (aim 1 and aim 2.1) seeks to recognize the quality gaps at the national level in the reported data by describing the overall difference between MOPH and NAP databases and by identifying the study sites for a field visit in the second part. The Second part (aims 2.2 and 2.3) aims to identify the workflow gaps in the study sites that cause the data quality gaps in the manner of providing useful information to stakeholders to improve service in the study sites. The third part was designed to provide the analytical results and inferences about the findings back to the authorities of the national level and to provide the study recommendation.

The statistical analysis, data management, and qualitative data coding and analysis were conducted using the software R 3.5.3, R Studio 1.2.5, R Qualitative Data Analysis (RDQA) 0.2-8, Python 3.7, and Anaconda 1.9.7.

Population and sampling strategy

There were three data sources involved in this study: the MOPH database, the NAP, and the EHR obtained during the field visits.

For the MOPH and hospital EHR, all available records were queried based on ICD-10 of B20, B21, B22, B23, B24, B200-B213, B217-B222, B227, B230-B233, B238, B240, Z21, Z210, and O987, Laboratory (Anti-HIV, CD4, and HIV Viral Load) and ARV prescription codes (See ARV Prescription code in Appendix) regardless of the period. The following variables were extracted from MOPH and EHR; demographic data, hospital visit date, appointment date, ARV prescription, health coverage scheme, first and last HIV-related laboratory (Anti-HIV, CD4, VL) results, and the date. Summary statistics were obtained from NAP and MOPH at the national level. No access to individual records was allowed at the national level nor the study sites because of privacy and confidentiality reason.

The study included 25 hospitals across 4 provinces given available resources and approved project timeline. The project personnel consisted of two teams of 2-5 members each. The provinces were identified according to the results from aim 2.1. The provinces that receive PEPFAR funding were preferred as there already established HIV activity cooperation and stakeholder connections to streamline the processes in the area (30).

Data quality assessment framework

Weiskopf's data quality framework

This research utilized Weiskopf's data quality framework for assessment (Figure 21). Due to limitations in accessing individual record data, we focused on measuring three dimensions of the framework: concordance, plausibility, and currency in this dissertation.

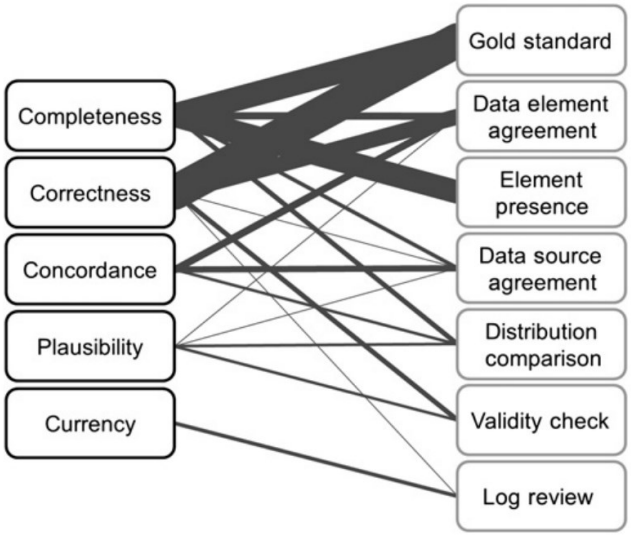


Figure 21 Weiskopf's data quality framework

Concordance and plausibility

According to Weiskopf's, concordance was defined in the study as an agreement between data elements within or among multiple data sources (31). Plausibility was defined as the data agreement with general medical knowledge and information.

Ideally, the patient's records should be the same regardless of data sources. Therefore, in this study, we assessed concordance and plausibility by comparing summary statistics (patient demographic, total record number, and follow-up status) between two data sources.

Using two data sources the difference of patient count was challenged in comparing between provinces as large provinces have far more patients count than small provinces. Therefore, using percentage was more reasonable in comparing across provinces. However, as several provinces may report having NAP patients count more than EHR, the percentage becomes negative causing the interpretation to be difficult. As our main interest was the magnitude of difference rather than the direction, we use the absolute percentage of two data sources difference in this study to allow better interpretation. The percentage of two data source differences were calculated using the formula below.

$$\% \text{ Two data sources difference} = |(\text{EHR} - \text{NAP}) / \text{NAP}| \times 100$$

The plausibility dimension was asses using the DQI Tools application results. The DQI Tools integrate both data sources and identify patients' records that were unreasonable given the current HIV knowledge. For example, assume that all HIV patients were diagnosed based on having positive Anti-HIV laboratory results. It was impossible to have no HIV results in the hospital database. Also, having negative Anti-HIV results could not be diagnosed with HIV.

Currency

Due to the sensitivity of HIV patient data, the only available timeliness data is the last follow-up date. Thus, in this study, we use the distribution of loss-follow-up patients counts by loss follow-up length to represent the currency dimension.

The reason is, as the number of loss follow-up patients largely contribute to the drop in Thailand's second 90-90-90 indicator, the study needed to explore whether the loss-follow-up number was valid and represented the current Thailand situation.

The 90-90-90 indicators were calculated based on alive HIV patients. Loss-follow-up patients, assuming not receiving any treatment for several years have an exceptionally low survival rate (32) and should be excluded from 90-90-90 indicators calculation. Not excluding dead patients results in overestimate the loss-follow-up patient number and underestimate the second 90-90-90 indicator.

Another possible cause of loss-follow-up patients reported is the patient is silently transferred to another hospital without updating the databases. In this case, the patient was counted as loss-follow-up despite regular follow-up at the hospital underestimating the second 90-90-90 indicators.

We determined the loss-follow-up length by calculating the duration since the last visit date was calculated from the difference between the last follow-up date and September 30, 2019. Patients with a duration longer than 180 days were classified as loss-follow-up.

Loss follow-up length (date) = Last hospital visit date to September 30, 2019

Aim 1 Determine the difference in the reporting quality between two main reporting systems in Thailand, the National AIDS Program (NAP) and the Ministry of Public Health (MOPH)

The summary statistics necessary for calculating the 90-90-90 indicators and patient demographic data in 2018 were obtained from both data sources. There are six data elements for the 90-90-90 indicators as described below.

- Number of confirmed HIV patient (Patient Living with HIV or PLHIV)
- Number of confirmed HIV patient receiving Anti-retroviral therapy (ARV)
- Number of confirmed HIV patients receiving ARV that achieved viral suppression (VL < 1,000 copies)
- Percentage of confirmed HIV patients to Model estimation (1st UNAIDS 90-90-90 indicator)
- Percentage of confirmed HIV patients receiving ARV (2nd UNAIDS 90-90-90 indicator)
- Percentage of confirmed HIV patients receiving ARV that achieve viral suppression (3rd UNAIDS 90-90-90 indicators)

The study assessed the difference in the national level summary statistics of the patient's characteristics, the distribution between two data sources as a proxy of reporting quality gaps or "concordance" according to Weiskopf's data quality framework (Figure 21) and assessed on how the difference between two data sources change the view of HIV situation in Thailand.

Aim 2-1 Identify facility and provincial level factors associated with reporting quality

The purpose of this aim was to explore and identify the facility-level and provincial-level factors that associate with the difference in two data sources, as a proxy for reporting quality gaps. The absolute percentage difference in HIV patients count between the two databases (NAP and MOPH database) was calculated as the dependent variable in the linear regression model.

Several facility factors that could impact reporting quality were identified. The higher care level and the bed capacity tend to have a more complex workflow. Having high workflow complexity is more prone to errors in the reporting process. However, there are several hospitals with similar care levels and bed capacity but a different affiliation (e.g. MOPH affiliated and the non-MOPH affiliated hospital). Each affiliation has a different process, workflow, and regulation. For example, the submission of patient medical records to the MOPH server from the non-MOPH affiliated hospital is not mandated but rather voluntary based. On the contrary, the submission of patient medical records was mandated for MOPH hospitals.

Another potential factor is funding as funders often require hospital personnel to deploy a specific intervention under the technical support from the funders. Thus, hospitals receiving external funding were more likely to have more resources, better reporting quality, and strong collaboration internally and externally. In Thailand, there were several external funding related to HIV, and PEPFAR is one of the most important sources.

PEPFAR funding requires several data quality measures to be submitted according to PEPFAR Monitoring, Evaluation, and Reporting (MER) 2.0 indicator (33). Provinces receiving PEPFAR funding were expected to have more intensive HIV activities and better data reporting system as PEPFAR provided support to the provinces to give better access to HIV testing and treatment especially among key populations (e.g. Men who have Sex with Men or MSM and Transgender or TG) in terms of training, funding and technical support (34).

Therefore, we identified the following facility level as independent variables; hospital class (community, general, regional, teaching), Ministry of Public Health affiliated (yes/no), receiving PEPFAR funding (yes/no). The error in data management practices causes data reporting quality problems in terms of currency, plausibility, and concordance as described in Figure 22. Univariate and multivariate linear regression was conducted to identify statistical associations with our dependent variable.

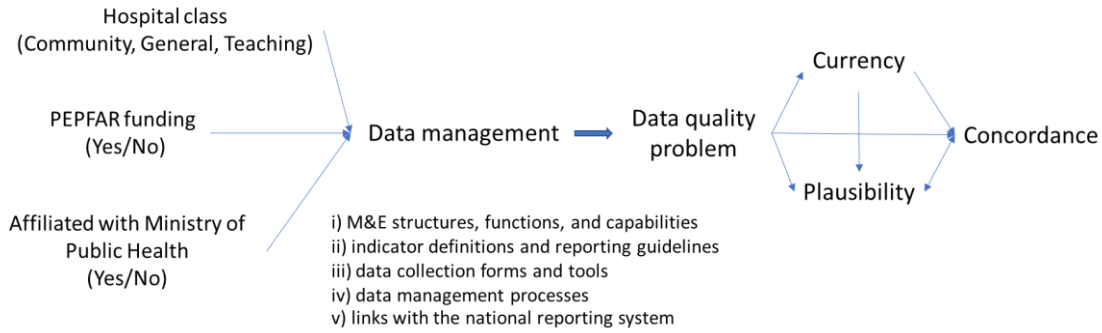


Figure 22 Conceptual framework

The study utilized the results of the linear regression model to identify the study sites for the field visits in aim 2-2 and 2-3. Twenty-five hospitals were selected with a purposive sampling strategy based on multiple regression outcomes along with the following considerations: logistically feasible, local personnel's capacity, cooperation, urban/rural area, and high HIV patient coverage.

A short-list of hospitals was submitted to each designated Provincial Health Office (PHO) for final approval and coordination for the field visit. Anonymous hospital name was used in the final report.

Aim 2-2 Identify the loss in Thailand HIV reporting system quality

UNAIDS MEASURE Data Quality Audit (DQA) tool

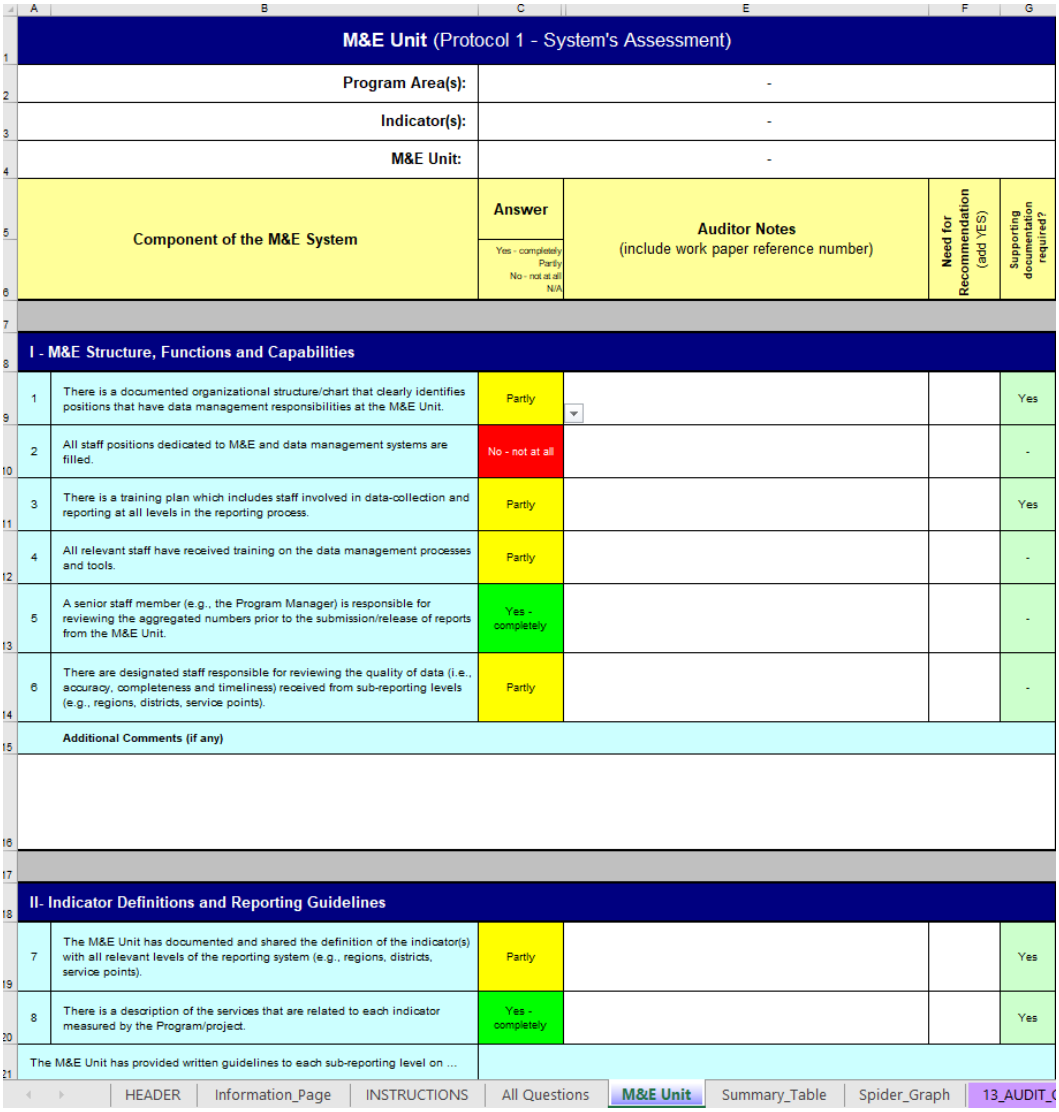
In Aim 2-2, the study aimed to assess the factors of the data management practice at the hospital level that can impact on the HIV reporting quality using the UNAIDS MEASURE Data Quality Audit (DQA) tool. The UNAIDS MEASURE DQA is a standardized tool that was deployed for HIV data quality assessment in several countries including Kenya (2). The tool contains five components: 1) M&E structures, functions, and capabilities 2) definition of the indicators and reporting guidelines 3)

data collection forms and tools 4) data management processes, and 5) links with the national reporting system. (See Appendix)

Several studies had explored HIV services quality and the success of deploying an electronic reporting system, however only a few explored the reporting quality: data auditing of hospitals in South-Africa (35) and data quality assessment (DQA) using MEASURE Tools in Malawi (36).

Initially, our study was designed based on WHO data quality assessment implementation tools using MEASURE DQA Tools. However, the Thailand HIV reporting system was unique compared to other countries implementing the tools. While WHO guidance recommends to recount HIV medical record and compare to the national HIV database, the method was not feasible in Thailand unique healthcare system as there were several reporting systems across three health coverage schemes overlapping on each other. The MOPH had no authority on all health coverage schemes reporting systems. Therefore, we cast our doubt on whether deploying the WHO guidance was feasible and sustainable for scaling up at the national level in Thailand. Unfortunately, recounting methods were not allowed in our study. Therefore, only the MEASURE DQA Tools were deployed as a standardized tool to assess data management practice.

Information was obtained by conducting field interviews during the field visits without voice recording, filling the responses in the DQA Tool Excel File (Figure 23). The Excel file template calculated the scores on each section and visualization using a spider chart as described in Figure 24. The score presented the current data management practice in hospitals and identified the components that needed to improve.



M&E Unit (Protocol 1 - System's Assessment)

Program Area(s):	-
Indicator(s):	-
M&E Unit:	-

	Component of the M&E System	Answer (Yes - completely / Partly / No - not at all / N/A)	Auditor Notes (include work paper reference number)	Need for Recommendation (add YES)	Supporting documentation required?
I - M&E Structure, Functions and Capabilities					
1	There is a documented organizational structure/chart that clearly identifies positions that have data management responsibilities at the M&E Unit.	Partly			Yes
2	All staff positions dedicated to M&E and data management systems are filled.	No - not at all			-
3	There is a training plan which includes staff involved in data-collection and reporting at all levels in the reporting process.	Partly			Yes
4	All relevant staff have received training on the data management processes and tools.	Partly			-
5	A senior staff member (e.g., the Program Manager) is responsible for reviewing the aggregated numbers prior to the submission/release of reports from the M&E Unit.	Yes - completely			-
6	There are designated staff responsible for reviewing the quality of data (i.e., accuracy, completeness and timeliness) received from sub-reporting levels (e.g., regions, districts, service points).	Partly			-
	Additional Comments (if any)				
II- Indicator Definitions and Reporting Guidelines					
7	The M&E Unit has documented and shared the definition of the indicator(s) with all relevant levels of the reporting system (e.g., regions, districts, service points).	Partly			Yes
8	There is a description of the services that are related to each indicator measured by the Program/project.	Yes - completely			Yes
	The M&E Unit has provided written guidelines to each sub-reporting level on ...				

HEADER | Information_Page | INSTRUCTIONS | All Questions | M&E Unit | Summary_Table | Spider_Graph | 13_AUDIT_(

Figure 23 UNAIDS MEASURE DQA Tools Excel Template for interviewing

SUMMARY TABLE Assessment of Data Management and Reporting Systems	I M&E Structure, Functions and Capabilities	II Indicator Definitions and Reporting Guidelines	III Data-collection and Reporting Forms / Tools	IV Data Management Processes	V Links with National Reporting System	Average (per site)
M&E Unit						
- -	2.00	2.43	2.17	2.54	2.50	2.33
Average (per functional area)	2.00	2.43	2.17	2.54	2.50	2.33

Color Code Key		
green	2.5 - 3.0	Yes, completely
yellow	1.5 - 2.5	Partly
red	< 1.5	No - not at all

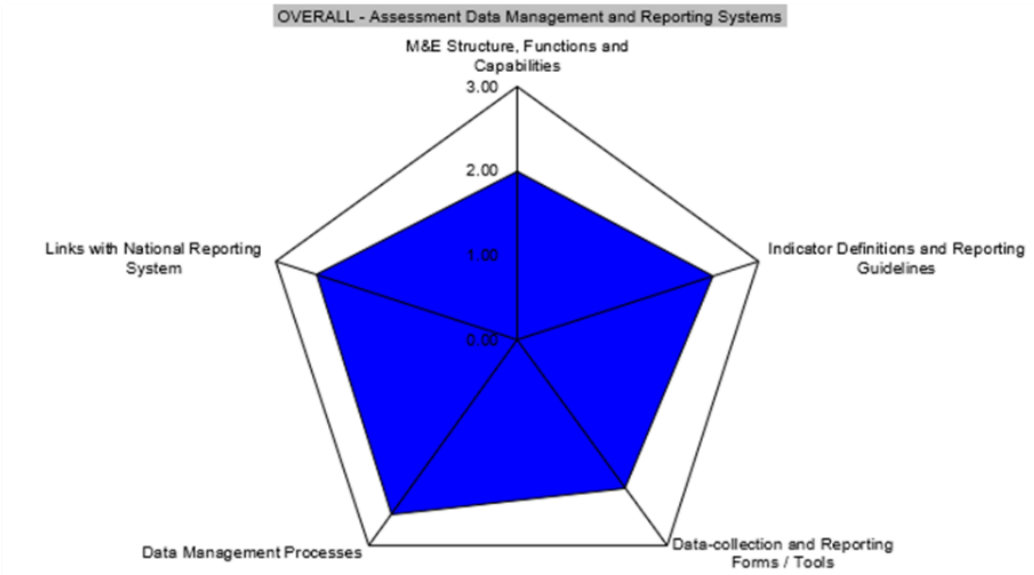


Figure 24 UNAIDS MEASURE DQA Tools score and visualization

Data Quality Improvement tools (DQI Tools)

In addition to the MEASURE DQA Tool, reviewing and analyzing the HIV medical records at the hospital during field visits as required to gain insight into the hospital workflow and to provide recommendations to the hospitals. However, as access to the HIV individual records was limited, we decide to indirectly obtain the summary statistic from the hospital during the field visit by providing the application to the local personnel to install and obtain summary statistics from the application instead. With this approach, no HIV patient records were brought outside hospitals while allowing local personnel to directly control our access to their EHR database.

Therefore, the Data quality improvement tools (DQI Tools) were developed by Thai-USCDC Collaboration (TUC). The function of the DQI Tools is to provide the necessary summary statistics

for assessing the reporting quality gaps and to generate additional reports requested by local personnel necessary to improve their HIV service.

The DQI Tools is a desktop application that was developed by TUC using Delphi as a programming language and Microsoft Access ® as a database. The application is still a prototype for field testing.

The application starts by importing the NHSO NAP database of individual HIV/AIDS records then matching with the MOPH reporting system using SSN (CID) as a primary key. The matching process was kept hiding as the NAP system currently does not allow direct matching between two databases using SSN for security and patient privacy reasons. Before the DQI Tool was developed, tracking and matching patient using SSN between two databases was difficult and prohibited by NAP. This caused the HIV/AIDS database utilization very challenges difficult for local personnel in the past. DQI Tools allow this process possible at the local hospitals by hiding sensitive processes from the local personnel while allowing the request of patient identity matching (Figure 25).

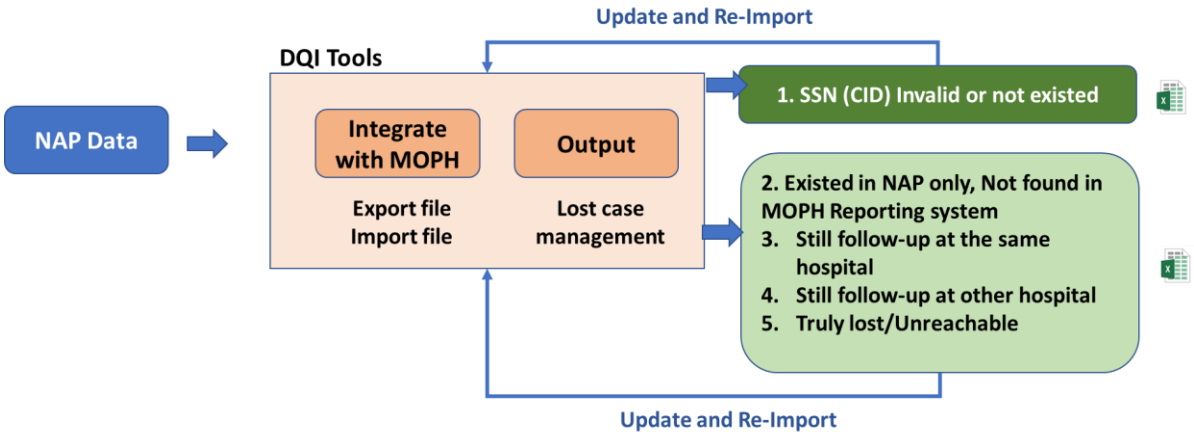


Figure 25 Summary workflow of DQI Tools. The DQI Tools obtain data from NAP and MOPH database, excluding deaths, then extract the current loss-follow-up patient list then generate four excel files; 1. Invalid SSN/CID, 2. Need to Verify Diagnosis 3. Following at the same hospital, 4. Following at other hospitals and 5. truly loss or unreachable. The meetings were held along with the files to decide the action and recommendation to improve the process.

The DQI Tools provide a report describing the characteristics of Loss-follow-up patients including whether they were dead, silently transferred to other hospitals, and their last ARV status (Figure 26).

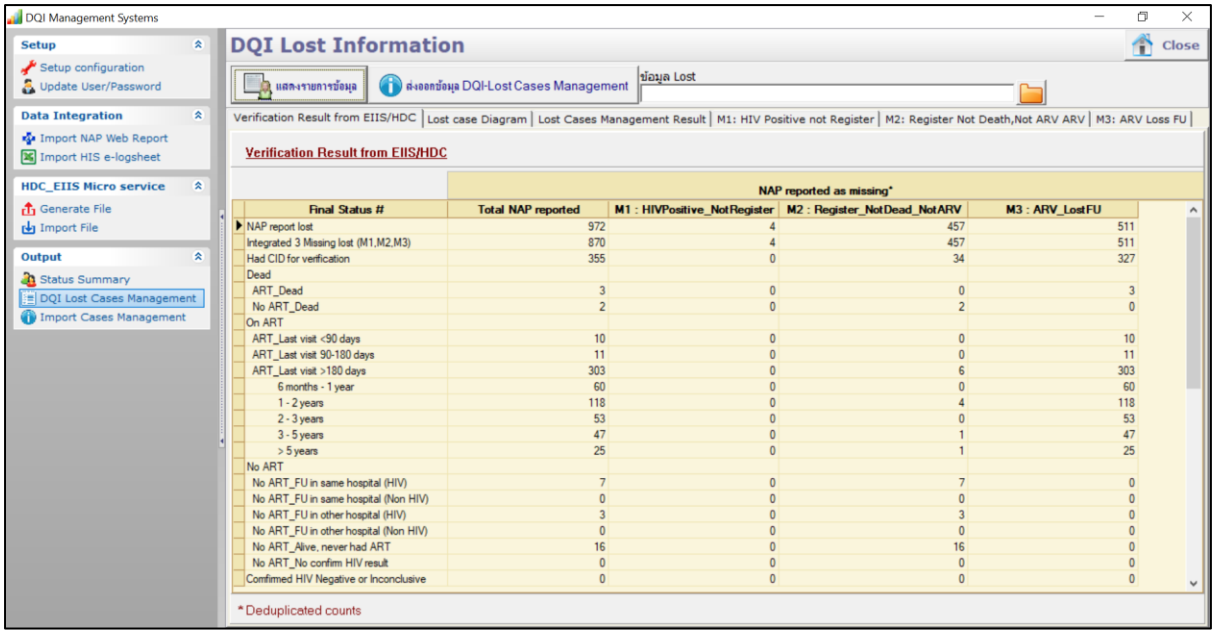


Figure 26 DQI Tools summary statistics report

The tools also generate the four Excel Files for each type of case that was forward to local personnel to verify, contact, and recruit patients back to the care system (Figure 25). Five excel tables and its subcategory was described below.

1. SSN (CID) Invalid or not existed
2. Existed in NAP only, Not found in MOPH Reporting system
    a. Diagnosed HIV/AIDS and lost follow-up > 180 days
    b. Not diagnosed with HIV but still follow-up
    c. Not diagnosed with HIV and loss follow-up > 180 days
3. Still follow-up at the same hospital
    a. Diagnosed HIV and still follow-up with ARV
    b. Diagnosed HIV and still follow-up without ARV
    c. Not diagnosed with HIV but still follow-up
4. Still follow-up at other hospitals
    a. Diagnosed HIV and still follow-up with ARV
    b. Diagnosed HIV and still follow-up without ARV
5. Truly lost/Unreachable patients

Each table has a set of similar variables set consisted of NAP ID, SSN (CID), healthcare coverage scheme, laboratory data, and result, ARV date, and regiment, last visit data, and lost 1-3 (Figure 72).

Lost 1-3 variables were generated from the NAP based on the following criteria.

1. Lost1: HIV positive but was not registered to NAP
2. Lost2: Registered to NAP but did not initiate ARV
3. Lost3: Lost follow-up after starting an ARV

Local personnel verifies and contact each patient in each Excel file. Unreachable patients were remarked in an excel file and reimported to DQI Tools. Those unreachable patients were excluded from the indicator calculation. This information is useful for local personnel to exclude unreachable patients to focus their efforts on those still reachable.

Aim 2-3 Identify the possible drop-off causes in the workflow

A field interview was conducted during the fieldwork on 1-3 personnel of each key informant of the following professional: physician, nurses, IT personnel, administrative personnel, medical coders, HIV division directors among 12 of 25 study sites. For privacy reasons, an anonymous name was used in the final report. The interview questions were based on our conceptual framework and the MEASURE Data Quality Audit tool, the dataflow mapping results, and other findings during the fieldwork that is relevant to research aims. Field notes were developed during the interview and serve as the main data sources for the qualitative analysis and results as audio recording and full official interview with consent form were not allowed under the IRB exemption category of this study. Thematic analysis was conducted in this section. The coding was done on field notes with R 3.5.3 and the Qualitative Data Analysis Package (RDQA) 0.2-8 without prior coding categories.

Aim 3 Assess the impact of having better NAP data quality on the 90-90-90 indicators compared to the existing NAP data quality situation.

In this aim, we utilized findings in aim 2-1 to 2-3 of the study and extrapolate the change in NAP data and Thailand 90-90-90 indicators assuming that all the data quality gaps in this study were addressed.

Field Activities

The fieldwork duration was 1-2 days per visit for each of the selected 25 study sites to minimize strain on local personnel. While the DQI Tools application from aim 2-2 was conducted on all 25 study sites, the DQA MEASURE tools activity of aim 2-2 and field interview activities in aim 2-3 were conducted on 12 of the 25 study sites. based on their progress, cooperation, and logistics and with guidance and permission from the provincial health office.

Ethical and IRB approval

The study was categorized as a government project for service improvement under the IRB exemption category and receive approval from the US-CDC Center for Global Health (CGH) and Division of AIDS, TB and, STIs, and Division of Epidemiology, Department of Disease Control, MOPH. The US-CDC approval was under the CDC Division of Global HIV and TB Data Quality Assessments in PEPFAR Supported Countries project. (See Approval Letters in Appendix)

Results

Descriptive Statistics from NAP database

In 2018, Thailand reported 450,548 alive HIV patients to NAP. Among them, the majority were male (55.76%) in the 25-49-year-old age group (68.71%). Table 7 and Figure 27 described the demographic distribution of NAP patients in Thailand, 2018.

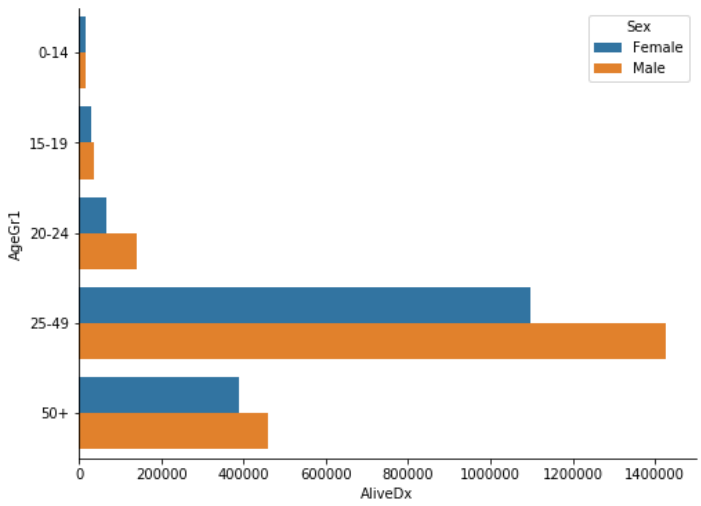


Figure 27 Demographics of HIV patients reported by NAP in 2018, Thailand

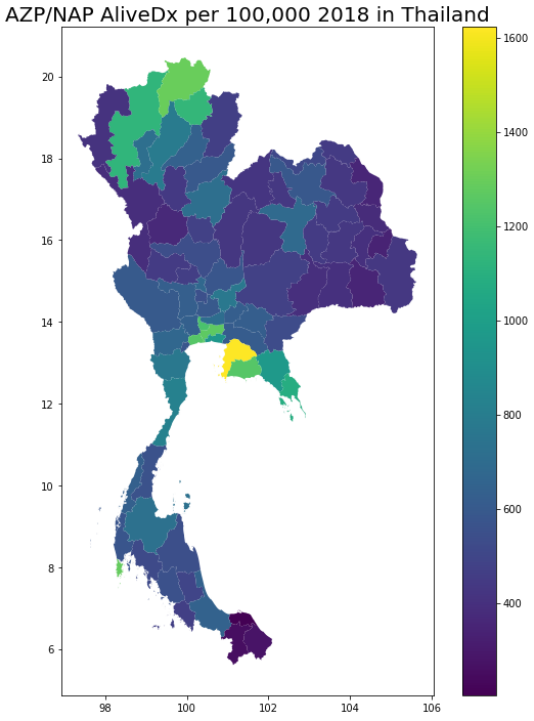


Figure 28 NAP reported HIV patient per 100,000 population, 2018, Thailand

Overall, the prevalence of HIV per 100,000 was concentrated in the northern and central areas of Thailand as described in Figure 28. Thailand's national HIV prevalence was 631 per 100,000 population with the highest provincial prevalence of 1,622 per 100,000 and the lowest of 203 per

100,000 population. Provinces with the lowest prevalence are in the southmost region of Thailand while the highest are in the northern and central regions.

When stratifying by health coverage scheme, Universal health coverage (UC) had the highest prevalence with 65.25%, followed by Social security (SSO) and Civil Servant Medical Benefit (CSMBS) with 29.79% and 4.09% respectively. The rests were from migrant workers and others (e.g. fee for service). Except for other and migrants, male contributed to the majority of HIV patients across the three main health schemes (Table 8). The most common age group is 25-49 (68.71%), >50 (23.42%), and 20-24-year-old (5.32%) respectively. The age group distribution is similar across most health coverage schemes except for migrants from having the lowest number of reported cases. Table 8 describes the sex distribution of HIV patients in the NAP database across health coverage schemes.

Table 7 NAP Health coverage scheme by age group composition, 2018, Thailand (n=450,548)

Age group	UC (%)	CSMBS (%)	SSO (%)	Migrant (%)	Other (%)	Total (%)
0-14	3,762 (1.28)	53 (0.29)	1 (0.00)	-	37 (0.95)	3,853 (0.86)
15-19	7,134 (2.43)	138 (0.76)	332 (0.25)	-	72 (1.85)	7,676 (1.70)
20-24	18,124 (6.16)	167 (0.9)	5,509 (4.11)	-	157 (4.03)	23,957 (5.32)
25-49	191,227 (65.03)	8,948 (48.59)	106,510 (79.37)	15 (95)	2,865(73.56)	309,565 (68.71)
50+	73,774 (25.09)	9,108 (49.46)	21,850 (16.28)	1 (6.25)	764 (19.61)	105,497 (23.42)
Total	294,021 (65.26)	18,414 (4.09)	134,202 (29.79)	16 (0.00)	3,895 (0.86)	450,548

Table 8 Sex distribution among NAP patients by health coverage scheme, 2018, Thailand

Health coverage scheme	Male (%)	Female (%)
UC	156,833 (53.34)	137,188 (45.66)
SSO	81,335 (60.61)	52,867 (39.39)
CSMBS	11,435 (62.10)	6,979 (37.90)
Migrants	5 (31.25)	11 (68.75)
Other	1,616 (41.49)	2,279 (58.51)
Total	251,224 (55.76)	199,25324 (44.24)

Descriptive Statistics from the Ministry of Public Health (MOPH) database

In the MOPH database, 445,551 HIV patients have been reported in 2018. The majority are male in the 25-49-year-old age group. Male patients contributed to the majority of patients of all age groups. Table 9 described the demographic distribution of HIV patients in the MOPH database. When stratified by health coverage scheme, UC contributed the highest proportion of 65.69% followed by SSO (18.09%) and others (10.31%) respectively. Male patients remained as a major contribution to the total patient across all health coverage schemes except for migrants (Table 10). Unfortunately, cross-tabulation between the age group and health coverage scheme was not possible with the MOPH database report system as of July 2019.

Table 9 MOPH reported HIV patients to stratified by age and sex, 2018, Thailand

Age group	Male (%)	Female (%)	Total (%)
0-14	4,483 (50.30)	4,430 (49.70)	8,913 (2.00)
15-19	3,947 (49.33)	4,054 (50.67)	8,001 (1.80)
20-24	13,403 (59.52)	9,116 (40.48)	22,519 (5.05)
25-49	156,358 (54.31)	131,545 (45.69)	287,903 (64.62)
50+	64,663 (54.70)	53,552 (45.30)	120,884 (27.13)
Total	242,854 (54.51)	202,697 (45.49)	445,551

Table 10 MOPH reported HIV patients to stratified by health coverage scheme and sex, 2018, Thailand

Health coverage scheme	Male (%)	Female (%)	Total (%)
UC	157,195 (53.71)	135,473 (46.29)	292,668 (65.69)
SSO	45,683 (56.67)	34,932 (43.33)	8,0615 (18.09)
CSMBS	10,988 (58.20)	7,891 (41.80)	1,8870 (4.24)
Migrants	3,190 (42.80)	4,264 (57.20)	7,454 (1.67)
Other	25,799 (54.87)	20,140 (42.83)	45,939 (10.31)
Total	242,855 (54.51)	202,700 (45.49)	445,555

According to the MOPH database, the prevalence of HIV (People Living with HIV or PLHIV) was concentrated in the northern, central, and upper southern areas of Thailand. Thailand's national HIV prevalence (PLHIV) was 681 per 100,000 population with the highest provincial prevalence of 1,835 per 100,000 and the lowest of 164 per 100,000 population. Provinces with the lowest prevalence were in the southmost region of Thailand while the highest were in the central region as shown in Figure 29.

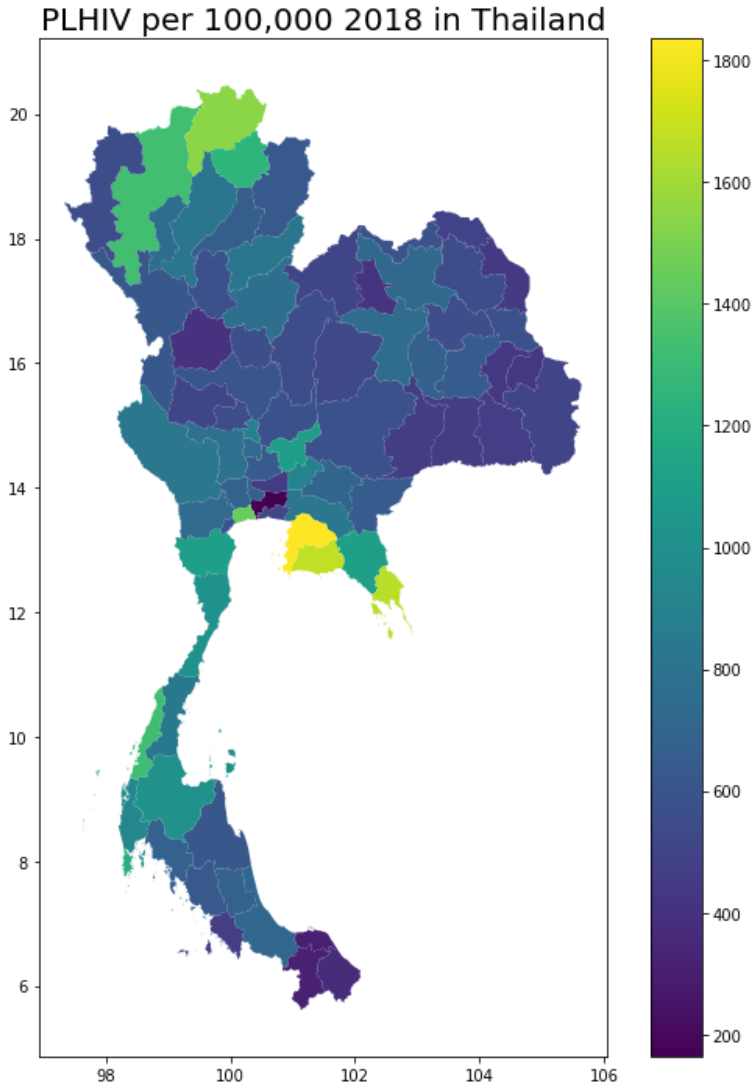


Figure 29 MOPH HIV prevalence per 100,000 population 2018, Thailand

Asian Epidemic Model (AEM) Estimation 2018

The AEM has estimated the total alive HIV patients in Thailand as 427,526 patients or 661 per 100,000 population in 2018. The model estimation showed that the trend was decreasing since 2010 from 514,837 in 2010 to 314,053 in 2030 (Figure 30).

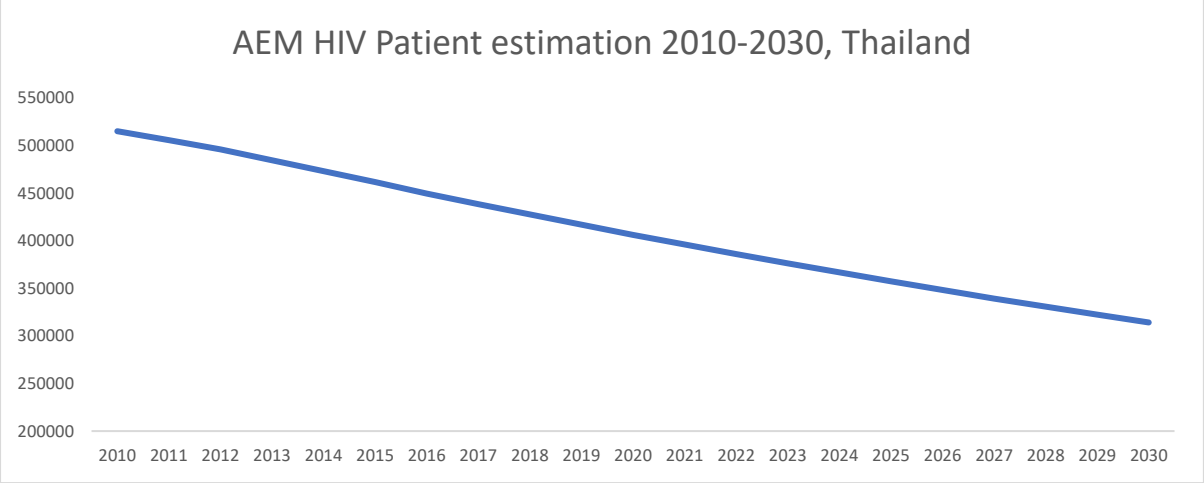


Figure 30 AEM HIV patient trend estimation 2010-2030, Thailand

The adult population (15+ years old) contributes to most of AEM estimation (99.34%), with the rest to children (<15 years old) estimation (0.66%). The estimation of the majority of patients was male in both age groups; 55.4% and 50.74% respectively as shown in Table 11.

Table 11 AEM HIV patient estimation stratify by sex and age group, 2018

AgeGr2	Male (%)	Female (%)	Total
15+	235,294 (55.40)	189,404 (44.60)	424,698
<15	1,435 (50.74)	1,393 (49.26)	2,828
Total	236,729 (55.37)	190,797 (44.63)	427,526

The lowest prevalence province resided in the central area (295 per 100,000) while the highest prevalence province was in the north region of Thailand (1,387 per 100,000). A similar pattern was shown in Figure 31, describing the clustering of HIV patients in the north and central region.

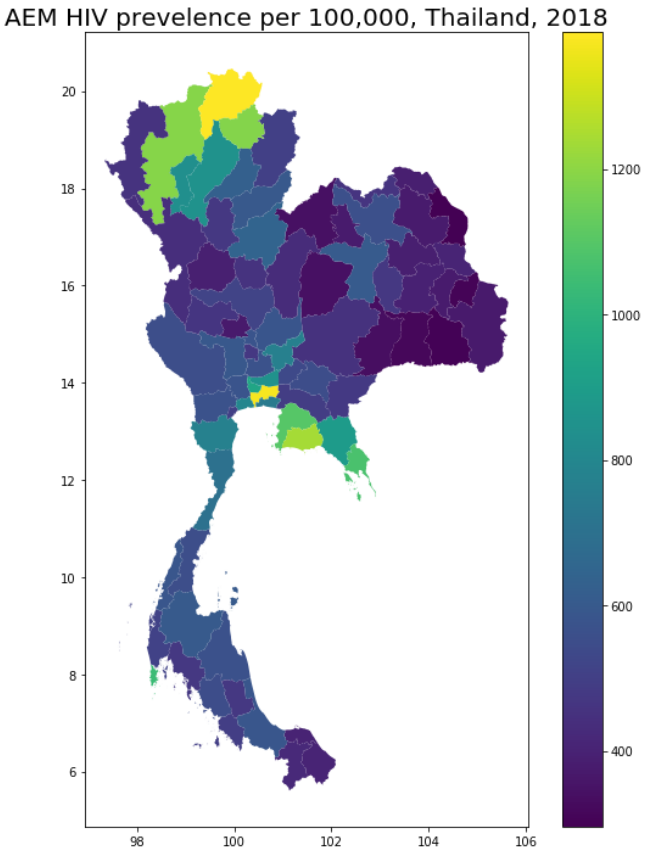


Figure 31 AEM HIV prevalence per 100,000 estimations, Thailand 2018

Thailand 90-90-90 Indicators (NAP)

Thailand uses NAP as a data source for 90-90-90 indicators calculation. In 2018, NAP reported 450,548 HIV patients, among them 323,637 receive treatment. Among HIV patients receiving treatment, 268,256 patients achieved Viral-Load (VL) suppression. Therefore, as of 2018, Thailand achieved the 90-90-90 indicators of 105%, 72%, and 83% respectively. Among patients knowing their HIV result, 126,911 did not receive treatment and 55,381 patients failed to achieve VL-suppression. Figure 32 broke down the HIV treatment cascade from the first indicator (having the HIV diagnosis), the second indicator (ARV coverage), and the third indicator (achieving VL suppression) along with the total drop-out or loss-follow-up patients count during the cascade.

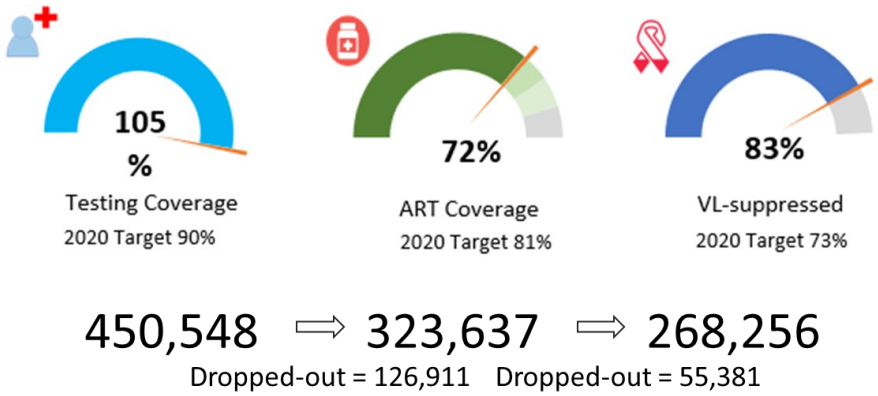


Figure 32 NAP 90-90-90 and treatment cascade, 2018

Generally, the first indicator level was well over 100% in most provinces with an average of 106.69% (range 50.86-156.27%). North region indicators were slightly lower than the rest of the country. One important characteristic was the lowest three provinces are clustered in Thailand south-most region as shown in Figure 33. Figure 34 described Thailand's 90-90-90 indicator using the boxplot. Thailand's first 90 indicators average was 106.69% ranging from 50.85% to 156.28%. The indicator had much higher variability (SD =16.04) compared to other indicators.

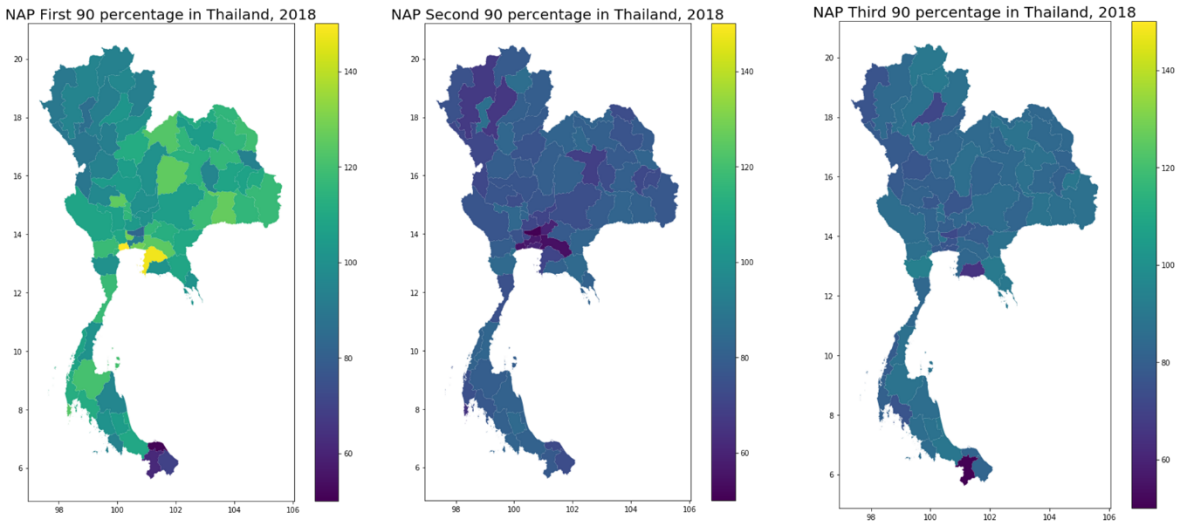


Figure 33 NAP 90-90-90 at the province level, (Left) First 90 indicator, (Middle) Second 90 indicator, (Right) Third 90 indicator

The second indicator showed a much lower value in general, with the low indicator in provinces clustering across the north and central region of Thailand. Thailand's second indicator was 76.19%

ranging from 47.46% to 86.67%. Compared to the first indicators, the second indicator had much lower variability and range but slightly more than the third indicator (SD = 7.69).

There were four outlier provinces for the first 90-90-90 indicators, two in the upper and two in the lower. Six provinces were identified as lower outliers for the second indicator. Two provinces were identified as the lower side outliers for the third indicator.

Only one province has categorized as an upper side outlier for the second indicator was a lower side outlier of the second indicator. There was no relation between outliers between the second and the third indicators.

Bangkok was identified as a lower side outlier for the second indicator only.

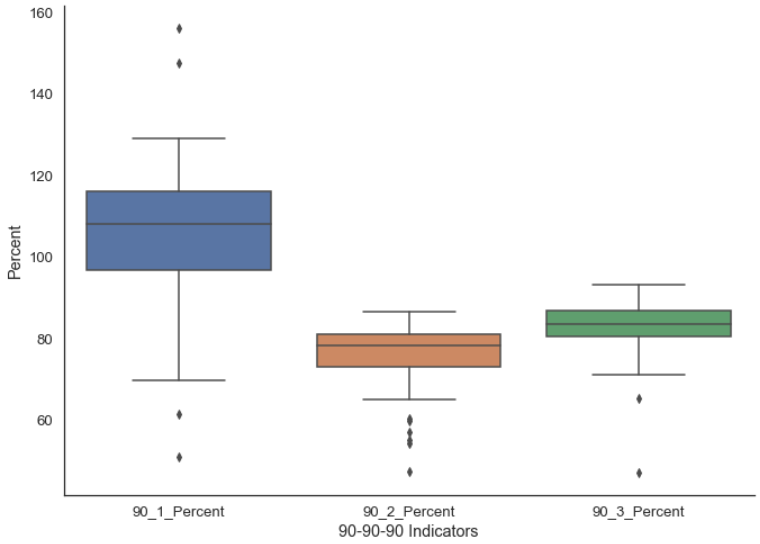


Figure 34 NAP 90-90-90 indicator distribution boxplots, Thailand, 2018

The third indicator did not show any prominent clustering pattern in any region of Thailand except for one province with the lowest indicator value in the south-most area of Thailand. Thailand's third indicator was 82.81 on average ranging from 47.08 to 93.25%, its variably was the lowest among the three indicators (SD=6.45).

MOPH 90-90-90 Indicators

In 2018, MOPH reported of 445,551 HIV patients. Among them, 229,165 received treatment. However, the MOPH database only had a 5,537 VL record count without a result. The numbers only indicate the number of tests conducted without specifying the Viral Load results, therefore calculating the third indicator was not possible. Therefore, we only provided the first two 90-90-90 indicators for the MOPH database of 104% and 52% respectively. Figure 35 described Thailand first and second, 90-90-90 using the MOPH database includes the dropped-out during the cascade.

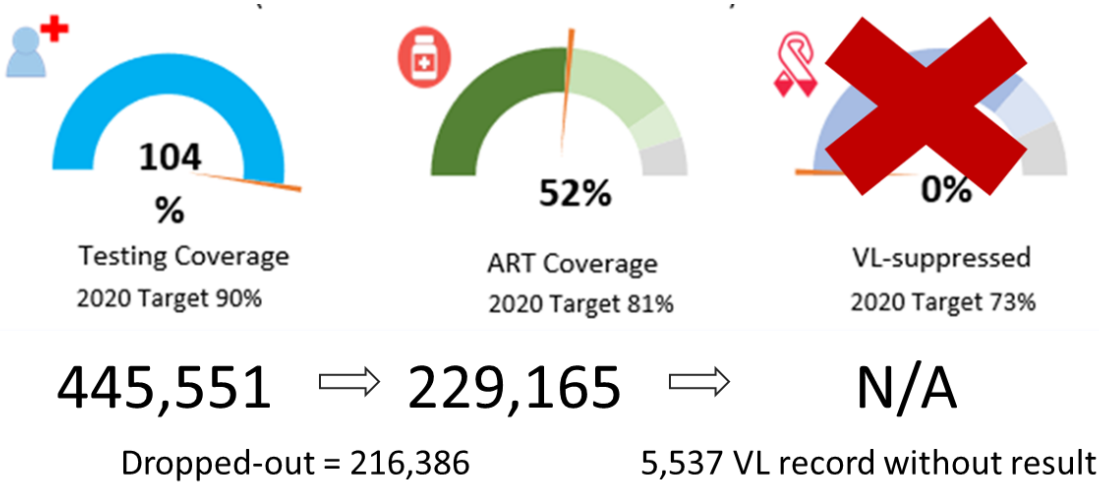


Figure 35 Thailand 90-90-90 indicators using the MOPH database. The third indicator is not available as the database did not store the Viral Load (VL) result.

Figure 36 and Figure 37 described the distribution of Thailand's first and second 90-90-90 indicators from the MOPH database at the provincial level.

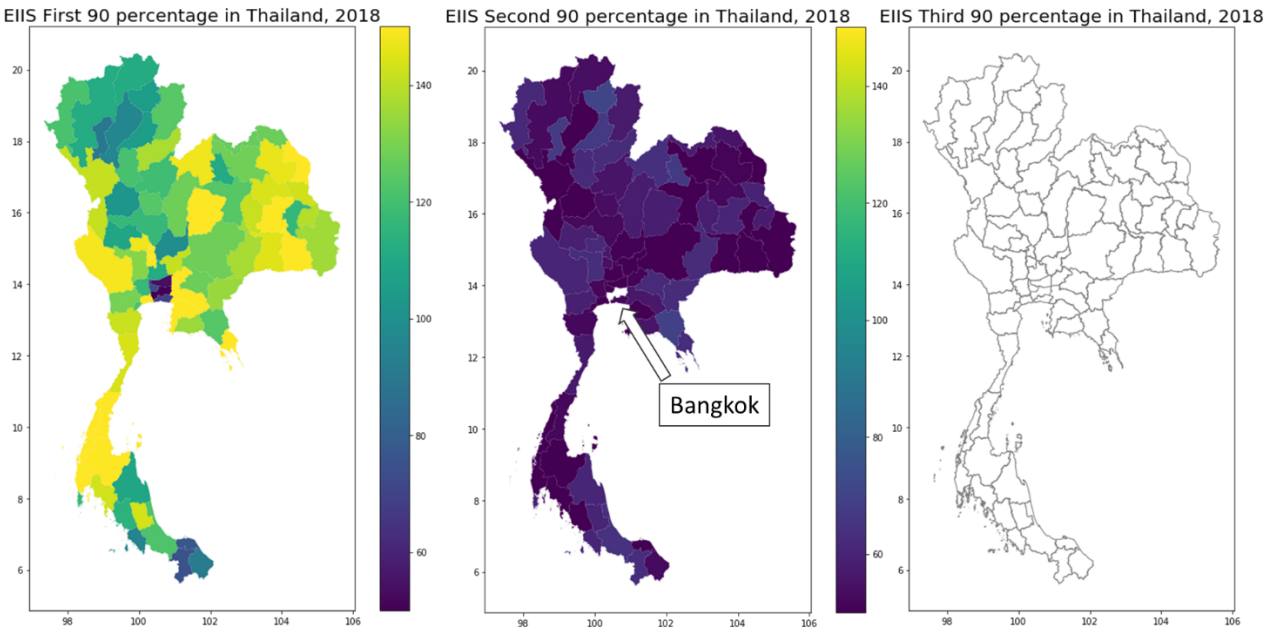


Figure 36 MOPH 90-90-90 at the province level, (Left) First 90 indicator, (Middle) Second 90 indicator, (Right) Third 90 indicator which is not available. Bangkok is the only province that does not have the second indicator because no data was submitted to the MOPH.

Overall, the majority of provinces achieved the first indicator level higher than 100% with an average of 128.03%, ranging from 11.99% to 225.50% and with high variability (SD=30.97%). Northern and southern region distinctly achieved the lower indicator value. Bangkok indicators were remarkably low achieving the first indicator of 11.99% far lower than the second-lowest province that achieved 53.58%. For the second indicator, Thailand achieved 53.61% on average with much less variability (SD=9.43%) ranging from 18.52% to 70.60%. There was no clustering pattering presented in Thailand's second indicator at the provincial level. It is important to emphasize that Bangkok was the only province without ARV coverage data available.

There were 3 outlier provinces on each indicator. For the first 90-90-90 indicators, one province was an upper side outlier and two provinces as the lower side outlier. In the second 90-90-90 indicators, all three outliers provinces were on the lower side. Bangkok was the only one outlier (lower side) in the first indicator also a lower side outlier in the second.

Bangkok was the only province having identified as an outlier (lower-side) on the second 90-90-90 indicator in both NAP and MOPH. No additional provinces were identified as outliers in the same indicator across two data sources.

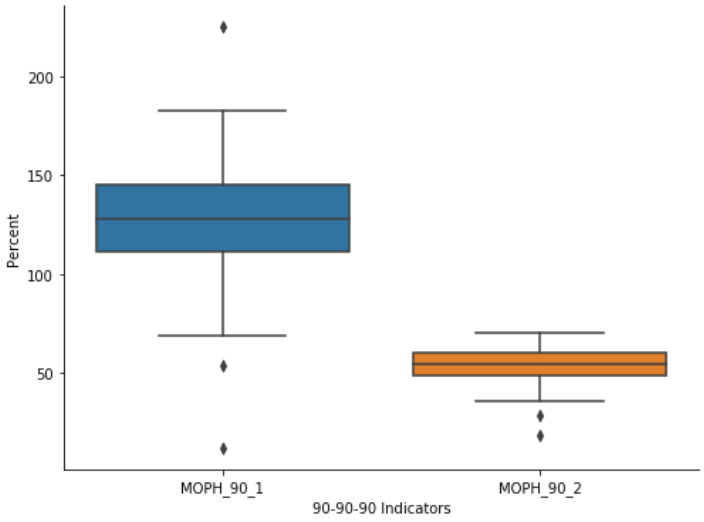


Figure 37 MOPH 90-90-90 distribution boxplot, Thailand, 2018. Noted that the third indicator is not available from lacks Viral Load Results data

MOPH-NAP Difference

Both databases reported a very similar total HIV number at the national level of 445,551 for MOPH and 450,548 for NAP. On average, MOPH had 650 patients less than NAP at the provincial level. The difference ranged from MOPH having 61,569 patients less than NAP and NAP to having 3,194 more than MOPH. The standard deviation was a very high of 7,249 patients. Assessing the two data sources difference distribution at the provincial level identified Bangkok having the highest number of 61,569 patients, far higher than the rest of the country. When calculating two data sources percentage difference.

We calculated the two data sources difference in percentage to address the difference in the total patients of each province. On average, Thailand MOPH reported 20% higher than NAP ranging from MOPH having 87.03% less than NAP to having 108.45% higher than NAP with a standard deviation of 25.42%. Two data sources percentage difference identified Bangkok (MOPH patient count 87.03%

less than NAP) and Ranong (MOPH patient count 108.45% more than NAP) as provinces with the highest difference as shown in Figure 38.

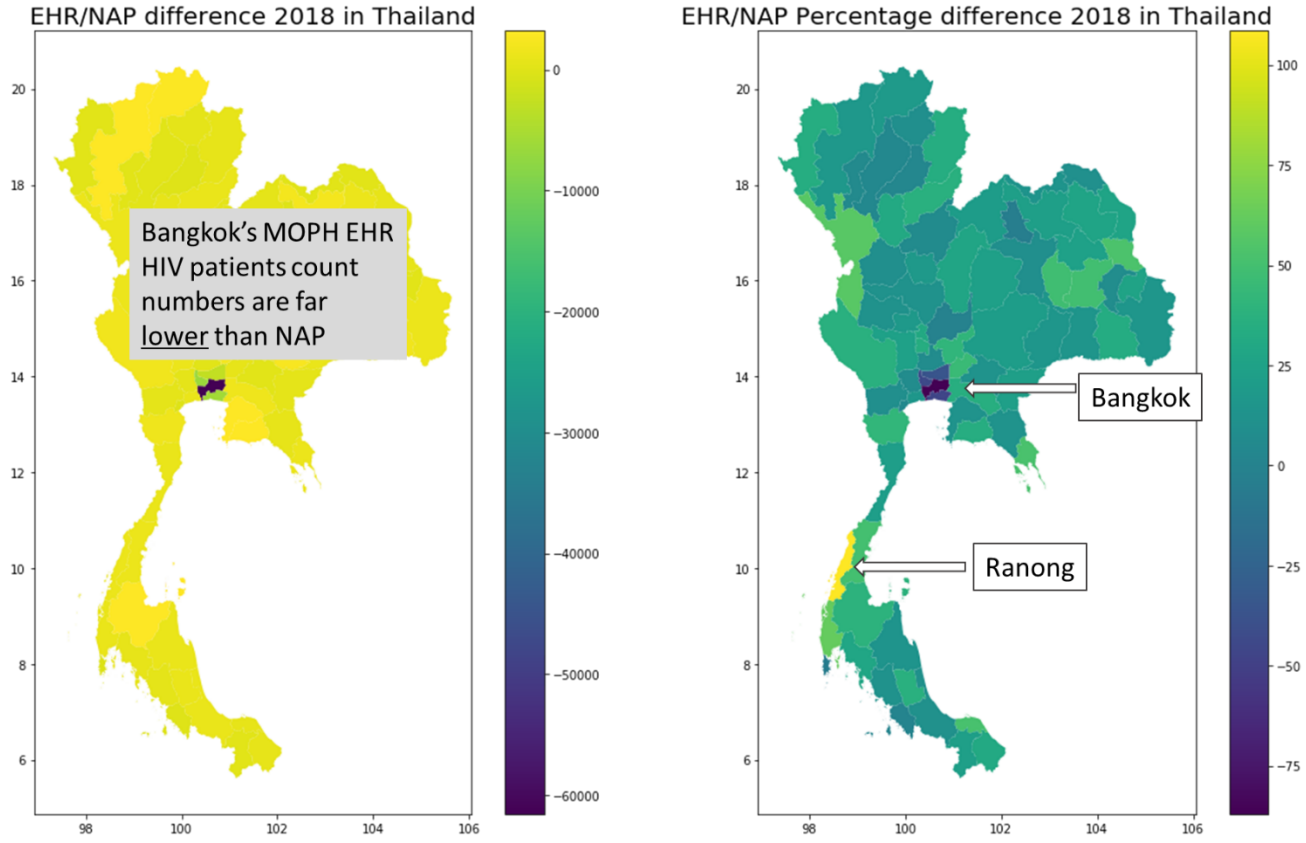


Figure 38 (Left) Patient count difference between NAP and MOPH. The difference is prominent in Bangkok. (Right) The percentage difference between NAP and MOPH. For percentage calculation, Bangkok remains the highest province having a MOPH patient count proportion less than NAP. Ranong, on the contrary, has more MOPH patient count proportion than NAP.

Identifying Bangkok as an outlier

The absolute percentage difference between the two data sources is presented in Figure 39 at the provincial level. On average, the absolute patient count difference is 1,935 patients ranging from 12 to 61,569 patients (SD=6,982). Bangkok remained as the province with the highest two data sources difference with 61,569 patents while the Ranong absolute difference on patients count difference was 1,219. Absolute percentage difference calculation shows an average difference of 26.23% ranging from 0.80% to 108.45%. Ranong had the highest absolute difference percentage of 108.45% followed by Bangkok of 87.03%.

For NAP 90-90-90 indicators, Bangkok achieved 92-**57**-76. Bangkok 2nd-90-90-90 indicator is the fourth-lowest in Thailand and 7th lowest for the 3rd 90-90-90 indicator. The Ranong 90-90-90 indicator was much better than Bangkok in an overall of 108-81-78.

For the MOPH 90-90-90 indicators, only the first indicator was available for Bangkok of 11.99%. Bangkok is the only province where the second MOPH 90-90-90 indicator was not available due to lacking ARV prescription data. Ranong, while its MOPH first 90-90-90 value was extremely high of 225.50%, Ranong's second MOPH indicator was available of 45.07%.

Moreover, Bangkok was identified as a lower-side outlier of the second MOPH 90-90-90 indicators and the first and the second NAP 90-90-90 indicators. Ranong, on the contrary, was identified as the higher side outlier of the first NAP 90-90-90 indicators.

As a result, Bangkok was recognized as an outlier. The finding required the need for a field visit to explore factors explaining its outlier status and to re-analyzing the results without Bangkok data.

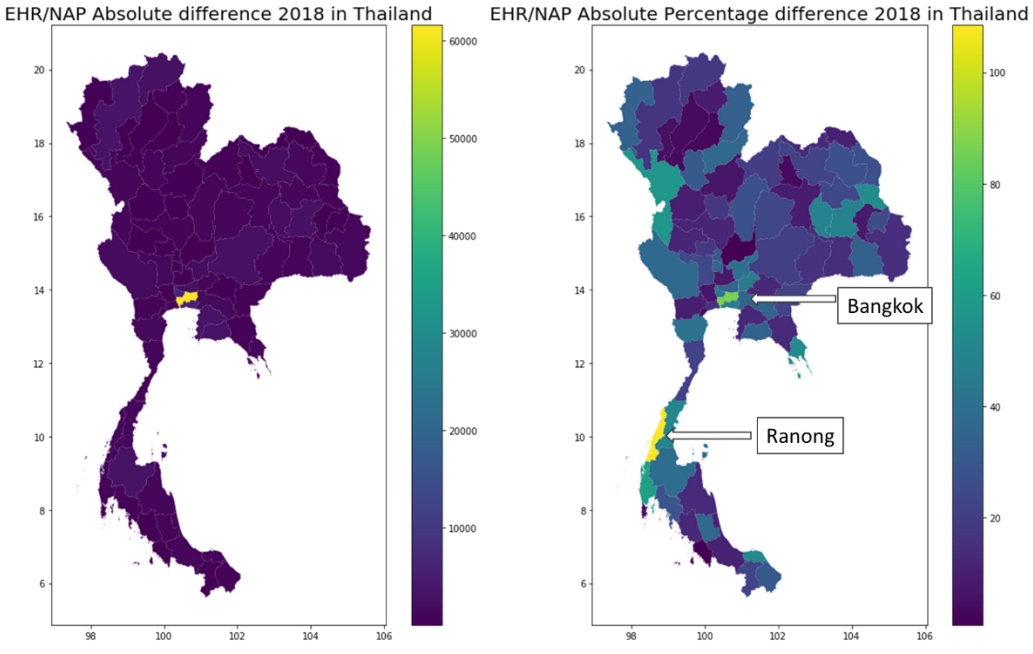


Figure 39 (Left) Absolute patient count difference between NAP and MOPH. The difference is prominent in Bangkok. (Right) Percentage absolute difference between NAP and MOPH. For percentage calculation, Bangkok remains the highest province having a MOPH patient count

proportion less than NAP. Ranong, on the contrary, has more MOPH patient count proportion than NAP.

Redoing analyses excluding Bangkok

At this stage, Bangkok was identified as an outlier province that may distort the Thailand HIV situation. Therefore, we re-examined the two data sources difference by excluding Bangkok to explore any changes in the distribution pattern. The analysis was done without Bangkok and presented in Figure 40.

Excluding Bangkok, the average two data source difference was MOPH has 745 patients more than NAP, ranging from MOPH having 6,432 less than NAP to 3,194 patients more than NAP (SD=1,462.45).

In terms of two data sources percentage, on average, the difference was 21.87% ranging from MOPH having 46.42% less than NAP to having 108.45% more than NAP.

While excluding Bangkok from calculation allow us to explore the finding in other provinces, there were no changes in overall distribution across the percentage of choropleth maps (Figure 41). No additional clustering pattern was observed.

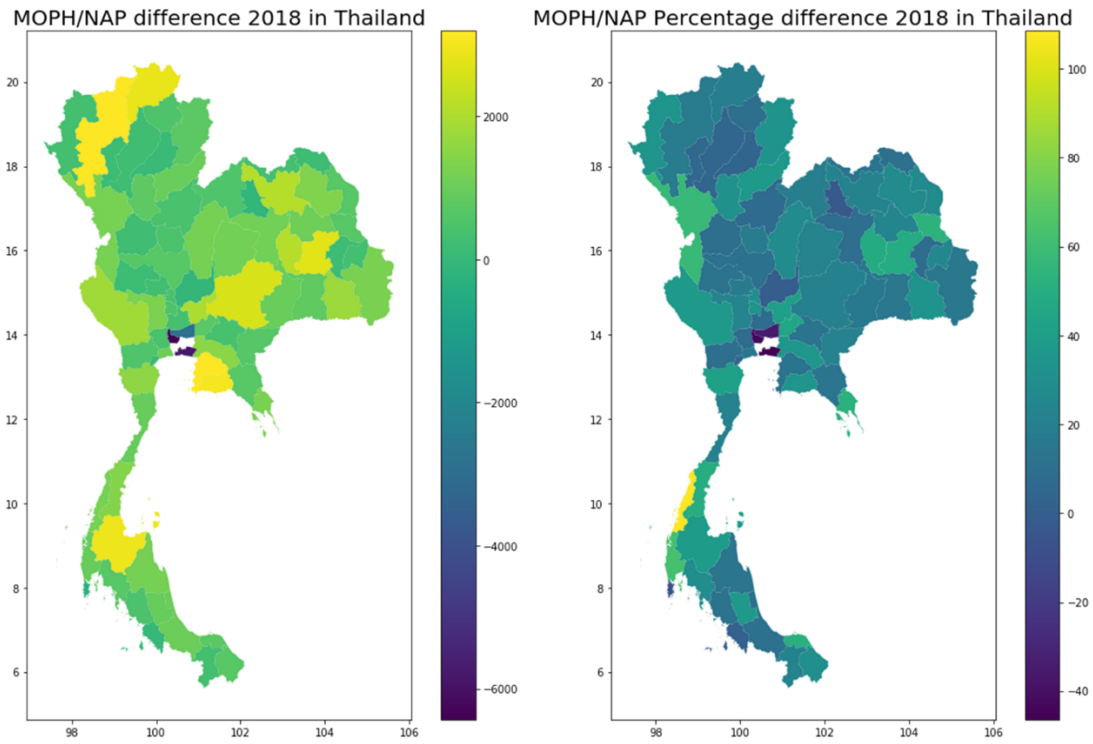


Figure 40 (Left) Patient count difference between NAP and MOPH excluding Bangkok. (Right) The percentage difference between NAP and MOPH, excluding Bangkok. Ranong remains as the province with the highest MOPH patient count proportion than NAP.

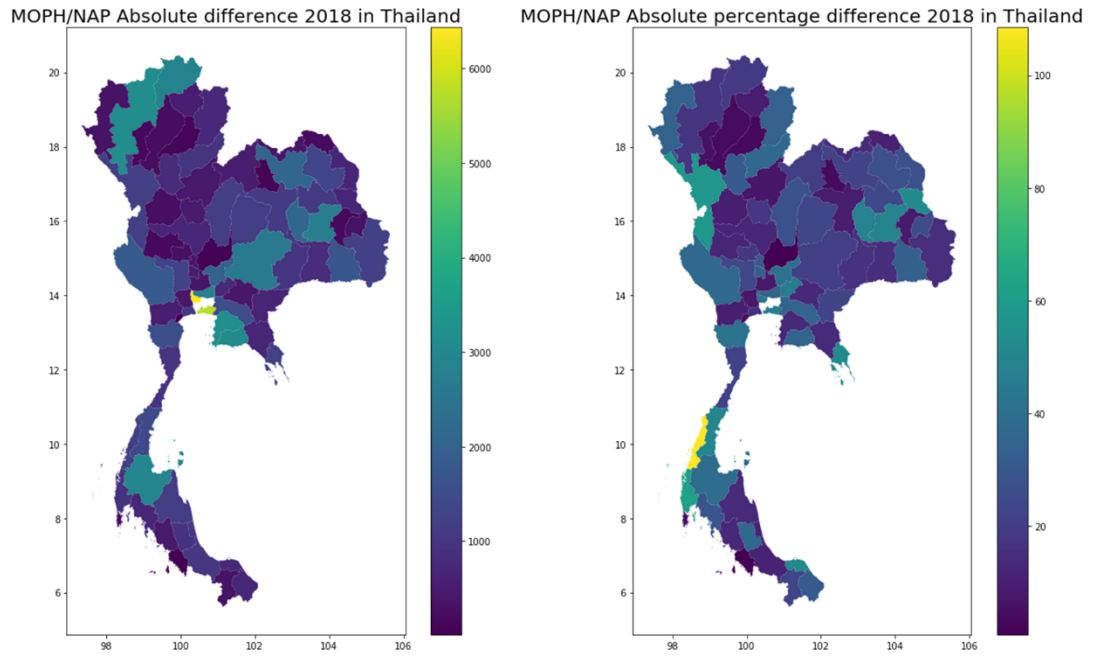


Figure 41 (Left) Absolute patient count difference between NAP and MOPH, excluding Bangkok. (Right) Percentage absolute difference between NAP and MOPH excluding Bangkok.

For percentage calculation, Ranong remains the province with the highest absolute percentage difference

Bivariate analyses of the main independent variables

In this section, we explore the possible contributing factors in the two data sources difference before analyzing with the univariate and multivariate linear regression model. The outcome variable was the absolute percentage difference, the second and the third 90-90-90 indicators, and the initial independents variables selected included bed capacity, PEPFAR funding, care level, and hospital class.

Two data sources difference

Of the 1,323 hospitals in Thailand, 1,021 hospitals submitted data to either database as of 2018. Among them, only 835 hospitals specified their care level. There were only 1 private hospital and 1 public non-MOPH hospitals that specified their care level as shown in Table 12.

Several hospitals only described care level and several hospitals only described hospital type causing inconsistency in the analyses on either care level or hospital type alone. Therefore, we explored whether the care level or the hospital class were better variables for the analyses.

Table 12 Cross-tabulation hospital type and care level, Thailand hospital 2018

Care level	Hospital type					
	Public Non-MOPH	MOPH Specialized	MOPH Community hospital	MOPH General hospital	MOPH Regional hospital	Private hospital
Primary (2)	0	0	1	0	0	1
Secondary (small) (522)	0	0	522	0	0	0
Secondary (medium) (199)	0	0	199	0	0	0
Secondary (advance) (73)	1	0	16	56	0	0
Tertiary (39)	0	1	0	13	25	0

Of 1,021 hospitals submitted to one of the databases (NAP or MOPH), 900 hospitals submitted HIV patients data to both databases. Only 121 hospitals submitted data to NAP only and no hospital

submitted data to MOPH without also submitting data to NAP. Using the median, hospitals submitted data to the NAP of 194 patients and 188 to MOPH. The median difference of 17 patients and 32.34%.

Table 13 described the two data sources difference stratified by hospital type. Private hospitals submit data to NAP far more than MOPH causing their two data sources difference to be the highest. This was expected as private hospitals were not reimbursed by NAP.

For public hospitals, MOPH Specialized hospitals had the highest two data sources difference percentage. MOPH general hospitals had the lowest difference percentage of all hospital affiliations. Regional MOPH hospitals, despite submitting the highest number, had the second-lowest two data sources difference percentage.

Also, the MOPH community, general and regional hospitals reported HIV patients to MOPH more than to NAP. The MOPH specialized and public non-MOPH reported most patients to NAP rather than MOPH because of having different management structures and regulations.

Table 13 Thailand two data sources difference at hospital level stratified by hospital type, 2018

Hospital Type (n)	Median Absolute Patient count difference (MOPH and NAP)	Median Absolute Percentage of Two-data sources difference	Median NAP HIV patient count	Median MOPH patient count
Public Non-MOPH (58)	360.5 (2-2,801)	93.27 % (0.45-6,900.0)	387 (1-5,626)	26 (0-7,187)
MOPH Specialized (17)	15.0 (3-6,491)	46.88 % (7.5-520.0)	32 (3-6,491)	17 (0-2,344)
MOPH Community hospital (MOPH) (741)	27.0 (0-1,714)	15.79 % (0.0-3,600.0)	171 (2-4,438)	198 (7-5,554)
MOPH General hospital (69)	390.0 (4-2,764)	38.16 % (0.65-182.32)	1,022 (268-2,952)	1,412 (300-5,679)
MOPH Regional hospital (25)	515.0 (41-2,625)	20.89 % (1.89-88.0)	2,465 (640-5,304)	2,980 (824-6,495)
Private hospital (113)	288.0 (0-2,995)	100.0 % (0.0-700.0)	288 (0-2,995)	0 (0-590)

When stratified by care level, all secondary and tertiary level hospitals submitted data to MOPH more than NAP. Their two data sources' difference percentage did not vary much from each other.

However, the two-primary care hospitals had a much higher two data source difference of 525% and submitted most data to NAP rather than to MOPH (Table 14). Possible reasons were a small number of primary care hospitals were available and one primary care hospital was private that did not submit data to MOPH.

Table 14 Thailand two data sources difference at hospital level stratified by care level, 2018

Hospital care level (n)	Median Absolute Patient count difference (MOPH and NAP)	Median Absolute Percentage of Two-data sources difference	Median NAP HIV patient count	Median MOPH patient count
Primary (2)	197.5 (19-414)	94.95 (100.0-950.0)	208 (2-414)	11 (0-21)
Secondary (small) (522)	20.0 (0-1230)	13.99 (0.0-3600.0)	143.0 (2-1455)	163 (9-2,511)
Secondary (medium) (199)	32.0 (2-1714)	11.47 (0.45-390.48)	279.0 (7-1088)	311 (7-2,631)
Secondary (advance) (73)	210.0 (3-2382)	25.39 (0.44-225.42)	827.0 (240-4438)	1,037 (300-5,554)
Tertiary (39)	426.0 (17-2764)	19.23 (1.08-106.8)	2,215.0 (569-5,304)	2,641 (795-6,495)

In the results, we identified a remarkable wide range of values. For example, the 0.45 -6,900 range for the median absolute percentage of two-data sources difference of Public non-MOPH hospital in Table 13. Those are the results from several hospitals that have a high number of data submissions to one database while having a very low data submission to another result in a ‘0’ in the lower-end range of both NAP and MOPH patient count. Having a disproportionately low number distorted our percentage of two data sources difference.

Normalization and case threshold definition

In the previous section, we identified several hospitals with a low number of HIV patients or only submitting to NAP alone causing the two data source percentages difference to become remarkably high. In Figure 42, we used a log function to normalize the two data source difference percentage on each hospital type and15 upper side outliers were identified. With normalization, the MOPH specialized and MOPH regional hospitals did not have any outliers. This is important as the MOPH

specialized hospital type has a wide range of two data sources difference. However, even with the log transformation, the distribution of two data sources difference was still remarkably different across hospital types.

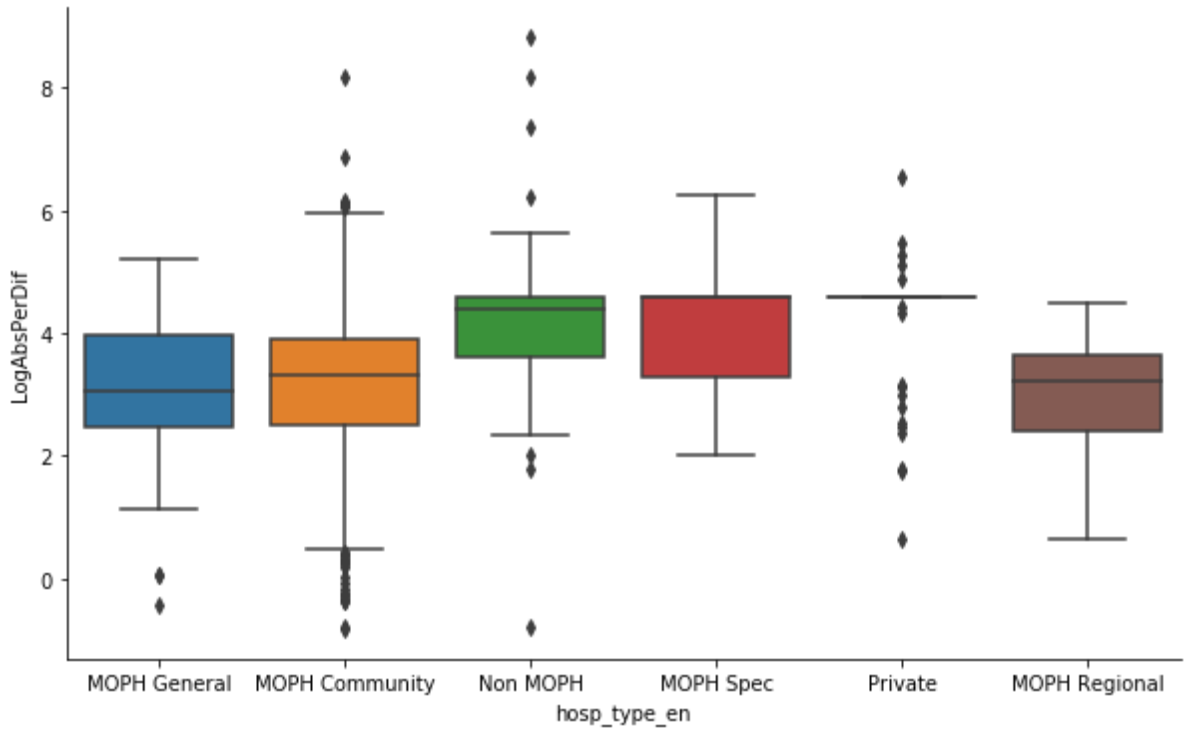


Figure 42 Normalized Two data sources difference percentage by hospital type. There were 15 upper side outliers and 41 lower side outliers

From our data set, we found that using the 50 cases as inclusion criteria eliminate most of the outliers. The hospitals that reported at least 50 cases were responsible for most of the lower side outliers and only three upper side outliers remained as described in Table 15. In other words, the hospital with the 50 cases threshold was more likely to have less two data source differences.

The two data source difference distribution became more consistent across hospital types (Figure 43). Therefore, we used the number of 50 as our case thresholds for analysis.

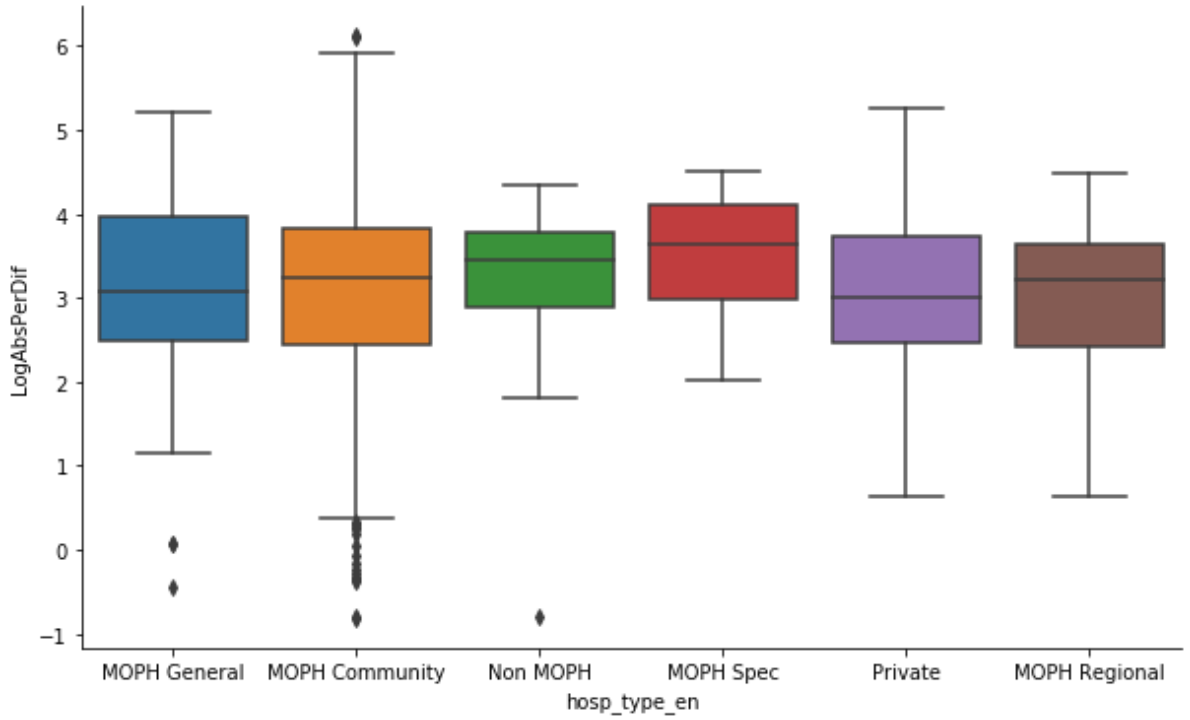


Figure 43 Normalized Two data sources difference percentage by hospital type among hospitals with at least 50 cases. There were 2 upper side outliers from MOPH Community hospitals. Of 21 lower side outliers hospitals, 17 were MOPH Community, 3 were MOPH General, and 1 from Public Non-MOPH hospitals.

The distribution of the two data sources difference distribution of 75 hospitals that reported less than our thresholds of 50 cases by each hospital type is shown in Figure 44. Their distribution was remarkably less consistent than those having more than 50 cases. They were responsible for 12 of the 15 upper sides two data source difference outliers. In other words, they were more likely to have a higher two data source difference.

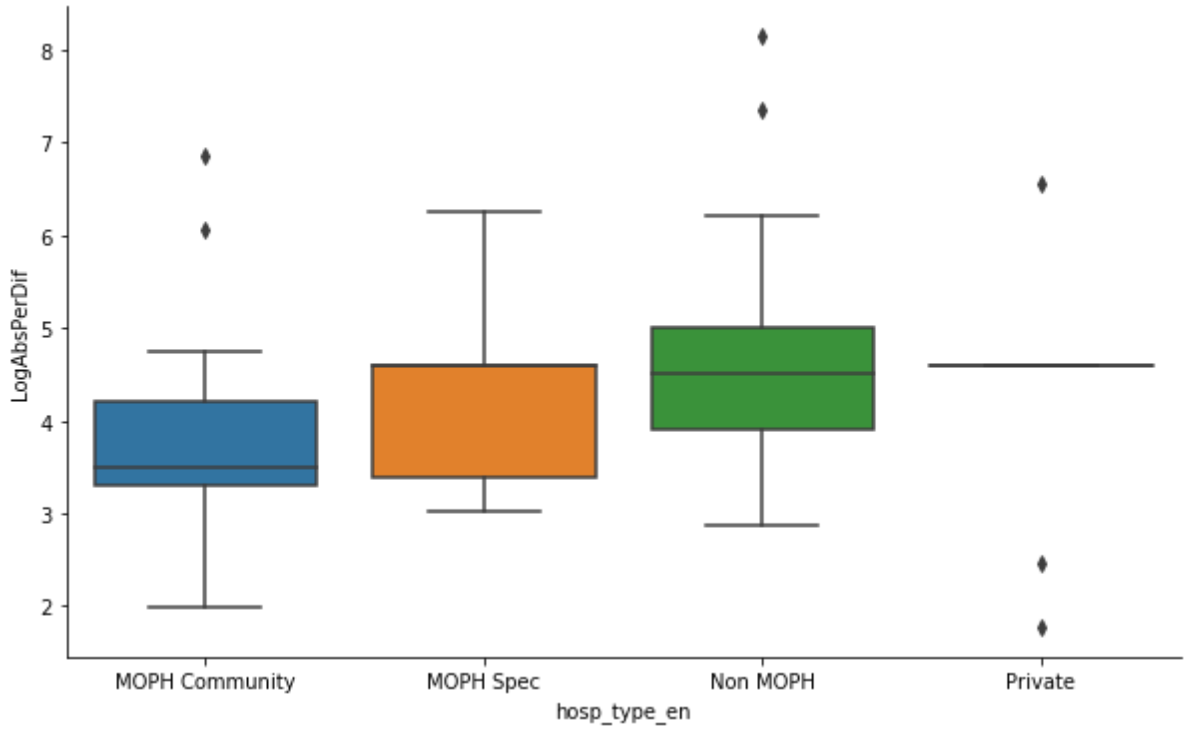


Figure 44 Normalized Two data sources difference percentage by hospital type among hospitals with less than 50 cases. There were 5 upper side outliers, 2 were from MOPH Community, 2 were from Public non-MOPH, and 1 from a private hospital. There were 4 lower side outliers from private hospitals

Table 15 Outliers of normalized two data source difference percentage by hospital type

	MOPH General	MOPH Community	Non-MOPH	MOPH Spec	Private	MOPH Regional
All hospitals						
Upper	0	6	4	0	5	0
Lower	3	21	3	0	14	0
Above 50 cases thresholds						
Upper	0	2	0	0	1	0
Lower	3	21	3	0	10	0
Below 50 cases threshold						
Upper	0	4	4	0	4	0
Lower	0	0	0	0	4	0

Of 75 hospitals that reported less than 50 HIV cases, most were community hospitals and private hospitals. None of the large hospitals (MOPH General and MOPH regional) were included, which were reasonable as they were more likely to submit more cases from having a larger capacity.

Table 16 described the two data sources difference among hospitals submitting less than 50 cases to both NAP and MOPH. The two data sources percentage were largely different across from hospital type from 0 in Public non-MOPH to 100% of private hospitals. Beside from MOPH community hospitals, there were several hospitals reported 0 patients to MOPH and NAP.

Table 16 Two data sources difference by hospitals submitting less than 50 cases stratified by hospital type, 2018

Hospital Type (n)	Median Absolute Percentage of Two-data sources difference	Median Absolute Difference between two data sources	Median NAP HIV patient count	Median MOPH patient count
Public Non-MOPH (12)	0.0 (2-35)	0.0 (17.65-3500.0)	10.5 (1.0-48.0)	10.5 (0-49)
MOPH Specialized (10)	10.0 (3-35)	42.55 (20.69-520.0)	23.5 (3.0-35.0)	13.5 (0-35)
MOPH Community hospital (32)	4.0 (3-38)	15.38 (7.32-950.0)	26.0 (2.0-49.0)	30.0 (7-48)
Private hospitals (21)	9.0 (0-39)	100.0 (0.0-700.0)	9.0 (0.0-39.0)	0.0 (0-34)

Therefore, we redid the analysis which includes only hospitals reporting at least 50 patients to both databases.

Table 17 Thailand two data sources difference with at least 50 patients submission to MOPH and NAP at hospital level stratified by hospital type, 2018.

Hospital Type (n)	Median Absolute Patient count difference (MOPH and NAP)	Median Absolute Percentage of Two-data sources difference	Median NAP HIV patient count	Median MOPH patient count
Public Non-MOPH (23)	7.0 (2-1561)	1.55 (0.45-76.39)	453.0 (72.0-5626.0)	446 (51-7187)
MOPH Specialized (4)	1069.5 (6-1997)	86.99 (7.5-91.15)	1229.5 (80.0-3213.0)	160 (86-2344)
MOPH Community hospital (MOPH) (669)	27.0 (0-1714)	14.52 (0.0-463.49)	186.0 (51.0-4438.0)	213 (51-5554)
MOPH General hospital (69)	390.0 (4-2764)	38.16 (0.65-182.32)	1022.0 (268.0-2952.0)	1412 (300-5679)

MOPH Regional hospital (25)	515.0 (41-2625)	20.89 (1.89-88.0)	2465.0 (640.0-5304.0)	2980 (824-6495)
Private hospital (11)	12.0 (4-243)	5.74 (1.9-194.23)	209.0 (52.0-491.0)	221 (51-590)

Of 801 hospitals that submitted at least 50 patients to both databases. The private hospital number had the largest drop in the hospital number from 113 to 11 hospitals followed by the Public Non-MOPH hospitals from 58 to 23 hospitals.

We observed a large decrease in the two data sources different among Public non-MOPH and private hospitals from 93.27% to 1.55% and 100% to 5.74% respectively. However, it was important to emphasize that the hospital number of both types were remarkably excluded by our threshold number of 50 cases.

On the contrary, the percentage difference was increased from 46.88% to 86.99% among MOPH Specialized hospitals. Similar to private hospitals, it was important to emphasize that the MOPH specialized hospitals largely decreased from 17 to 4 hospitals.

When stratified by the care level, with the case threshold of 50 cases, several remarkable changes were observed. All primary care facilities were excluded. The highest value of the two data source difference of the secondary (medium) level facilities was greatly decreased from 3,600.00% to 328.35%.

Table 18 Thailand two data sources difference with at least 50 patients submission to MOPH and NAP at hospital level stratified by care level, 2018

Hospital care level (n)	Median Absolute Patient count difference (MOPH and NAP)	Median Absolute Percentage of Two-data sources difference	Median NAP HIV patient count	Median MOPH patient count
Secondary (small) (468)	23.0 (0-1230)	14.7 (0.0-463.49)	156.5 (51.0-1455.0)	179.5 (51-2511)
Secondary (medium) (184)	38.0 (2-1714)	13.13 (0.45-328.35)	289.5 (55.0-1088.0)	327.5 (52-2631)
Secondary (advance) (73)	210.0 (3-2382)	25.39 (0.44-225.42)	827.0 (240.0-4438.0)	1037.0 (300-5554)

Tertiary (39)	426.0 (17-2764)	19.23 (1.08-106.8)	2215.0 (569.0-5304.0)	2641.0 (795-6495)

Kappa and two data sources agreement

In this section, we calculate the data sources agreement and Cohen's kappa to address the two data sources concordance of the Weiskopf data quality framework among those submitted at least 50 cases to both data sources.

Table 19 Two data sources agreement and Cohen's Kappa among hospital submitted at least 50 cases stratified by hospital type

Hospital Type	Agreement	Cohen's Kappa
Public Non-MOPH	0.99	0.98
MOPH Specialized	0.57	0.13
MOPH Community hospital	0.94	0.87
MOPH General hospital	0.86	0.72
MOPH Regional hospital	0.91	0.83
Private hospital	0.97	0.95

The agreement and kappa were consistency with the two data sources different stratified by hospital type in the previous section, MOPH Specialized hospitals remain the hospital type with the lowest agreement and kappa.

Table 20 Two data sources agreement and Cohen's Kappa among hospital submitted at least 50 cases stratified by care level

Care level	Agreement	Cohen's Kappa
Secondary (small)	0.94	0.87
Secondary (medium)	0.94	0.88
Secondary (advance)	0.9	0.8
Tertiary	0.92	0.84

When stratified by care level, the agreements and cohen's kappa were more consistent across the care level. The tertiary care level, while its agreement and cohen's kappa was the lowest on the contrary to the two data source agreements, the difference is narrow compared to other care levels.

As Bangkok was identified as an outlier, we focus on exploring the Bangkok two data source differences in the next section.

Bangkok area

Of the 138 hospitals in Bangkok, only 59 hospitals submitted to NAP. Among them, 9 hospitals submitted to both databases and 50 hospitals submitted to NAP only. No hospitals submitted to MOPH without also submitted to NAP.

Table 21 described the characteristics of hospitals in Bangkok. Most hospitals in Bangkok were private and public non-MOPH hospitals. Only one hospital had care level data available. Therefore, analysis of the two data sources difference stratified by care level for Bangkok hospitals was not possible.

Table 21 Bangkok two data sources difference at the hospital level, 2018

Hospital Type (n)	Median Absolute Difference between two data sources	Median Absolute Percentage of Two-data sources difference	Median NAP HIV patient count	Median MOPH patient count
Public Non-MOPH (19)	1475.0 (2-2801)	100.0 % (22.82-100.0)	1475.0 (2.0-2936.0)	0 (0-2266)
MOPH Specialized (5)	2065.0 (32-3355)	94.25 % (27.05-100.0)	2191.0 (32.0-3355.0)	126 (0-2344)
Private (35)	752.0 (6-2995)	100.0 % (100.0-100.0)	752.0 (6.0-2995.0)	0 (0-0)

Using the median, no hospitals in Bangkok submitted data to MOPH while submitting 791 to NAP. The median difference percentage was 100%.

Table 21 shows the differences between the hospitals based on their type. On the contrary to the findings of all hospitals in Thailand, Bangkok hospitals submitted data to NAP more than to MOPH in every hospital type. No private hospitals submitted data to MOPH. The public non-MOPH and MOPH specialized hospitals submitted data to both data sources but much fewer data were reported to MOPH.

In all three hospitals' types, the two data source differences were nearly 100%. The public non-MOPH and private MOPH two data sources difference percentages were nearly identical to the Thailand average in Table 13. This finding implied that both hospital type data submission policies were different from MOPH hospitals.

When including only hospitals reporting at least 50 patients to both NAP and MOPH, only 8 from 59 hospitals remain (Table 22). All private hospitals and most of the public non-MOPH hospitals were excluded by our criteria. The finding suggests that most hospitals in Bangkok did not submit data to MOPH. No private hospital submitted data to MOPH at all.

Table 22 Bangkok two data sources with at least 50 patient's submission to MOPH and NAP difference at the hospital level, 2018

Hospital Type (n)	Median Absolute Difference between two data sources	Median Absolute Percentage of Two-data sources difference	Median NAP HIV patient count	Median MOPH patient count
Public Non-MOPH (5)	458.0 (317-698)	26.86 % (22.82-43.6)	1705.0 (727.0-2936.0)	1247 (410-2266)
MOPH Specialized (3)	1997.0 (142-1997)	91.15 % (27.05-91.15)	2191.0 (268.0-3213.0)	194 (126-2344)

As Bangkok was considered in our study as a very important outlier, we explored in the next section if removing Bangkok altered Thailand's findings.

Non-Bangkok area

In this section, we explored the two data sources difference in non-Bangkok hospitals. After excluding Bangkok, 891 hospitals submitted to both NAP and MOPH. There were 71 hospitals submitted data to NAP only. No hospitals submitted to MOPH without also sending data to NAP.

Removing Bangkok only eliminates one MOPH Specialized hospital from care level and hospital-type crosstabulation as shown in Table 23. In other words, nearly all hospitals that specified their care level in the database were outside of Bangkok.

With only 1 of 835 hospitals missing, we assumed the results to be identical to Table 14 and did not further conduct any analysis on two data sources difference stratified by care level among non-Bangkok hospitals.

Table 23 Cross-tabulation by hospital type and care level, excluding Bangkok, Thailand hospitals 2018

Care level	Hospital type					
	Public Non-MOPH	MOPH Specialized	MOPH Community hospital	MOPH General hospital	MOPH Regional hospital	Private hospital
Primary (2)	0	0	1	0	0	1
Secondary (small) (522)	0	0	522	0	0	0
Secondary (medium) (199)	0	0	199	0	0	0
Secondary (advance) (73)	1	0	16	56	0	0
Tertiary (38)	0	0	0	13	25	0

After excluding Bangkok, the MOPH community, general and regional hospitals still reported to MOPH more than NAP with the lowest two data sources percentage difference than other hospital types. Private hospitals percentage difference remains the highest across non-Bangkok hospitals as described in Table 24.

Table 24 Thailand two data sources difference at hospital level stratified by hospital affiliation, excluding Bangkok, 2018

Hospital Type (n)	Median Absolute Difference between two data sources	Median Absolute Percentage of Two-data sources difference	Median NAP HIV patient count	Median MOPH patient count
Public Non-MOPH (39)	102.0 (2-2484)	66.67 (0.45-6900.0)	153.0 (1.0-5626.0)	51.0 (0-7187)
MOPH Specialized (12)	11.0 (3-6491)	44.9 (7.5-520.0)	24.5 (3.0-6491.0)	13.5 (0-86)
MOPH Community hospital (MOPH) (741)	27.0 (0-1714)	15.79 (0.0-3600.0)	171.0 (2.0-4438.0)	198.0 (7-5554)
MOPH General hospital (69)	390.0 (4-2764)	38.16 (0.65-182.32)	1022.0 (268.0-2952.0)	1412.0 (300-5679)

MOPH Regional hospital (25)	515.0 (41-2625)	20.89 (1.89-88.0)	2465.0 (640.0-5304.0)	2980.0 (824-6495)
Private hospital (78)	184.5 (0-1278)	100.0 (0.0-700.0)	184.5 (0.0-1278.0)	0.0 (0-590)

The analysis with only hospitals submitted at least 50 patients to both NAP and MOPH of non-Bangkok hospitals presented in Table 25 was nearly identical to those of Thailand level in Table 17 except for the specialized MOPH hospitals. Thus, the finding supports our hypothesis that hospitals that report only a few HIV cases or did not report to both databases are causing the two data source difference percentage to become remarkably large.

Table 25 Non-Bangkok two data sources with at least 50 patient's submission to MOPH and NAP difference at the hospital level, 2018

Hospital Type (n)	Median Absolute Difference between two data sources	Median Absolute Percentage of Two-data sources difference	Median NAP HIV patient count	Median MOPH patient count
Public Non-MOPH (18)	33.0 (2-1561)	8.45 (0.45-76.39)	390.5 (72.0-5626.0)	423.5 (51-7187)
MOPH Specialized (1)	6.0 (6-6)	7.5 (7.5-7.5)	80.0 (80.0-80.0)	86.0 (86-86)
MOPH Community hospital (MOPH) (669)	27.0 (0-1714)	14.52 (0.0-463.49)	186.0 (51.0-4438.0)	213.0 (51-5554)
MOPH General hospital (69)	390.0 (4-2764)	38.16 (0.65-182.32)	1022.0 (268.0-2952.0)	1412.0 (300-5679)
MOPH Regional hospital (25)	515.0 (41-2625)	20.89 (1.89-88.0)	2465.0 (640.0-5304.0)	2980.0 (824-6495)
Private hospital (11)	12.0 (4-243)	5.74 (1.9-194.23)	209.0 (52.0-491.0)	221.0 (51-590)

The hospital level of 90-90-90 indicators

Because the AEM, a denominator of the first 90-90-90 was not available at the hospital level, only the second and the third indicator were available. The median was 80.66% and 84.21% for the second and the third 90-90-90 indicators, respectively. We further broke down the indicators by hospital type in Table 26.

Table 26 Thailand second and third 90-90-90 at hospital level stratified by hospital type, 2018

Hospital Type (n)	Second 90-90-90	Third 90-90-90
Public Non-MOPH (58)	72.75 (0.0-100.0)	71.65 (0.0-100.0)
MOPH Specialized (17)	75.47 (0.0-100.0)	57.14 (0.0-100.0)
MOPH Community hospital (741)	81.54 (25.0-100.0)	85.94 (0.0-100.0)
MOPH General hospital (69)	79.68 (41.61-86.98)	86.23 (54.28-94.14)
MOPH Regional hospital (25)	79.31 (51.95-85.15)	84.86 (9.96-92.39)
Private hospital (113)	65.24 (0.0-100.0)	0.0 (0.0-100.0)

In both second and third 90-90-90 indicators, no hospital achieved a level of higher than 100%. However, several private hospitals report an indicator of 0%. Of 35 hospitals report 0% of the second 90-90-90 indicators, 32 were private hospitals. Of 78 hospitals report 0% of the third 90-90-90 indicators, 59 were also private hospitals. There was 35 hospitals report both indicators of 0%, 32 of them were private hospitals.

This was consistent as the private hospital did not have a reimbursement of laboratory and ARV expenses from NAP. While they still reported the HIV patients' number to NAP, they did not report the patients receiving ARV and those who achieve the viral suppression level. Thus, the second and third 90-90-90 indicators were not available.

Table 27 The second 90-90-90 Indicators categories stratified by hospital type, Thailand 2018

	The second 90-90-90 indicators		
Hospital Type (n)	0-50 (%)	51-75 (%)	75-100 (%)
Public Non-MOPH (58)	15 (25.86)	16 (27.59)	27 (46.55)
MOPH Specialized (16)	7 (41.18)	1 (5.88)	9 (52.94)
MOPH Community hospital (741)	7 (0.94)	132 (17.81)	602 (81.24)
MOPH General hospital (69)	2 (2.9)	15 (21.74)	52 (75.36)
MOPH Regional hospital (25)	0 (0.0)	6 (24.0)	19 (76.0)
Private hospital (113)	46 (40.71)	16 (14.16)	51 (45.13)

We broke down the second and the third indicator by hospital type in Table 27 and Table 28 respectively. When stratified into the 90-90-90 indicators progress category of 0-50, 51-75 and 75-100% respectively, the three-hospital type of public non-MOPH, MOPH specialized and private hospitals had the lowest 75-100% category percentage across both second and the third indicators.

Table 28 The third 90-90-90 Indicators categories stratified by hospital type, Thailand 2018

	The third 90-90-90 indicators		
Hospital Type (n)	0-50 (%)	51-75 (%)	75-100 (%)
Public Non-MOPH (50)	17 (29.31)	15 (25.86)	26 (44.83)
MOPH Specialized (11)	8 (47.06)	3 (17.65)	6 (35.29)
MOPH Community hospital (736)	16 (2.16)	108 (14.57)	617 (83.27)
MOPH General hospital (69)	0 (0.0)	12 (17.39)	57 (82.61)
MOPH Regional hospital (25)	1 (4.0)	2 (8.0)	22 (88.0)
Private hospital (54)	65 (57.52)	22 (19.47)	26 (23.01)

The highest number and percentage of the 0-50 category of both second and third indicators, were private hospitals and the MOPH Specialized hospitals.

All MOPH hospitals, except for the MOPH specialized, had an exceptionally low hospital count in the 0-50 category of both indicators. MOPH community hospitals achieve the highest hospital count proportion of the second 90-90-90 indicator 75-100 category while the MOPH regional hospitals count proportion is the highest in the third 90-90-90 indicators.

Bed capacity

When stratified by hospital type, MOPH regional hospitals had the largest bed capacity. Public Non-MOPH had 322.47 bed capacity on average but their capacity varies greatly from 10 – 1,792 beds. MOPH community hospital had the smallest capacity of all (42.84 beds on average). The private hospital had 130.22 bed capacity on average ranging from 10-600 beds. Table 29 summarized the bed capacity across hospital types.

Table 29 Hospital bed capacity stratified by hospital type, Thailand 2018 (Only those submitted data to at least one databases)

Hospital Type (n)	Average Bed capacity (Lowest-Highest)

Public Non-MOPH (58)	322.47 (10-1,792)
MOPH Specialized (17)	242.06 (15-909)
MOPH Community hospital (740)	42.84 (6-269)
MOPH General hospital (69)	336.29 (120-600)
MOPH Regional hospital (25)	703.24 (370-1,039)
Private hospital (113)	130.22 (10-600)

There were care level data available for 834 hospitals. The Primary care hospital had a 100 beds capacity. However, the number was from a single primary care hospital in the database. Three classes of secondary level had an average bed capacity of 363, 54.98, and 269.93 beds for small, medium, and advanced classes, respectively. Tertiary care had the largest average bed capacity of 615.79 beds as shown in Table 30.

Table 30 Hospital bed capacity stratified by care level, Thailand 2018

Hospital care level (n)	Average Bed capacity (Lowest-Highest)
Primary (1)	100 (100-100)
Secondary (small) (522)	363 (6-120)
Secondary (medium) (199)	54.98 (10-152)
Secondary (advance) (73)	269.93 (60-578)
Tertiary (39)	615.79 (200-1,039)

At the provincial level, Bangkok bed capacity was far higher than the rest of the country (31,241 beds vs the country average of 1,869.49 beds). Before excluding Bangkok, the figure clearly shows bed capacity concentration in the Bangkok area (Figure 45). After excluding Bangkok, the figure show concentrate on Northern, North-Eastern, and southern where a large regional city exists. The provincial bed capacity average also dropped to 1,483.3 beds.

At this point, we determine that using the care level data for the hospital category was not feasible as several hospital data were missing. As higher care levels also had more bed capacity, we assume that the hospital treatment capability was taken into account by the bed capacity. Therefore, only hospital type data was used to categorized hospitals.

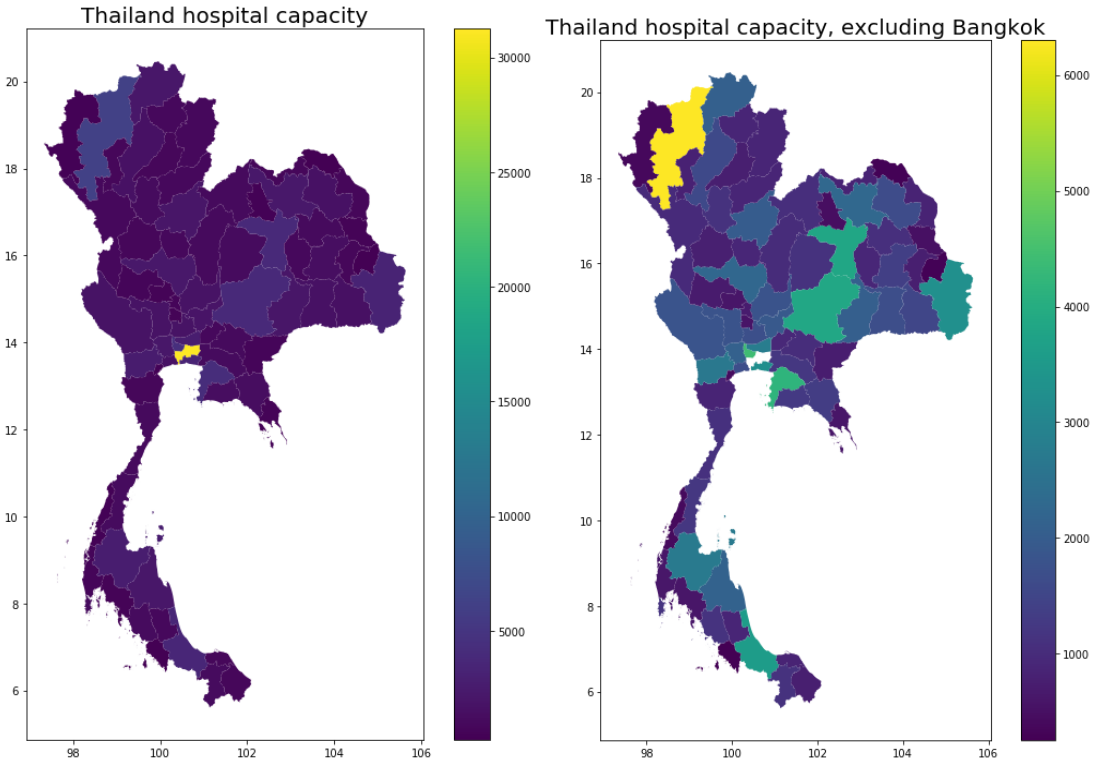


Figure 45 Provincial total bed capacity (Left) With Bangkok (Right) Without Bangkok

In several previous two data sources difference tables, each hospital type shows a remarkable wide range. These findings provide a clue about the different nature of each hospital type internally, which needed to be explored in the field visit. Therefore, we explored whether stratified bed capacity by quartiles may reveal the pattern of the two data source difference.

Table 31 Thailand two data sources difference at hospital level stratified by hospital bed capacity, 2018

Bed capacity (n)	Median Absolute Difference between two data sources	Median Absolute Percentage of Two-data sources difference	Median NAP HIV patient count	Median MOPH patient count
1-30 (495)	33 (0-940)	30.69 % (0-3600)	121 (0-746)	142 (0-1,305)
31-100 (311)	70 (0-1,714)	31.69 % (0-6900)	262 (0-1,503)	257 (0-2,631)
101-500 (167)	264 (2-2,995)	49.19 % (0.45-281.82)	796 (2-5,626)	497 (0-7,187)
501-1,000 (44)	754 (17-6,491)	35.44 % (18-100)	2,141 (90-6,491)	2,201 (0-6,495)
>1,000 (5)	791 (148-2,801)	100 % (64-100)	2,452 (716-3,931)	0 (0-5,209)

Bed capacity available for 1,022 hospitals and they were classified into 5 categories to replicate the care level categories. More than 75% of hospitals had less than 100-bed capacity. Approximately half of the hospitals were classified into 0-30 beds.

The largest hospital category (>1,000 beds) had the highest two data source difference. The reason was 3 of 5 >1,000-beds hospitals were Public non-MOPH hospitals, the other two hospitals were MOPH hospitals. In other words, only 2 hospitals in this category were bound to submit data to MOPH causing the two data sources difference to be exceptionally large.

The second largest two data source difference came from the 100-500 beds hospitals. While their two data sources difference were less than the >1,000 beds category, they have more impact on Thailand from their higher number of 44 hospitals compared to 5 hospitals from the >1,000 beds category.

When stratified the second and the third indicator by bed capacity categories (Table 32 and Table 33), the hospital with a bed capacity of 100-500 had the lowest hospital counts that achieved both indicators of 75-100%. The results from the largest hospital's capacity of >1,000 beds fluctuated very high from its low hospital counts of 5 hospitals. The difference between the other hospital bed capacity categories was narrow.

Table 32 The second 90-90-90 Indicators categories stratified by bed capacity, Thailand 2018

	The second 90-90-90 indicators		
Bed capacity (n)	0-50 (%)	51-75 (%)	75-100 (%)
1-30 (495)	9 (1.82)	90 (18.18)	396 (80.0)
30-100 (311)	32 (10.29)	52 (16.72)	227 (72.99)
100-500 (167)	34 (20.36)	34 (20.36)	99 (59.28)
500-1000 (44)	2 (4.55)	7 (15.91)	35 (79.55)
>1000 (5)	0 (0.0)	3 (60.0)	2 (40.0)

Table 33 The third 90-90-90 Indicators categories stratified by bed capacity, Thailand 2018

	The third 90-90-90 indicators		
Bed capacity (n)	0-50 (%)	51-75 (%)	75-100 (%)
1-30 (495)	20 (4.04)	78 (15.76)	397 (80.2)

30-100 (311)	47 (15.11)	44 (14.15)	220 (70.74)
100-500 (167)	36 (21.56)	32 (19.16)	99 (59.28)
500-1000 (44)	2 (4.55)	7 (15.91)	35 (79.55)
>1000 (5)	1 (20.0)	1 (20.0)	3 (60.0)

PEPFAR Funding

As of 2018, 33 hospitals across 5 provinces in Thailand received funding and support from PEPFAR. Ten hospitals were in Bangkok. The majority of the hospitals were MOPH community hospitals and other MOPH hospitals type. There were Public non-MOPH hospitals and no MOPH specialized hospitals.

Table 34 described two data sources difference among PEPFAR funded hospitals. Among them, 29 hospitals submitted data to both databases. Four hospitals submitted to NAP only, and no hospitals only data to MOPH. Using the median, the hospitals submitted data to the NAP of 589 and 531 patients to the MOPH. The median difference was 41 patients or 26.86 %.

Unlike the rest of the study, PEPFAR funded MOPH general hospitals submitted data to NAP more than MOPH with the exceptionally low two percentage difference of less than 10%. However, the number was from only one hospital.

While there was no MOPH specialized receiving PEPFAR funding, the public non-MOPH achieved the highest two data sources difference among PEPFAR funded hospitals (Table 34).

Table 34 PEPFAR hospitals two data sources difference at hospital level stratify by hospital affiliation, 2018

Hospital Type (n)	Median Absolute Difference between two data sources	Median Absolute Percentage of Two-data sources difference	Median NAP HIV patient count	Median MOPH patient count
Public Non-MOPH (11)	1,283.0 (179-2801)	75.78 % (22.82-100.0)	1,693 (196 - 2,936)	410 (0- 2,266)
MOPH Community hospital (MOPH) (18)	32.5 (12-713)	7.33 % (2.73-212.84)	444 (126 – 1,294)	476 (85-1,921)
MOPH General hospital (1)	191.0 (191-191)	6.47 % (6.47-6.47)	2,952 (2,952-2,952	2,761 (2,761-2,761

MOPH Regional hospital (3)	917.0 (822-1845)	21.37 % (19.15-40.47)	4,292 (3,931-4,559	5,209 (5,114-6,404)

For the second and the third 90-90-90 indicators, only two of the PEPFAR funded hospitals achieve 0-50% of the second indicators and no hospitals achieve 0-50% of the third indicators. PEPFAR funded hospitals, overall achieved much better of the third 90-90-90 indicators than the second indicator (Table 35 and Table 36).

Table 35 The second 90-90-90 Indicators categories stratified by bed capacity, PEPFAR funded hospitals, Thailand 2018

	The second 90-90-90 indicators		
Bed capacity (n)	0-50 (%)	51-75 (%)	75-100 (%)
1-30 (11)	1 (9.09)	2 (18.18)	8 (72.73)
30-100 (18)	0 (0.0)	3 (16.67)	15 (83.33)
100-500 (1)	0 (0.0)	0 (0.0)	1 (100.0)
500-1000 (3)	0 (0.0)	2 (66.67)	1 (33.33)
>1000 (11)	1 (9.09)	2 (18.18)	8 (72.73)

Table 36 The third 90-90-90 Indicators categories stratified by bed capacity, PEPFAR funded hospitals, Thailand 2018

	The third 90-90-90 indicators		
Bed capacity (n)	0-50 (%)	51-75 (%)	75-100 (%)
1-30 (11)	0 (0)	2 (18.18)	9 (81.82)
30-100 (18)	0 (0)	1 (5.56)	17 (94.44)
100-500 (1)	0 (0)	0 (0.0)	1 (100.0)
500-1000 (3)	0 (0)	0 (0.0)	3 (100.0)
>1000 (11)	0 (0)	2 (18.18)	9 (81.82)

Analysis of possible association factors for the two data sources difference with multivariate linear regression

In this section, we explored the potential associated factors of the two data sources difference using multivariate linear regression. The dependent factor was defined as an absolute percentage of two data sources difference while bed capacity, PEPFAR funding, and hospital classes were included as

independent factors, the results are described in Table 37. Only hospitals submitting more than 10 patients to NAP were included in the regression.

Table 37 Multivariate linear regression of two data sources potential associate factors, hospital level

Contributing factors	Co-efficiencies	p-value
Bed capacity	0.01	0.64
PEPFAR Funding	-7.17	0.46
Hospital type		
- MOPH Community hospital	19.49	0.18
- Public Non-MOPH	42.56	<0.05*
- MOPH Specialized	39.37	<0.05*
- MOPH General hospital	13.52	0.32
- MOPH Regional hospital	Ref	
- Private hospital	70.13	<0.05*

Using MOPH regional hospitals as a reference, Public non-MOPH, MOPH specialized, and private hospitals show a statistically significant association of having a higher two data sources percentage difference. Having PEPFAR support is the only contributing factor that reduces the two data sources' difference. However, the PEPFAR support association was not statistically significant.

Table 38 Multivariate linear regression of two data sources potential associate factors, hospital-level excluding Bangkok

Contributing factors	Co-efficiencies	p-value
Bed capacity	-0.001	0.68
PEPFAR Funding	-6.73	0.56
Hospital type		
- MOPH Community hospital	8.21	0.67
- Public Non-MOPH	26.70	0.14
- MOPH Specialized	25.39	0.31
- MOPH General hospital	7.27	0.63
- MOPH Regional hospital	Ref	
- Private hospital	57.43	<0.05*

After Bangkok was excluded, only private hospitals association remain statistically significant.

We explored further by switching the unit of analysis to the province to facilitating site selection as the final selection for the qualitative assessment needed to be approved by provincial authority.

Absolute two data sources percentage difference remained as the dependent variable and total bed capacity, PEPFAR funding as the independent variables.

Table 39 Multivariate linear regression of two data sources potential associated factors, provincial level

Contributing factors	Co-efficiencies	p-value
Bed capacity	0.02	<0.05*
PEPFAR Funding	-37.70	<0.05*

Table 39 describes potential associated factors to two-data source difference, with hospital and province as a unit of analysis respectively, we found bed capacity was positively associated with the absolute two data sources percentage difference. Having PEPFAR funding negatively associate with the two data sources difference. In other words, the finding provides a clue that PEPFAR support may contribute to the discrepancies reduction between the two data sources. However, the association completely changed after excluding Bangkok as described in Table 40.

Table 40 Multivariate linear regression of two data sources potential associate factors, provincial level, excluding Bangkok

Contributing factors	Co-efficiencies	p-value
Bed capacity	0.001	0.84
PEPFAR Funding	8.73	0.32

The finding is remarkable considering that PEPFAR funding also supports several capacities including training, technical support, and funding. However, having PEPFAR support did not shows statistically significant association regardless of the hospital or provincial level. The changes in the results after removing Bangkok show the magnitude to what extent the impact it had on the national situation interpretation and the importance of conducting the Bangkok field visit in this study.

Considering the limited time and logistics challenge, the team decided to focus on PEPFAR funded province (Bangkok is one of the provinces receiving PEPFAR funding) as PEPFAR funded province have much better cooperation as PEPFAR is one of the dissertation's stakeholder.

Analysis of possible association factors to the second and the third 90-90-90 indicators with multivariate linear regression

This section explored the possible association factors to the second and the third 90-90-90 indicators using multivariate linear regression.

Table 41 Multivariate linear regression of the second 90-90-90 indicators and possible contribution factors

Contributing factors	Co-efficiencies	p-value
Bed capacity	0.0002	<0.05*
PEPFAR Funding	0.06	< 0.05*
Hospital level		
- MOPH Community hospital	0.16	<0.05*
- Public Non-MOPH	-0.17	<0.05*
- MOPH Specialized	-0.27	<0.05*
- MOPH General hospital	0.07	0.06
- Private hospital	-0.37	<0.05*

In Table 41, most independent factors achieved statistically significant to the second 90-90-90 indicators. While most factors association were positive, public non-MOPH, MOPH specialized, and the private hospital have a negative association. Only MOPH general hospitals did not have a statistically significant association.

Although having more bed capacity was associate with a higher second 90-90-90, the association is very weak. Having PEPFAR funding, also improve the second indicators. In comparison to MOPH regional hospital, the MOPH community hospital type has a much higher second indicator while the private hospitals achieve the lowest. MOPH General hospital achieves a similar level of the second indicator compared to the MOPH regional hospitals.

Table 42 Multivariate linear regression of the third 90-90-90 indicators and possible contribution factors

Contributing factors	Co-efficiencies	p-value
Bed capacity	0.0001	<0.05*
PEPFAR Funding	0.09	<0.05*
Hospital level		
- MOPH Community hospital	0.14	<0.05*

-	Public Non-MOPH	-0.14	<0.05*
-	MOPH Specialized	-0.26	<0.05*
-	MOPH General hospital	0.09	0.06
-	Private hospital	-0.36	<0.05*

For the third 90-90-90 indicators in Table 42, the direction and strength of the association were identical to those of the second indicators. A possible reason was for the calculation of the third indicator we used the number of patients receiving ARV as the denominator. The patient receiving ARV, however, was the nominator of the second indicator calculation.

The additional analysis was conducted using univariate linear regression and found that the second and the third indicators association is strong with a statistically significant coefficient of 0.83.

The value of 0.83 is the same as the third 90-90-90 indicator of 83%. This is because the patients who achieve the VL suppression level are those who receive ARV and were used to calculate for both the second and the third indicators. Therefore, we imply collinearity and did not include the second indicator as to the independent variable for the third indicator multiple linear regression.

Normalized multiple linear regression

In the previous section, the analysis was conducted using linear regression when the assumption of normality holds per requested from stakeholders. However, we discovered that the distribution was not normal and there was needed a normalizing of the two data sources using the log function.

In this section, we re-did the multiple linear regression using the log absolute two percentage difference as dependent factors

Of all hospitals in the study, we identify the public non-MOPH, MOPH specialized, and the private hospital was statistically associated with higher normalized two data source differences.

Unlike the non-normalized regression, the bed capacity and PEPFAR funding association were not statistically significant.

Table 43 Multivariate linear regression of normalized two data source difference and possible contribution factors

Contributing factors	Co-efficiencies	p-value
Bed capacity	-0.001	0.29
PEPFAR Funding	-0.16	0.47
Hospital level		
- MOPH Community hospital	0.005	0.99
- Public Non-MOPH	1.14	<0.05*
- MOPH Specialized	1.11	<0.05*
- MOPH General hospital	0.04	0.89
- MOPH Regional hospital	Ref	
- Private hospital	1.31	<0.05*

Of hospital submitting more than 50 cases, no factors were statistically significantly associated with the normalized two data sources difference.

Table 44 Multivariate linear regression of normalized two data source difference and possible contributing factors among hospital submitted more than 50 cases

Contributing factors	Co-efficiencies	p-value
Bed capacity	-0.001	0.51
PEPFAR Funding	0.03	0.89
Hospital level		
- MOPH Community hospital	-0.09	0.84
- Public Non-MOPH	0.10	0.80
- MOPH Specialized	0.46	0.48
- MOPH General hospital	0.05	0.89
- MOPH Regional hospital	Ref	
- Private hospital	-0.10	0.86

Among hospitals submitting less than 50 cases, bed capacity remains non-statistically significant, non of the PEPFAR funded hospitals were among this group. It was important to emphasize that no MOPH regional hospitals submitted less than 50 cases, therefore, we could not use the MOPH regional hospitals as a reference group and we switched to MOPH community hospital instead. MOPH specialized and private hospitals were statistically significantly associated with having a high two data source difference. The finding supports our hypothesis that the hospital submitted less than 50 cases largely contribute to the association with the two data source difference.

Table 45 Multivariate linear regression of normalized two data source difference and possible contributing factors among hospital submitted less than 50 cases

Contributing factors	Co-efficiencies	p-value
Bed capacity	-0.001	0.83
PEPFAR Funding	-	-
Hospital level		
- MOPH Community hospital **	Ref.	
- Public Non-MOPH	1.24	<0.05*
- MOPH Specialized	0.78	0.07
- Private hospital	0.84	<0.05*

**Because there was not MOPH Regional hospital that submitted less than 50 cases, the reference group was switched to MOPH Community hospital instead.

DQI Results

Patients and hospital characteristics

Of the 26 hospitals that agreed to participate in the study, one hospital was excluded from DQI Tools implementation due to a technical problem, therefore 25 hospitals across 5 provinces were included in the study. The excluded hospital remained to participate in our field visits and field interviews.

This section focused on the DQI Tools report generated from the hospital database during the field visit. While DQI Tools also provide local health personnel with several reports for HIV care services, discussing their usability was not within the study scope.

Overall, hospital characteristics were shown in Table 46. There were 7,213 beds capacity in total or 288.52 beds on average covering 36,115 MOPH and 35,947 NAP HIV patients with an average absolute two data sources difference of 499% according to both database reports. When stratified by hospital type, 11 hospitals were community and 10 were non-MOPH hospitals. There were 11 secondary hospitals, 4 tertiary hospitals, and one primary care hospital included in the field visit. The rest did not specify their care level nor hospital type in the database.

Table 46 Participated Hospitals by characteristics from NAP and MOPH national level, 2018

Characteristic	Number
Total Bed capacity	7,213
Average bed capacity	288.52 (30-1,039)

Hospital type	
- MOPH Community hospital	11
- Public Non-MOPH	9
- Private	1
- MOPH General hospital	1
- MOPH Regional hospital	3
Care level	
- Secondary basic	3
- Secondary medium	5
- Secondary advance	3
- Tertiary	4
NAP PLHIV	
- Total	36,115
- Average	1,445 (139-4,559)
- Median	813
MOPH HIV Count	
- Total	35,947
- Average	1,437 (0-6,404)
- Median	1,048
Absolute Percentage difference Average	499% (3.38-212.84)
Median	32.51%

The DQI Tools reports provided a total of 63,721 HIV patients including 10,810 deaths from the NAP database among 25 study sites, several of them do not have demographic data (36,997 or 58.6%). Among them, males remained as a major patients population (21,615 or 58.42%). Patients older than 50 years old were responsible for the highest percentage across both sexes (33.18%) as shown in Table 47. The highest patient count population was male patients older than 50 years old. Unfortunately, analyzing more details on the entire HIV database at study sites were not allowed.

Table 47 NAP patient demographic among 25 study sites

Age group	Male (% Column)	Female (% Column)	Total (%)
<15	98 (0.56)	87 (0.45)	185 (0.50)
15 TO 19	107 (0.82)	126 (0.5)	233 (0.63)
20 TO 24	791 (3.50)	538 (3.66)	1,329 (3.59)
25 TO 29	1,849 (5.40)	831 (8.55)	2,680 (7.24)
30 TO 34	2,550 (6.77)	1,041 (11.80)	3,591 (9.71)
35 TO 39	2,703 (10.12)	1,557 (12.51)	4,260 (11.51)
40 TO 44	3,129 (16.67)	2,564 (14.48)	5,693 (15.39)
45 TO 49	3,420 (21.49)	3,306 (15.82)	6,726 (18.18)
50+	6,950 (34.62)	5,325 (32.15)	12,275 (33.18)
UNKNOWN	18 (05)	7 (08)	25 (07)
Total	21,615 (58.42)	15,382 (41.58)	36,997

DQI Tools Loss-follow-up Output

There were 7,991 loss-follow-up patients among 25 study sites from the NAP database. However, the number includes 499 duplicated records. There were 5 records with invalid SSN and 96 records without SSN in the NAP database among study sites, which were also excluded. At this point, 7,391 loss-follow-up HIV patients remained.

Among remaining patients, only 3,337 (45.1%) have sex data, and males remained to be the majority of patients of 1,927 or 57.75%. Patients older than 50 years old (50+) remained as the highest contribution age group for both sexes as shown in Table 48.

Table 48 NAP loss-follow-up patient demographic among 25 study sites

Age group	Male (% Column)	Female (% Column)	Total (%)
0 TO 15	3 (0.16)	3 (0.21)	6 (0.18)
15 TO 19	8 (0.42)	13 (0.92)	21 (0.63)
20 TO 24	111 (5.76)	80 (5.67)	191 (5.72)
25 TO 29	229 (11.88)	129 (9.15)	358 (10.73)
30 TO 34	286 (14.84)	165 (11.70)	451 (13.52)
35 TO 39	247 (12.82)	170 (126)	417 (12.50)
40 TO 44	226 (11.73)	201 (14.26)	427 (12.80)
45 TO 49	212 (110)	249 (17.66)	461 (13.81)
50+	601 (31.19)	397 (28.16)	998 (29.91)
UNKNOWN	4 (0.21)	3 (0.21)	7 (0.21)
Total	1,927	1,410	3,337

We explored further on loss-follow-up characteristics. NAP has three loss-follow-up patient categories.

- Lost1: HIV positive but was not registered to NAP
- Lost2: Registered but no ARV was given
- Lost3: Lost follow-up after ARV.

Of 25 study sites, NAP reported 7,991 lost follow-up patients. Among them, 499 duplicated were identified and removed by the DQI tools, along with 96 invalid SSN and 5 without SSN. At this stage, 7,391 loss-follow-up were left for further analysis.

Among 7,391 patients, there were 1,043 patients with HIV positive but did not register to NAP (Lost1), 1,978 patients when registered but did not receive ARV, and 4,372 who lost follow-up after ARV initiation. Sixty-eight patients were found to be dead. After removing 68 deaths, there were 7,323 lost-follow-up patients remained (Table 49).

Table 49 NAP Loss-Follow-up by loss follow-up category and alive/dead status among 25 hospitals, after removing duplicate

Alive/Dead	Lost1	Lost2	Lost3	Total
Alive	1,039	1,948	4,336	7,323
Dead	2	30	36	68
Total	1,041	1,978	4,372	7,391

There was 7 patient status generated from DQI Tools: “Currently on ARV”, “Follow-up without ARV at other hospitals”, “Lost follow-up after ARV”, “Lost follow-up before ARV initiation”, “Misdiagnosis (negative HIV test or Inconclusive)”, and “need HIV result verification”. We started by looking at DQI tools generated list of patients' status and compared to NAP Lost 1-3 category in Table 50.

Table 50 DQI Tools generated final patient status by NAP lost patient categories

DQI Output Patient Status	Lost1	Lost2	Lost3	Count (%)
Currently on ARV				886 (12.10)
			x	859
		x		27
Follow-up with ARV in other hospitals				390 (5.33)
			x	357
		x		33
Follow-up without ARV at other hospitals		x		5 (07)
Lost-follow-up after ARV				3,120 (42.61)
Lost-follow-up before ARV				1,140 (15.57)
		x		1,021
	x			119
Misdiagnosis (HIV negative or Inconclusive)		x		2 (03)
Need HIV result verification				1,780 (24.31)
		x		860
	x			920
Total				7,323

There were 886 patients reported from NAP who remained on ARV treatment and regularly follow-up with their physician. There were 390 patients remained on ARV in other hospitals and 5 patients regularly follow-up without ARV in other hospitals. In other words, 1,281 from 7,323 (17.49%) lost follow-up reported by NAP were still receiving their treatment regularly.

The "Need HIV result verification" category consisted of 1,780 patients and it was important as they had absolutely no HIV-related laboratory nor ARV prescribing history in both NAP and MOPH. Moreover, 920 of 1,780 were labeled as Lost1 or never registered to NAP (no patient ID) but were existed in the NAP database. One important concern was patients in this category have no patient ID, recruiting them back to the HIV care system was impossible.

Two patients were identified as misdiagnosis or having negative HIV results but were recorded to NAP as HIV positive patients.

The number of confirmed loss-follow-up was 4,260 from Lost follow-up after ARV had the highest number of 3,120 (42.61%) and Lost-follow-up before ARV (1,140 or 15.57%).

At this point, among 7,323 lost follow-ups, 6,040 (82.48%) were identified by the DQI Tools (1780 Need to confirm HIV laboratory result and 4,260 confirmed as loss-follow-up) as a list to verify their HIV laboratory results and recruit back to the HIV care system or as potential excluded from the calculation of the 90-90-90 indicators.

So far, the number of confirmed loss follow-up patients was 4,260 or 58.17% of the total reported as loss-follow-up by NAP. In other words, only 58.17% of NAP reported loss-follow-up is a real loss.

The overall summary of DQI Output is visualized in Figure 46.

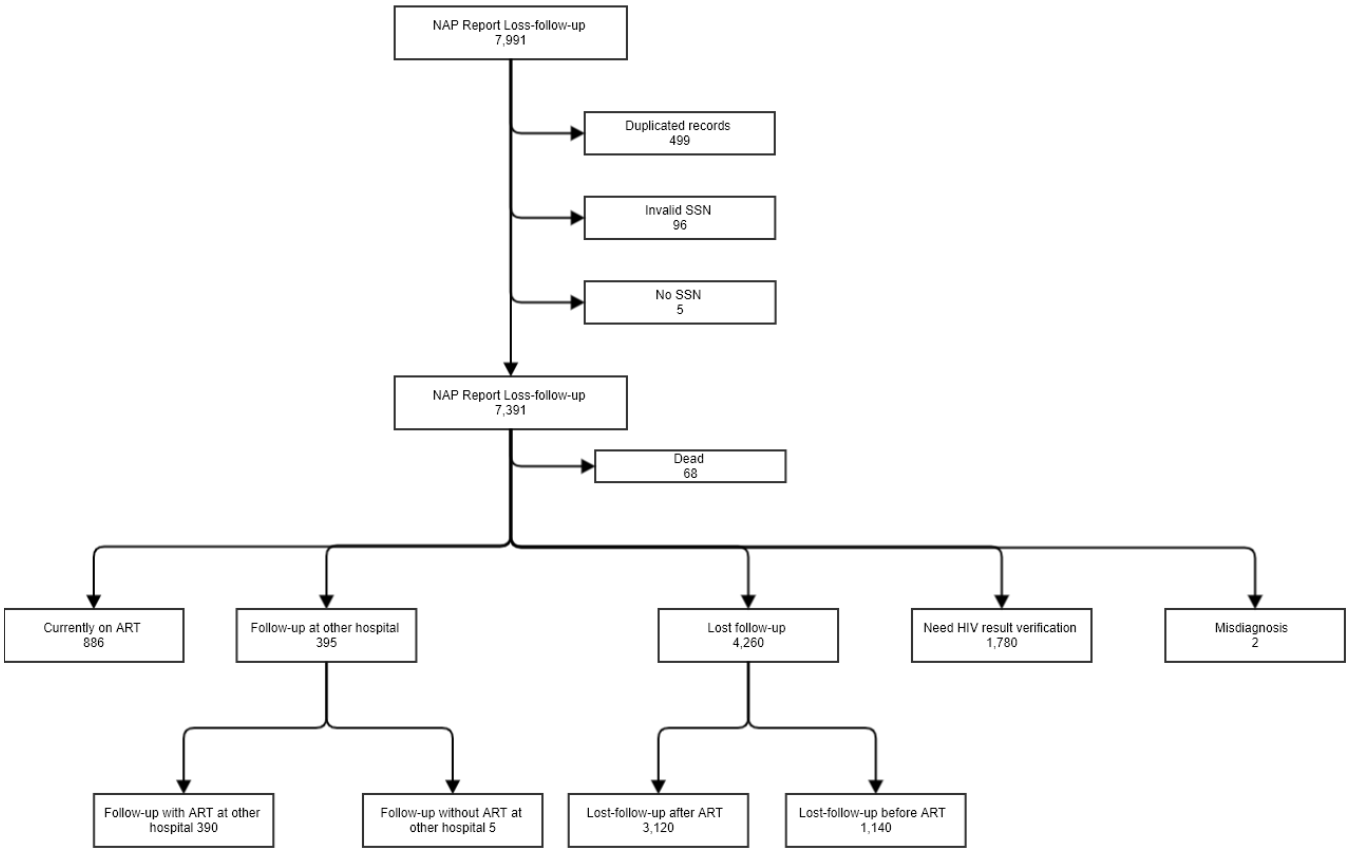


Figure 46 TUC DQI Tools results of 23 hospitals break down by output category. NAP reported of 7,991 lost-follow-up patents. After cleaning with DQI Tools, 7,391 were left for analysis.

Starting from NAP reported loss-follow-up of 7,991 patients, the number where stakeholders obtained before DQI Tools. We were able to identify duplicated invalid data and provide the list of patients among “Lost follow-up” and “Need HIV result verification” from whom hospitals have to work on medical record reviewing and recruit them back to the HIV care system. This was extremely useful for the hospital HIV personnel as they only needed to look at 4,260 lost follow-up patients instead of 7,991 or a 46.69% reduction in their workload. However, among the “Need HIV result verification” category, the MOPH and NAP may have to decide on what extent records of this category should be removed from the indicator calculation.

DQI Loss-follow-up length

We explored the DQI results further by assessing the loss-follow-up length from NAP as presented in Table 51. Most loss-follow-up patients were in the "0-1 years" bracket followed by "1-2 "and "> 10 years", respectively. Most patients in the "Need HIV result verification" category were diagnosed more than 10 years ago. However, from the "Need HIV result" category was from the 7-10 years bracket. Also, most patients (1,124 of 1,126 patients or 99.82%) who were in "still follow-up" were in the 0-1 years loss-follow-up length reported by NAP. The last patient that was reported of the follow-up was in the 3-4 years bracket. Among two misdiagnosis cases, the last patient was reported by NAP in the 1-2 years bracket.

Table 51 DQI Status output by NAP loss follow-up length

DQI Status Output	Loss follow-up year reported in NAP										
	2018-2017	2016-2017	2015-2016	2014-2015	2013-2014	2012-2013	2011-2012	2010-2011	2009-2010	2008-2009	<2008
Still follow-up	1124	1		1							
Lost Follow-up	1797	1187	475	235	151	91	67	30	35	29	182
- Lost after ARV	1347	857	356	187	115	73	54	30	35	29	55
- Lost before ARV	450	330	119	48	36	18	13				127
Misdiagnosis	1	1									
Need HIV result verification	455	252	80	33	23	19	10				984
Total	3377	1441	555	269	174	110	77	30	35	29	1166

Follow-up chart-review by local personnel

At the end of the DQI activities, the list of the loss-follow-up patients and those who needed to confirm diagnosis were distributed in a list of 6,040 patients (1,780 "Need HIV result verification" and 4,260 "Loss follow-up") in four Microsoft Excel files for the local personnel along with other HIV service reports recruiting back the patients to the HIV care system. The results of 1,488 were submitted to the project team within 3 months period after the training workshop and were described in Table 52. Of 1,780 "Need HIV result verification" category, 4 patients were confirmed as HIV negative, 9 patients had no HIV test results and 30 were unreachable.

Table 52 Chart review results from DQI Tools

Chart review and recruit summary	Lost-follow-up after ARV	Lost-follow-up before ARV	Need HIV result verification	Total
Confirm HIV Negat	1		4	5
No HIV test			9	9
Unable to contact	841	262	30	1,133
Recruited back to HIV care		6		6
Follow-up with ARV at this hospital	93	79	9	181
Follow-up with ARV at other hospitals	100	50	3	153
Dead		1		1
Total	1,035	398	55	1,488

During the reviewing of the chart, we identified 5 additional confirmed HIV negative patients within the NAP database. One dead patient was found despite being reported as alive in NAP. Also, 181 patients were found "regularly following up" at their hospitals while 153 patients reported being "follow-up with other hospitals". Additional 340 patients were confirmed as "HIV negative", "recruited back to care", "still follow-up up" and "dead" were also excluded. At this stage, the loss-follow-up number was reduced to 5,700 patients (77.83%) from 6,040. The rest were under review by personnel as of December 2019.

VL Level among loss-follow-up patients

Among 7,323 patients, 1,276 were reported as a loss by NAP but found to be currently in follow-up (Table 53), of the 1,194 patients with information about Viral Load level, and 1,152 (96.48%) achieved viral suppression (VL < 1,000 copies). This was important as normally loss-follow-up patients were not included in the third 90-90-90 indicator calculation. The viral suppression level among both groups was much higher than those of the Thailand national third 90-90-90 indicators of 83%.

Table 53 Recent VL Level among NAP loss-follow-up but reported as currently follow-up by DQI Tools

DQI generated patient status	<50	50-1,000	>1000	Total

Currently on ARV	783 (93.77)	27 (3.23)	25 (2.99)	835 (69.93)
Follow-up with ARV in other hospital	327 (919)	15 (4.18)	17 (4.74)	359 (307)
Total	1,110 (92.96)	42 (3.52)	42 (3.52)	1,194

Assessing DQI Tools impact on 90-90-90 Indicators among study sites

At this stage, we developed a proposal for adjusting the NAP HIV report and the 90-90-90 indicators among study sites. However, as the AEM calculation was available only at provincial levels, calculating the first 90-90-90 indicators was not feasible, only the second and third 90-90-90 indicators are available.

At first, calculating NAP among 25 study sites yielded the 90-2 and 90-3 indicators of 802% and 68.68% respectively. We established four scenarios using the DQI Tools application for adjusting the HIV cascade and the 90-90-90 indicators. Each scenario has a different interaction with the revised AEM 2019 estimation and impacted the90-90-90 indicators for the decision-makers to decide based on one of the four scenarios or by requiring additional conditions.

1. DQI Corrected-1

   This is a default correction by the tools, by integrating both Ministry (MOPH) and NAP databases
2. DQI Corrected-2

   DQI Corrected-1 + excluding patient without HIV results
3. DQI Corrected-3

   DQI Corrected-1 + exclude loss-follow-up and unreachable patients
4. DQI Corrected-4

   DQI Corrected-1 + excluding patient without HIV results and unreachable loss-follow-up patients

At the start of the study, 52,912 Patients were Living with HIV (PLHIV) as reported from NAP. This number was the only number local personnel could obtain before deploying DQI Tools. As stated in the previous section, there were 4 possible data correction scenarios. The tools with the default correction (DQI-Corrected-1) removed 101 invalid SSN and 499 duplicated records and reduced the loss-follow-up from 7,991 to 6,047, (-1,944 patients), or a 24.32% reduction. That left 52,313 (98.87% compared to PLHIV reported from NAP or 1.13% reduction) patients at this stage. The second scenario (DQI-Corrected-2) further excluded 1,780 patients who needed HIV result verification further reducing the PLHIV number to 50,533 and the loss-follow-up patient to 4,267, 3,724 patients or 46.60% reduction from NAP report. The third scenario excluded 1,103 unreachable HIV patients from DQI-Corrected-1, reducing the PLHIV number to 51,210 and loss-follow-up patients to 4,944, 3047 patient reduction, or 38.13% reduction from NAP. The fourth scenario removed both HIV result verification and unreachable HIV patient from DQI-Corrected-1, giving the final PLHIV of 49,430 (93.42% or 6.58% reduction) and loss-follow-up patients to 3,164, reducing 4,827 patients or 60.41% from NAP. The overall flow and all DQI-Corrected scenarios were described in Figure 47.

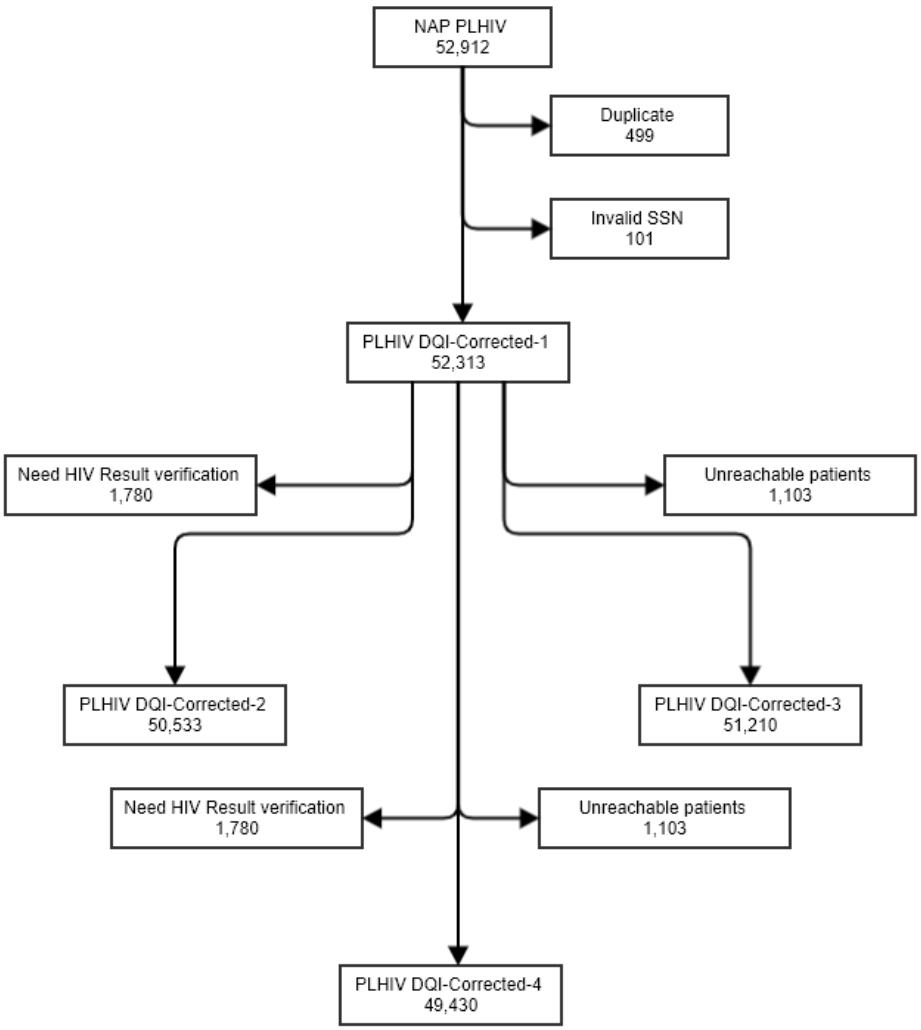


Figure 47 PLHIV Flow chart from NAP report to DQI-Corrected scenarios 1-4.

On the contrary to loss-follow-up and PLHIV, the scenarios did not have much impact on both patients receiving ARV and VL-suppressed. In addition to the 29,077 patients achieving VL-suppression from NAP, an additional 1,152 (3.96% increase) patients that also achieved VL-suppression among loss-follow-up patients were identified and added by the DQI Tools. That resulted in 30,229 total patients achieving VL-suppression in the DQI-Corrected-1. The number remained unchanged throughout the DQI-Corrected 2-4.

The DQI Tools also identified 1,276 (31% increase) patients who were receiving ARV but were categorized as loss-follow-up in NAP and adding back to 42,339 patients receiving ARV reported in

NAP. That gave the final number of 43,615 patients. Similar to the VL-suppression, the number remained unchanged through DQI-Corrected 2-4 scenarios as shown in Table 54 and Figure 48.

Table 54 HIV cascade and 90-90-90 indicators comparison between NAP, DQI-corrected and DQI-corrected without patients with no HIV result and both among 25 study sites

Cascade	NAP Report	DQI Corrected-1	DQI Corrected-2	DQI Corrected-3	DQI Corrected-4
PLHIV	52,912	52,313	50,533	51,210	49,430
Receive ARV	42,339	43,615	43,615	43,615	43,615
Loss Follow-up	7,991	6,047	4,267	4,944	3,164
VL Suppressed	29,077	30,229	30,229	30,229	30,229
90-2	802%	83.37%	86.31%	85.17%	88.24%
90-3	68.68%	69.31%	69.31%	69.31%	69.31%

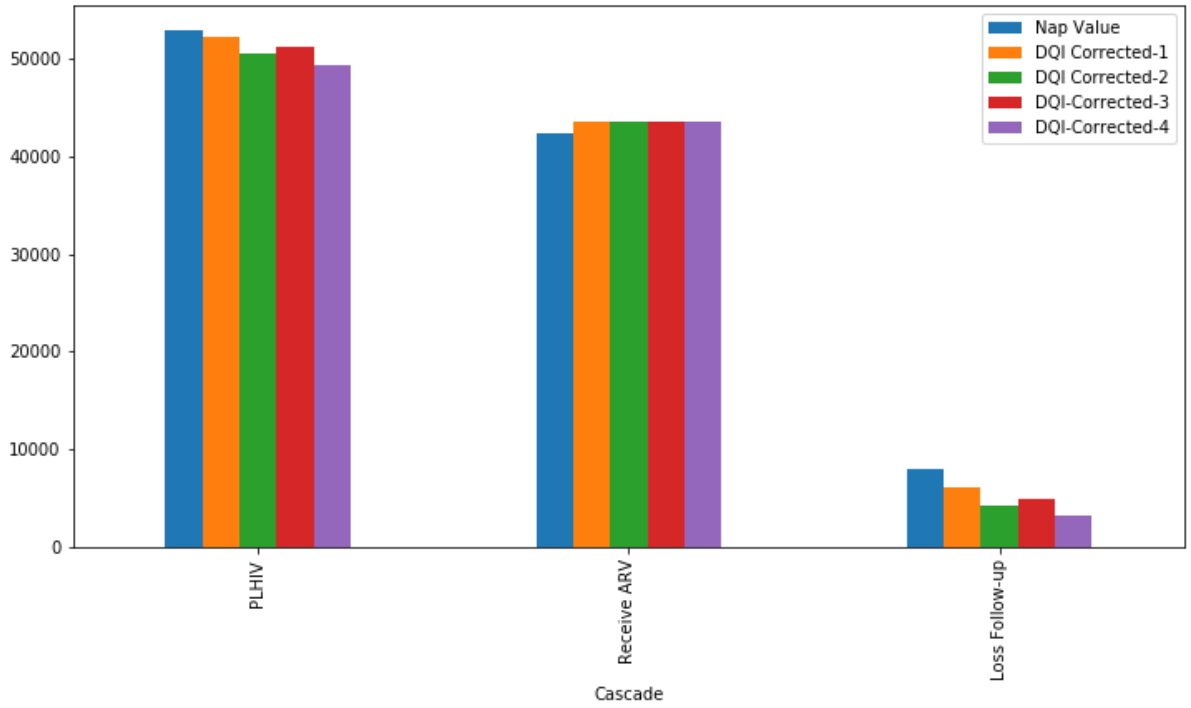


Figure 48 HIV cascade comparison across NAP values and the four DQI corrected scenarios among 25 study sites

Table 54 described the HIV cascade and the 90-2 and 90-3 indicators across four DQI Corrected scenarios compared to the NAP report. With the default DQI Tools correction in scenario 1, both 90-2 and 90-3 indicators were improved to 83.37 and 69.31% respectively. In scenario 2 of excluding all

1,780 lost-follow-up patients without HIV result generated from DQI tools in addition to default correction, 90-2 indicator was improved to 86.31%. The 90-3 indicator remained unchanged as all lost-follow-up patients without HIV result did not have any ARV prescription therefore the 90-3 nominator (Receiving ARV) and denominator (VL suppressed) remain the same. Scenario 3 used DQI Tools default correction and 1,103 patients unreachable by local healthcare personnel improving the 90-2 indicator to 85.17% from the NAP Report. The 90-3 indicator, remained unchanged as unreachable patients did not have ARV prescriptions as well. The last scenario used the DQI Tools default correction along with excluding patients without HIV result and those who were unable to contact of 2,883 patients resulting in the 90-2 and 90-3 indicators of 88.24% and 69.31%. The last scenario improved the 90-2 indicator to nearly achieving a target of 90%. Overall, the impact of the tools was largely on the 90-2 indicators as shown in Figure 49.

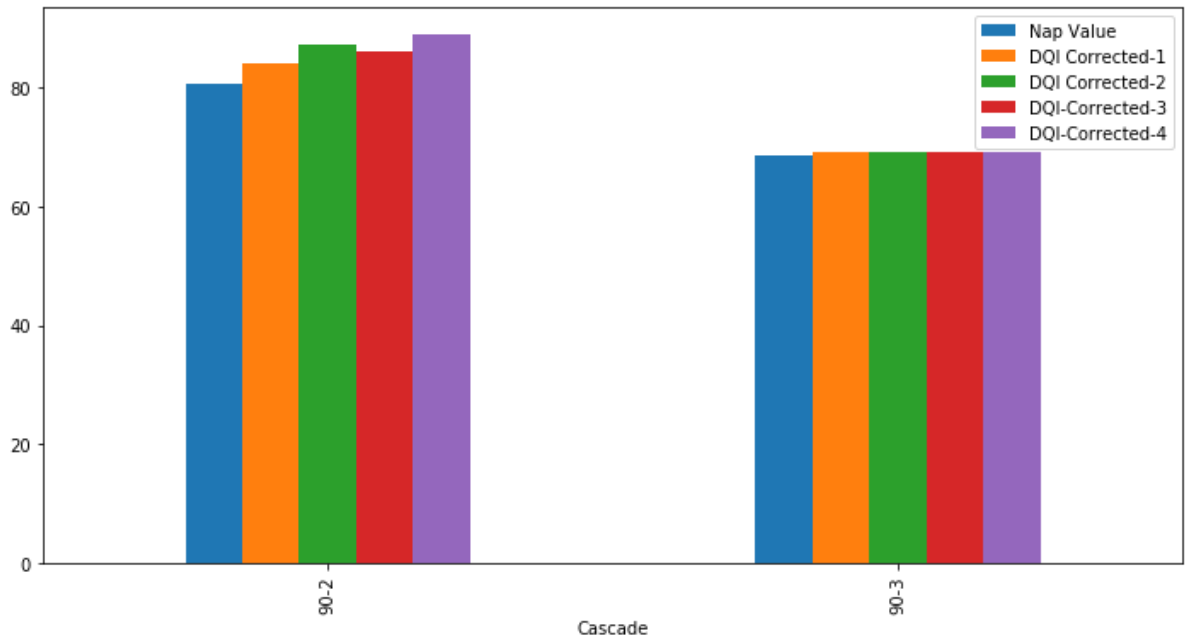


Figure 49 Second and third 90-90-90 indicators comparison across NAP value and four DQI-Corrected scenarios among 25 study sites.

DQI Scenario at individual study sites level

With the NAP report alone, none of 25 sites in this study would be able to achieve the second 90-90-90 indicator goal of 90% or higher. Even with DQI-corrected-1, none of them surpassed the 90% target threshold.

With the standard correction (DQI-corrected-1), the tool reduced the PLHIV by 1.95% on average (08-24.24%). The reduction, however, increased in other DQI-corrected scenarios. DQI-corrected-2 increased the second 90-90-90 indicators for 5.87% (2.11-27.55%) on average. DQI-corrected-3 increased the second 90-90-90 indicators for 4.59% (0.16-29.52%) and DQI-corrected-4 increased the second 90-90-90 indicators for 7.70% (2.11-31.22%)

DQI-corrected-2 scenario increased the indicator surpassing the 90% threshold among 6 hospitals. DQI-corrected-3 increased the number of hospitals surpassing the 90% threshold to 5 hospitals. The DQI-corrected-4 scenario was able to achieve 8 hospitals that surpassed the threshold, the highest number among all scenarios.

None of the study sites were able to achieve the threshold level of 90% of the third 90-90-90 indicator even with the tool deployed. As stated in the previous section, the third 90-90-90 improvement only occurs in the DQI-corrected-1 and remains unchanged through our other scenarios. The DQI-corrected-1 improved the third 90-90-90 indicator of 0.56 % on average (-0.11-9.58%). Figure 50 describes the comparison across four scenarios and the NAP report among 25 study sites.

Figure 50 90-90-90 Indicators comparison across NAP report and DQI-Corrected scenarios at hospital level among 25 study sites. The green dash line represents a 90% target threshold.

Field visit qualitative results

Of the 25 hospitals in this study 12 were visited for field interviews to assess their data workflow at the hospital. The team visited one primary care facility, 4 tertiary care hospitals, and 7 secondary care level hospitals. The average bed capacity among 12 study sites was 394.17 beds (1-1,680). Six hospitals resided in Bangkok and three hospitals for each of the two provinces.

As formal interview and voice recordings were not allowed by the health authorities in this study, we conducted field interviews among 64 key informants during a one-day field visit. All findings were based on team observation and field notes. Most interviewees were nurses, IT personnel, and laboratory technicians respectively as presented in Table 55. For privacy reasons, we did not collect any details on demographics data.

Table 55 Characteristics and number of interviewed personnel during field visits

Interviewed professionals	Number
Physician	6
Nurses	19
IT Personnel	16
EHR Vendors	3
Pharmacists	5
Laboratory Technicians	10
Others	5
Total	64

MEASURE DQA Tools

Table 56 described the MEASURE DQA Tools scores to represent the data management practice in this study. Overall, hospitals scored 2.62 on average with the highest score on “Links with National Reporting System” and the lowest on “Data Management Processes”. The MEASURE score did not show much variation between hospitals. The only primary care facility in this study achieved the lowest score in nearly all fields.

Table 56 MEASURE Data Quality Audit (DQA) Tools results from 12 hospitals across two provinces, 2018, Thailand

Hospital ID	Hospital class	Care level	M&E Structure, Functions,	Indicator Definitions and	Data-collection and	Data Management Processes	Links with National

				and Capabilities	Reporting Guidelines	Reporting Forms / Tools		Reporting System
1	Public non-MOPH	Secondary care	Bangkok	2.33	2.75	3	2.38	3
2	Private	Tertiary care	Non-Bangkok	2.67	2.75	2.75	2.13	3
3	Public non-MOPH	Secondary care	Bangkok	2.33	2.75	2.5	2.13	3
4	Public non-MOPH	Secondary care	Bangkok	2	2.75	2.5	2.13	3
5	Public non-MOPH	Tertiary care	Bangkok	2.67	2.75	2.25	2.13	3
6	MOPH - Community	Secondary care	Non-Bangkok	2.67	2.75	2.5	2.13	3
7	MOPH - Regional	Primary care	Non-Bangkok	2	2.75	2.5	1.88	3
8	MOPH-Community	Secondary care	Non-Bangkok	2.67	2.75	3	2	2.75
9	Public non-MOPH	Tertiary care	Bangkok	3	2.75	3	2.38	2.75
10	Public non-MOPH	Secondary care	Bangkok	2.67	3	3	2	2.75
11	Public non-MOPH	Secondary care	Bangkok	2.67	2.75	3	2.25	2.75
12	MOPH - Regional	Tertiary care	Non-Bangkok	2.67	2.75	2.75	2.5	3
Average				2.53	2.77	2.73	2.17	2.92

There were 12 hospitals deployed with the MEASURE DQA Tools, 7 hospitals located in the Bangkok area. We did not observe any remarkable nor statistically significant difference in the MEASURE DQA scores between Bangkok and non-Bangkok hospitals as presented in Table 57.

Table 57 Comparing the MEASURE DQL average score of Bangkok and non-Bangkok hospitals from the field visit.

Row Labels	Average of M&E Structure, Functions, and Capabilities	Average of Indicator Definitions and Reporting Guidelines	Average of Data-collection and Reporting Forms / Tools	Average of Data Management Processes	Average of Links with National Reporting System
Bangkok	2.52	2.79	2.75	2.2	2.89
Non-Bangkok	2.54	2.75	2.7	2.13	2.95
T-test p-value	0.95	0.36	0.75	0.56	0.44

The reason for having a high score on the national reporting system was because Thailand already had the infrastructure in place from both MOPH and NAP which already had several protocols that conformed to the MEASURE question. The same reason explained the high score on "Indicator Definitions and Reporting guidelines" and "Indicator Definitions and Reporting Guidelines" as MOPH used direct database extraction and submission while NAP uses manual data entry through the NAP's website. However, there was no quality control process in place for data entry and submission of NAP and MOPH causing the Data Management Processes score to be the lowest.

Thailand HIV workflow

Hospital workflow

Among 12 study sites, there were three main workflows categories: "fully paper-based", "parallel paper-based, and electronic-based", and "full electronic-based systems". Overall, the patient registration processes were similar, the difference was how physicians recorded the patient history and stored it in the hospital EHR database.

The paper-based only system let physician write down into a paper document which was scanned and stored in the EHR as an image file. Designated hospital personnel were to read the records either from a scanned document or the paper record and manually enter into the NAP system. The paper documents were discarded later at the end of the process. Data for MOPH submission were extracted by IT personnel and submitted to MOPH monthly.

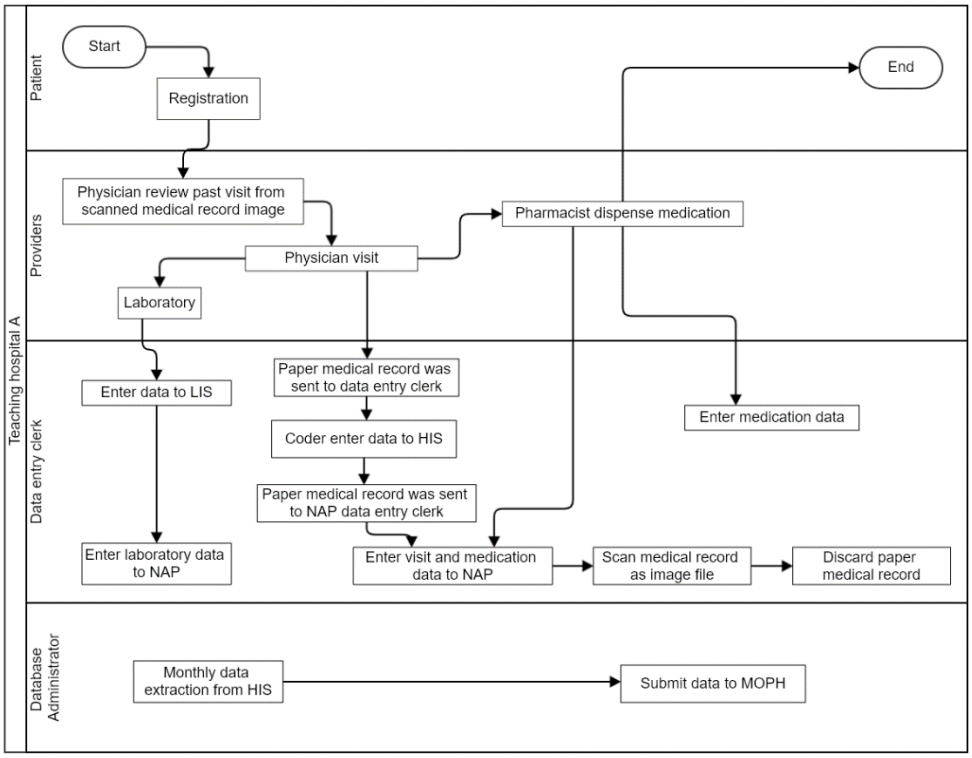


Figure 51 An example of the fully paper-based system at tertiary care hospital

The parallel system (Figure 52) allows the physician to choose whether to write down patient history in paper or type directly into EHR. Like the paper-based only system, the paper documents were scanned into EHR, and manually entered to NAP by designated personnel, and data were extracted and submitted to MOPH. The electronic system, (Figure 53) only allows physicians to enter data into EHR.

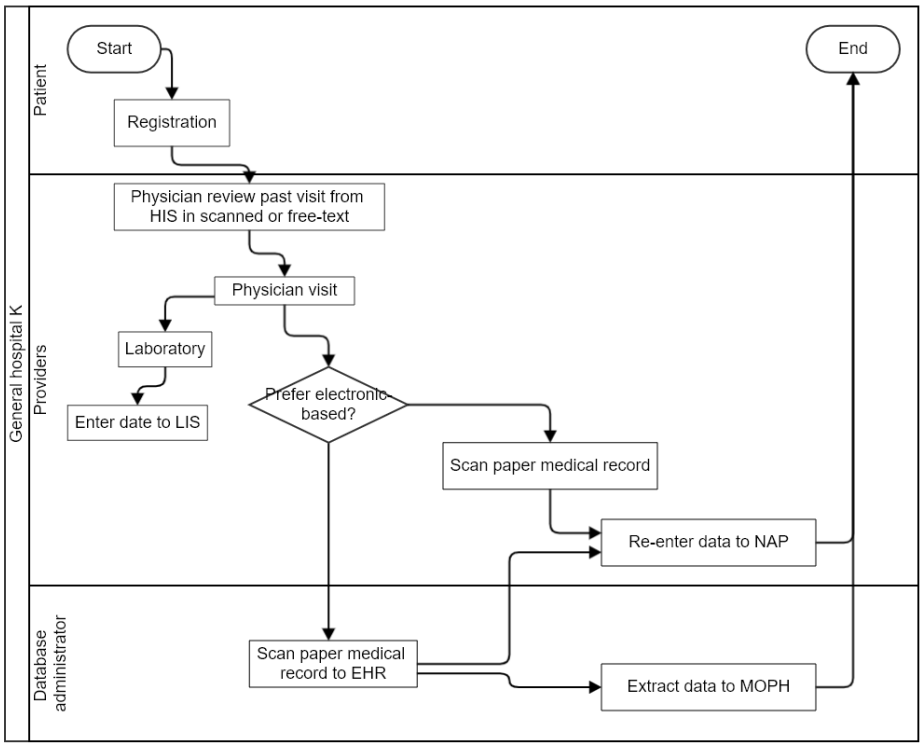


Figure 52 An example of a parallel workflow at tertiary care level hospital

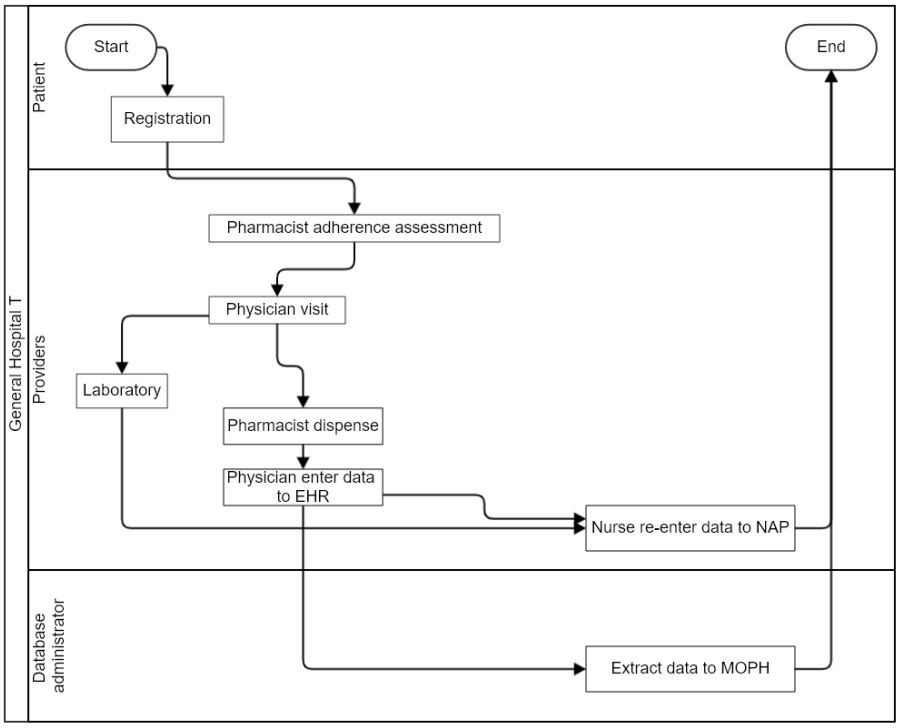


Figure 53 An example of the fully electronic hospital at secondary care level hospital

All the workflow diagrams presented in these figures were based on the out-patient department (OPD) workflow. For the inpatient department (IPD), all hospitals in this study still used paper-based medical records for IPD works which were summarized and entered into the EHR for billing when the patient was discharged, referred to or expired, and manually to NAP later.

For HIV laboratory results, Anti-HIV testing was conducted within the hospital laboratory departments. However, VL and CD4 required more extensive laboratory equipment and were only available in 56 laboratory centers across Thailand. Those laboratory centers were laboratory departments within tertiary care level hospitals. There were three laboratory care levels in the hospital included in the field visit.

Non-tertiary care hospitals entered laboratory requests into NAP and forward specimen to one of the designated 56 laboratory centers in Thailand. The results were shared with senders depending on the laboratory center's technical capacity and policy. The laboratory results, when available, were updated to NAP by laboratory centers in the hospitals.

The hospitals stored the result in PDF format or scan and store as an image file. All non-laboratory center hospitals did not store the laboratory in usable numeric or text format as they fear to violate the regulation, nor they want to increase the workload burden on their personnel.

Clerk or nurses at the HIV clinic were assigned to enter data into NAP and were entered as soon as possible to obtain reimbursement. With few exceptions, the databases were extracted and submitted to the MOPH routinely monthly by the IT department. MOPH data submission was part of a routine national reporting system, the entire hospital EHR databases were extracted into the MOPH format and submitted. Physicians did not have any involvement in this process.

External laboratory

Figure 54 described the flow of HIV laboratory (VL and CD4) among non-laboratory center hospital. The flow started by designated personnel at the sender hospital to enter the laboratory request to NAP and submitted the laboratory specimen to the assigned laboratory center. The laboratory center received specimens, processes, and enter results into the NAP system. The reason was that the

laboratory center is the one that receives laboratory reimbursement from NAP directly by entering results into the NAP system. Then the result is notified and shared with the sender. There were three different methods the laboratory center returns to the sender: paper-based, electronic document file (PDF), and directly update the sender's laboratory information system (LIS). The sender hospital then stored results in its database. Laboratory center hospitals themselves stored the results in the LIS and EHR database.

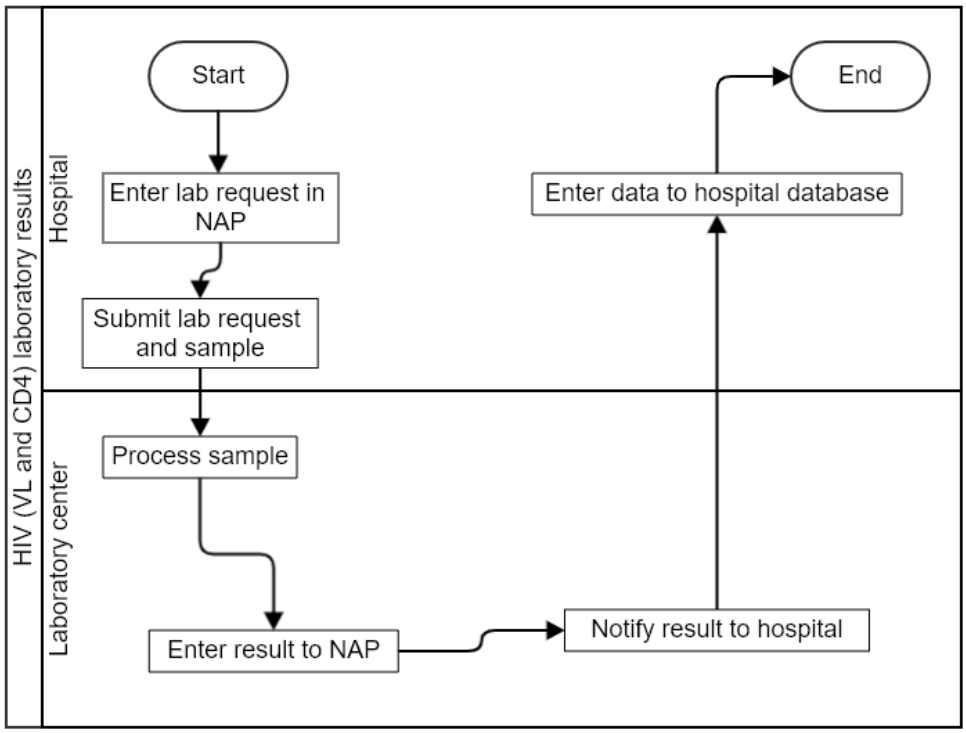


Figure 54 HIV Laboratory (VL and CD4) workflow across hospital sender and laboratory center

Challenges to NAP data quality

Three main themes were identified during field visits that contribute to the NAP reporting quality gaps: legacy system migration, referral problems, and a disincentive for data correction.

Legacy system migration

Before NAP existed in 2008, there was an old system called "National Access to Antiretroviral Program for People who have AIDS" (NAPHA). In 2008, the NAP to NAPHA database migration had a failure and the team managed to manually re-enter entire records from NAPHPA to NAP,

compromising historical data before 2008. This was the reason why we found several patients without HIV results in the NAP databases.

"The database migration in 2008, for some reason has a failure. At that time what we know is they manually re-enter all data from paper-based documents into the newly established NAP system. The process, however, causes several human errors in the process" - Head physician who was involved in the migration process.

Figure 55 shows an example of migration error in the Date of Birth in the NAP database found during the field visit. The date of 17th August B.E. 2544 (A.D. 2001) misspelled to B.E544 (A.D. 0001). The visit dated before NAP go-live in 2008, and it was not possible in the current NAP system as the data entry date was selected from a calendar selection. Therefore, it was more likely a data entry error from migration in 2008.

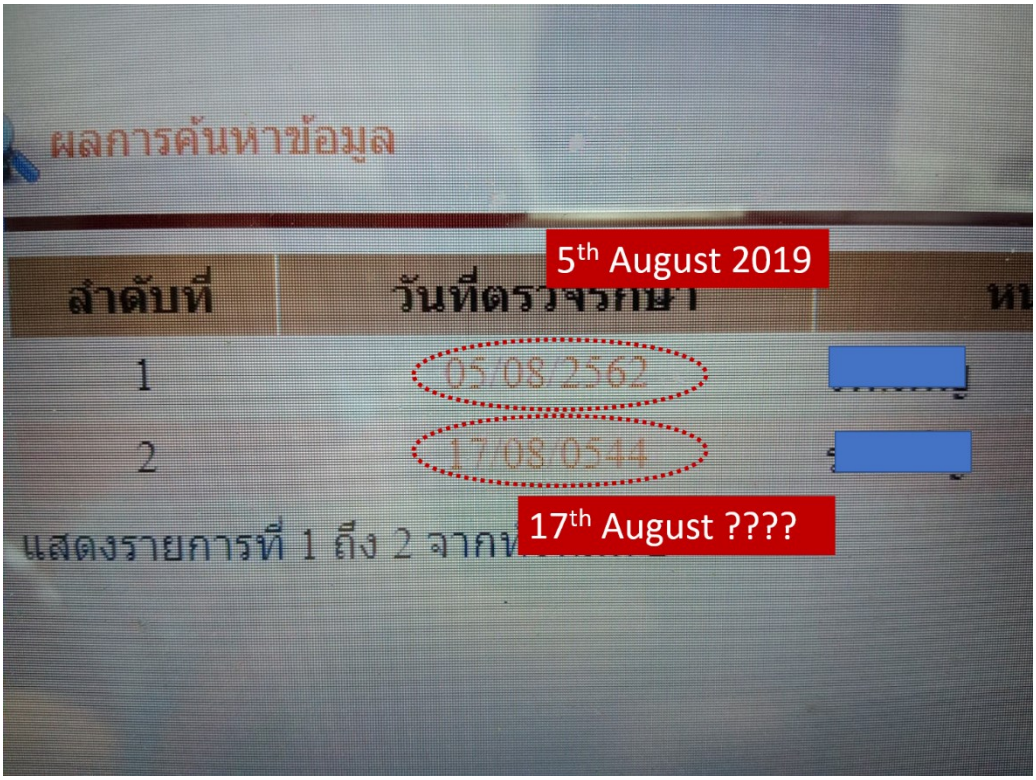


Figure 55 An example of an error in the NAP system the year B.E. 2544 (A.D. 2001) was entered to B.E. 0544 (A.D. 0001)

Data correction obstacle

Because of migration failures in 2008, several data problems needed to be corrected. However, the NAP system did not allow the hospital to directly update the data. Hospitals needed to submit the data correction requests to NAP which further putting an additional burden on the personnel. The request process takes an exceptionally long time, usually more than 6 months, and requires several administrative paper works. The long and burdensome process caused the personnel to be reluctant to submit further data correction requests to NAP. Furthermore, personnel also fear that correcting NAP data may impact hospital reimbursement and they might be prosecuted.

"We're fear that correcting NAP data may change the reimbursement from NAP. If that the case, we are not sure whether one of us is going to get prosecuted or held responsible for it."-HIV Clinic nurse at secondary care level hospital

"It'd be nice if NAP allows us and provide an incentive in some way to correct data by ourselves because we know all the patients here. That should increase overall NAP data quality"-HIV Clinic nurse2 at secondary care level hospital

"One of the patient's identities we're treating is not compatible with what NAP has. But we're not sure what the data correction complication will lead to. The best scenario is that we lost all his treatment historical data in NAP"- HIV Clinic nurse at secondary care level hospital

Not returning necessary information to the hospital

One of the main complaints about the NAP observed during the workshop and in nearly all visits was that the system did not return the data the hospitals needed the most, the SSN.

SSN is very important for the hospital as it was the only ID that could link the patient identity from the EHR to the NAP record. While the NAP system provided NAP ID and Hospital Number (HN), it was the hospital's responsibility to create, store, and maintain their master sheet that provides a mapping between NAP ID, HN, and SSN.

While it's understandable by the reason of privacy and confidentiality, hospital personnel overcome this problem by creating their version of reference table manually, in an excel file a master sheet mapping between NAP ID and patient identity, in a paper tally sheet, inside EHR or in front of the paper-based copy of the medical record and may increase the concern on hospital personnel.

"We are very concern about storing NAP ID in our EHR as they increased the risk of a data breach or their identity to be revealed."- HIV Clinic nurses at secondary care level hospital

Figure 56 showed an example of how the hospital store NAP ID by attaching to the paper medical record and stored inside a locked cabinet inside the HIV clinic. Table 58 showed an example of a master tally sheet mapping between NAP and EHR. The sheet usually contained SSN, HN, NAP ID, risk population, and contact telephone number for contact and reminder. Hospital usually stored the sheet in Microsoft Excel file and paper sheet.

Figure 56 An example of NAP ID storage in hospitals with a parallel system.

Table 58 An example of a tally sheet storing NAP ID mapping with HN, risk population, and SSN.

No.	NAP ID	SSN	Population	HN	Comment	Diagnosis date	Tel.
1	D4-2007-XXXX	XXXXXXXXXXXX	7. General population	XXXX	Regulary follow-up	27/12/XXX	

As this is the only way of mapping patient identification between NAP and EHR, losing the mapping file means identifying patients and recruiting them back to HIV care were impossible. The only solution in this situation was submitting a request to NAP.

Referral problem

The referral problem in the NAP system was one of the main problems identified during our survey. For example, when patients had been receiving ARV at private non-NAP hospitals for a long time and were referred to the public hospital, they were marked as first receiving ARV at the public hospital. The first date patient visiting the public hospital was recorded as ARV initiate date, even though patients had received ARV from a private hospital for a long time.

This causes errors in the inpatient record related to HIV care. For example, when patients from the private hospital visited the public hospital for the first time, the patient ARV initiation was recorded. However, the hospital had to re-confirm the HIV test results for every new patient which usually takes 1-2 days after the visit. The HIV results report date was recorded as an HIV diagnosis date. As a result, patients had an ARV initiation date before the diagnosis date.

The same problem happened when the patient initiates ARV at NAP hospital but was referred or silently transfer themselves to non-NAP hospital.

"We have several referred HIV patients here, many from the private non-NAP hospital. We have to refill their ARV while waiting for the confirmation of the Anti-HIV test. That's the reason why many patients have started ARV date before diagnosis date." Nurse at tertiary care level hospital

The second problem was the failure referral process on the NAP website. Several hospitals reported that when they updated their referral state in NAP, the patients often remained under their hospitals and was marked as 'loss-follow-up' even though patients were referred to destination hospital. This caused the destination hospital to unable to see the treatment history from the sender. A similar situation occurred when patients switched from a NAP hospital to a non-NAP hospital or switching from the UC to a non-UC health scheme, as NAP provides reimbursement for UC only, non-UC health scheme data entry to NAP were voluntary-based, causing information before switching to UC health scheme to be missing.

This problem caused that the hospital personnel was unable to know whether patients were lost follow-up nor they were receiving treatment regularly at the new hospital and unable to recruit them back to the HIV care system effectively. Moreover, even hospital personnel managed to confirmed loss-follow-up patients and manage to recruited back, the patients were marked as loss follow-up at the origin hospital and reduce the 90-2 indicator for both provincial and hospital levels.

Awareness

None of the hospitals in this study had been visited by an external organization regarding HIV reporting quality. All visits from the external organization were mainly on HIV services quality

assessment. One nurse state clearly during our field visit that they did not know about data management or quality as their duty was to provide service to patients.

"Your team is the first one that helps us explore our data quality. All hospital HIV related visits were about our HIV service assessment but not data itself and we never have a visit from NAP."- Nurse at secondary care level hospital

"We are nurses and only provide care to patients. We don't know much about data management." Nurse at secondary care level hospital

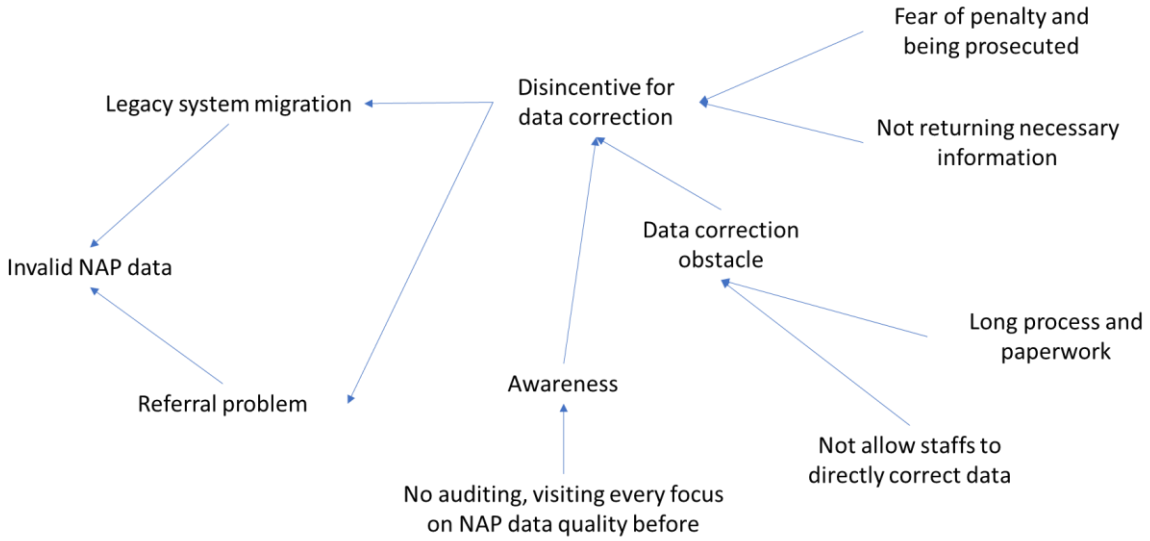


Figure 57 NAP Challenges for data quality thematic map

The challenge to MOPH data submission

Legacy system migration

All 6 Bangkok hospitals in this study use EHR from the same vendor, "EPHIS". There were 5 EPHIS EHR and 1 EHCIS, a primary care variant of EPHIS EHR used by one primary care center in this study. EPHIS was an EHR vendor that has the contract to maintain all hospital-affiliated Bangkok Health Department (public non-MOPH hospital). EPHIS and its variance, EHCIS is a cloud-based EHR. Therefore, all medical records and databases among Bangkok affiliated hospitals in this study were stored outside at a 3rd party cloud server.

Both two non-Bangkok tertiary care hospitals used different EHR vendors (HomC and Opserv), while the rest of the non-Bangkok hospitals' public hospitals use the HosXp EHR vendor. However, while most hospitals under the Bangkok Health department had been using EPHIS EHR for several years, three secondary care level hospitals in this study were migrated from legacy EHR to EPHIS for less than one year. Their old EHR system was not compatible with the MOPH data submission system causing the hospital unable to submit data to MOPH. Historical records before EHR migration were achieved and can be accessed on-demand.

While the newly deployed EHR in the hospitals had to overcome several technical challenges to submit data to MOPH, the hospitals can still enter data to the NAP system.

This caused MOPH data among hospitals from newly deployed EHR to be completely missing as the technical challenges from newly deployed EHR were preventing hospitals from submitting data to the MOPH while legacy EHR did not support MOPH data submission.

In other words, the hospital could not submit data to MOPH while able to enter data to NAP. This was one of the explanations for large two-data source differences in Bangkok.

"The old legacy system is problematic and could not submit data to MOPH. The new one is much better, able us to submit data to MOPH. However, the submission is still incomplete because of newly deployed and need more modification."- IT Personnel at secondary care hospital

Historical data were archived and can be accessed with the legacy system. However, maintaining two systems at the same time was a huge burden to the hospital. As a workaround to reduce the burden, physicians summarized historical data from legacy EHR and put it in the new EHR to reduce the need for legacy system causing several data (e.g. first diagnosis HIV laboratory results and date) to be missing.

"I tried my best to summarize patients' records to the new system, but I do this alone so it's not perfect and may miss some details." – Physician at secondary care level hospital

The primary care level hospital in this study also suffered a technical problem from deploying EHR forcing the hospital to store patients' medical records in a paper document and a Microsoft Excel file. The EHR was used only for administrative tasks. Because of this reason they could not submit data to MOPH and unable to deploy our DQI Tools and were excluded from our quantitative results. However, they were still entering data manually to NAP regularly.

"The EHR we are using is slow and very hard to use, we don't' like it so we use only it for administration. Our HIV data resides in paper records and NAP." – Physician at primary care level hospital

Vendor dependence

Eleven of twelve hospitals in the field visit study purchased EHR systems from vendors. Only one hospital developed its EHR.

Purchasing EHR limit hospitals to modify their systems to accommodate additional data storage, (e.g. NAP ID) deploying the MOPH data submission system by themselves, or solving arising technical problems. Hospitals needed to contact vendors to do that with additional cost.

Tertiary care hospitals receive more priority as they have stationed a vendor's developer that could apply the change in a short time. On the contrary, smaller secondary care level hospitals, face more challenges as vendors usually did not station a developer at the hospital. Moreover, the smaller secondary care level hospital could not afford to make costly EHR modifications.

"Unlike large teaching hospitals, our software is less mature and slower to apply the change. They only station IT Support here, not a developer so the change is much slower." IT Personnel at a secondary hospital

"Because our LIS is older than other hospitals, EHR integration will cost additional money and we, a small hospital could not afford it." IT Personnel at a secondary hospital

Sensitive records were only available in paper-based

Sensitive records including those among the vulnerable populations (e.g. prisoner) were routinely stored in the NAP database. However, storing in the EHR and obtaining the MOPH submission was far more challenging.

In hospitals with a parallel system, sensitive records were stored in paper-based medical records only to reduce the risk of the data breach. The EHR contained only the visit number without any medical record data. In addition to the data breach risk, there were several factors to store sensitive patients' medical information in paper-based only.

First, the detention facility did not allow any electronic device inside. One of the hospitals in this study also covered HIV patients in the detention facility, which does not allow them to bring any electronic devices. Physicians and care teams had to record the prisoner's medical records in a paper document. The record was reentered to NAP but not to EHR to minimize workload causing data to be missing from the MOPH submission system.

The second challenge was when patients were released from the detention facility, there was no way the hospital could track patients whether he or she went to the follow-up at other hospitals and was marked as a loss follow-up in the hospital EHR.

"Our hospital has a contract with detention facility. Because the facility does not allow electronic devices, all medical history has to be noted in the paper record. While we have visit date in the hospital EHR, we did not re-enter data there, so they only exist in medical records. "- HIV clinic nurse at secondary care level hospital

Third, all hospitals in this study also stored patient records in another source for internal communications. Most of the time, this source existed before the EHR and contains historical data that did not exist within the EHR and even NAP (e.g. First HIV diagnosis data, first ARV start date, CD4 level at ARV initiation from 15 years ago). Figure 58 shows an example of the separated paper medical records for internal communication, several data including initial ARV regiment, HIV

diagnosis date (masked) that were not available in NAP nor EHR were recorded there. The record also contains NAP ID, SSN, and HN but was masked for privacy reasons.

"Besides from EHR, we have our separated HIV paper record for internal communications. I summarized important data like ARV start date some of those do not exist in EHR." – HIV Clinic nurse at secondary care level hospital

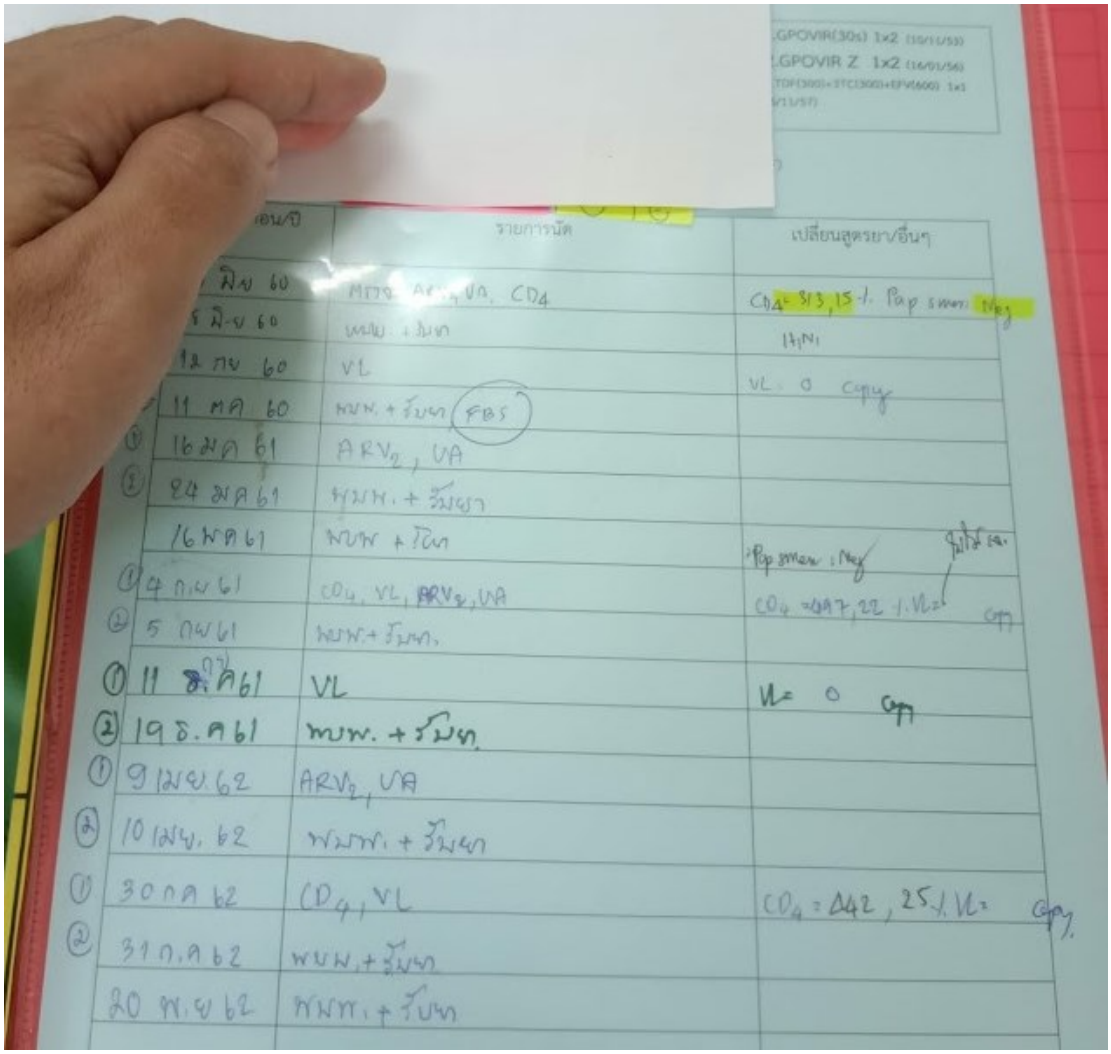


Figure 58 An example of the HIV separated paper for internal communications. The record contains initiation ARV regimen and date and visits summarize. NAP ID, SSN, and HIV diagnosis date were masked for privacy reasons.

Unclear regulation in storing laboratory data

A major challenge in the MOPH database was nearly empty of VL laboratory results causing the third 90-90-90 indicator calculation to be not possible.

We found that every hospital was concerned with an unclear regulation whether the laboratory result that was done outside of the hospital (laboratory center hospital) could be stored in EHR as free text/numeric or not. Therefore, most hospitals scanned and stored with images and PDF file formats that were not compatible with the MOPH database. As a result, the results were not submitted to MOPH.

The team also discussed with the hospital on whether they were able to input laboratory data into EHR if we can confirm that the entering data was valid. While most hospitals agreed to enter data, one hospital declined concerning the increasing workload among their personnel as MOPH did not provide reimbursement for submitting the result.

"My boss does not want our hospital to do that because it increases our workload for nothing. We're busy enough already."- Laboratory technician at secondary care level hospital.

"We want to store them so we can analyze. However, we concern whether doing that is legal, so we only keep them as a scanned image."- HIV Clinic nurse at secondary care level hospital

On the contrary, the laboratory center hospital did keep results in their LIS and submit only their results to MOPH. Results of the HIV laboratory requested from the non-laboratory center hospital were not submitted to MOPH and were left in the database.

No single unified national laboratory data standard across health schemes

As Thailand did not has a national laboratory standard similar to LOINC, the hospitals deployed their local code system instead and mapped to the standard as required by the reimbursement organizations (MOPH and CSMBS). While MOPH used its own 7 digits ICD-10TM laboratory coding system, the CSMBS deployed its 5-digits laboratory coding system.

In other words, hospitals had to map four coding systems including laboratory procedures and laboratory results together for HIV reimbursement alone. The mapping process was labor-intensive and time-consuming as several departments in the hospital such as IT and laboratory have to work together.

Another challenge was the MOPH laboratory coding has been changing several times in the past. For example, the MOPH results only available at 0, 1, 2 while hospital laboratory results format is four digits numeric such as 300, 400. The different coding systems between the hospital and MOPH causing data submission to be a failure and the hospital had to repeatedly do the mapping process and increase the workload among hospital personnel.

"The MOPH database coding has changed several times in the past. Our data in the hospital database does not valid anymore and it did not go through." IT personnel at tertiary care level hospital.

No single unified medication data standard across health coverage schemes

The low percentage of the second 90-90-90 indicated that several ARV medication records were missing. The reason was an incompatible medication coding system between MOPH and hospital. MOPH used its own 24 digits medication coding system maintained by the Food and Drug Administration (FDA Thailand) while NAP did not require any coding as data directly entered into the NAP system. On the contrary to MOPH, the most hospital used Thai Medical Terminology (TMT), a medication code derived from SNOMED CT to receive reimbursement from the CSMBS health scheme among government officers.

It was important to emphasize that the NAP and CSMBS health scheme provided reimbursement to hospitals while MOPH did not. As a reason, all EHR in this study supported TMT but did not fully support MOPH 24 digits and require additional mapping works to submit to MOPH.

"We never do it before because unlike TMT we are not getting more money from this (mapping medication coding to MOPH 24 digits.)"- IT personnel at a tertiary care center.

For example, we found one of the main ARV medications in Thailand, TEEVIR (Tenofovir Disoproxil Fumarate/ Efavirenz/ Emtricitabine) along with several ARV did not have MOPH 24 digits code in the EHR causing data submission to MOPH to be missing. The hospital personnel thought that the code system was deprecated and did not receive enough Maintainance from FDA (See "Thai FDA ARV medication coding ID" in Appendix). Unfortunately, as reviewing the medication code was not

feasible in this study from minimum resources and logistic constraints, we were unable to determine the contribution of this problem to the MOPH reported ARV prescription and the second 90-90-90 indicator.

No reimbursement nor incentive for deploying data standard

As the data mapping process from hospitals local data standard to MOPH is a resource-consuming process, most hospitals allocate their resources to mapping only those that provide the reimbursement, the CSMBS health scheme (TMT and CSMBS laboratory data standard), the MOPH 24 digits medication, or the MOPH ICD-10TM laboratory standard receive less priority as there was no reimbursement provided.

"You have to understand, with our resources available, coding that receives reimbursement receive priority."- IT Personnel at tertiary care hospital.

That was the reason why we did not identify hospitals submitting data to MOPH alone, despite being the primary source of Thailand's healthcare and surveillance system. On the contrary, several hospitals only submit data to NAP for the same reason.

The finding was supported by the MOPH dashboard as seen in Figure 59. As of July 2019, the dashboard number only provides the record counts without stratifying results in positive, inconclusive, or negative. As a result, we could not calculate the 3rd indicator as mentioned earlier in the previous section.

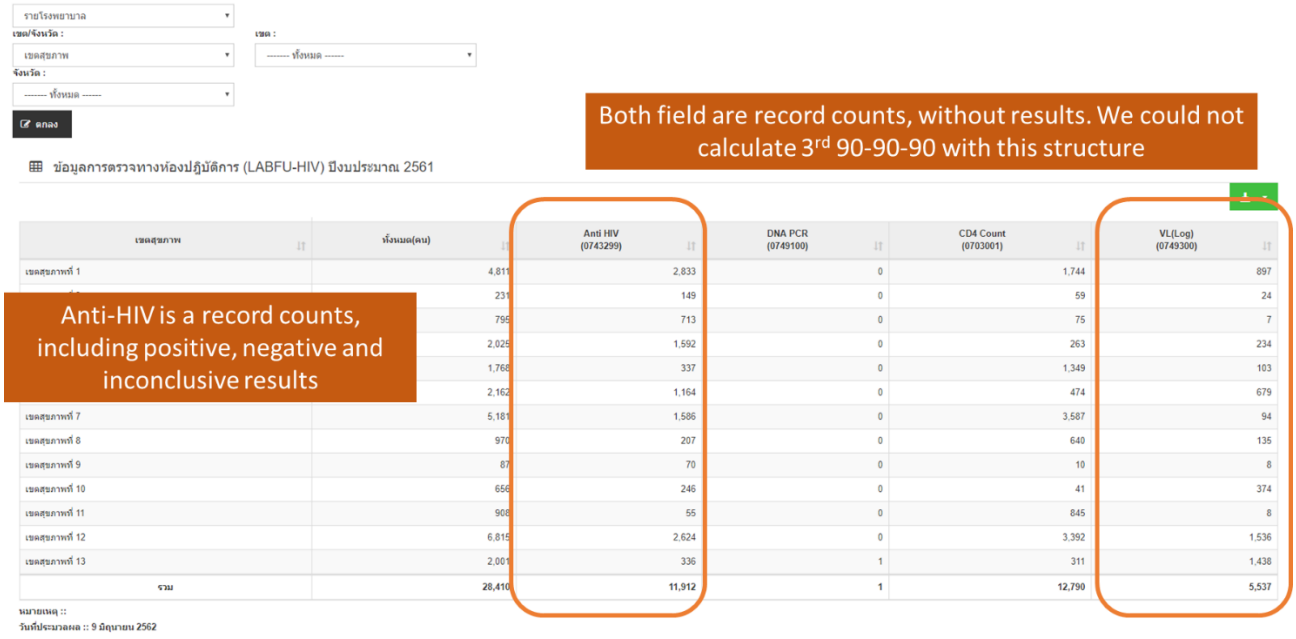


Figure 59 MOPH HIV dashboard showing the number of records with Anti-HIV, CD4, and VL without stratifying by results (Accessed July 2019)

To submit data to MOPH while minimizing cost and workload to their personnel, several hospitals that were using the same EHR vendor pool their modification request together, submit to the vendor in bulk to save cost. The EHR modification to support new MOPH laboratory coding from one vendor was expected to go-live by the end of 2019. Unfortunately, hospitals with different EHR vendor systems that could not pool the request had to do mapping on their own.

"We are lucky that our public hospital in this province uses a similar version of the same EHR vendor so it's easy to negotiate to make a change. Otherwise, it's going to be a big challenge." IT personnel at tertiary care level hospital

Technical difficulties in deploying the MOPH reporting system in Bangkok

Bangkok hospitals and stakeholder structure

While most hospitals in this study affiliated with the Bangkok Metropolitan Administration (BMA) already submitted data to MOPH, other affiliations did not as there were several reasons and challenges to overcome.

First, deploying the MOPH data submission from scratch was a very complicated process in hospitals that never submitted data to MOPH before and without any reimbursement in return.

While several Bangkok hospitals in this study deployed the popular EHR like EPHIS and HosXP, several EHR vendors were being deployed in Bangkok or even in-house developed EHR. There was no official survey on the number of EHR vendors.

Therefore, pooling modification together was not possible in several Bangkok hospitals, not even with the support from the Bangkok Health Department as negotiations had to be made with numerous EHR vendors.

"There never a survey to know how many of them, but what we've seen so far, our best guess is several dozen not mentioning the variation across different versions of the same vendors. We've been trying to implement the MOPH system for 2-3 years without success."- BMA Personnel

According to data provided by BMA Health Department during the Bangkok field visit, only 13 of 155 hospitals or 8% of all hospitals in Bangkok are bound to submit date to MOPH, the rest submitted voluntarily. There were 142 hospitals not affiliated with the MOPH.

Among the other 142 hospitals, 107 are private hospitals, 10 under other ministries (e.g. Ministry of Justice, Ministry of Defense, etc.), 12 hospitals affiliated with BMA, 9 specialist hospitals, and 4 university hospitals as shown in Table 59 as of December 2019.

Table 59 Distribution of hospitals in Bangkok Source: Bangkok Metropolitan Administration, December 2019*

Hospital Type in Bangkok	Total
MOPH	13
Private	107
Non-MOPH	35
- Other ministries	10
- Local authority	12
- Excellence center	9
- University hospital	4
Total	155

*BMA data was more updated than our hospital database from MOPH. However, we only have access to hospital affiliation data.

"Many stakeholders, many hospital affiliations put challenges on coordinate for data submission as most hospitals in Bangkok are not affiliated with us or MOPH" -BMA Personnel

Figure 60 described the current state of Bangkok data submission. As some hospitals only submit data to NAP and few submitted to both systems. BMA, despite having authority over BMA affiliated hospitals had no control over the dataflow causing a data stewardship concern.

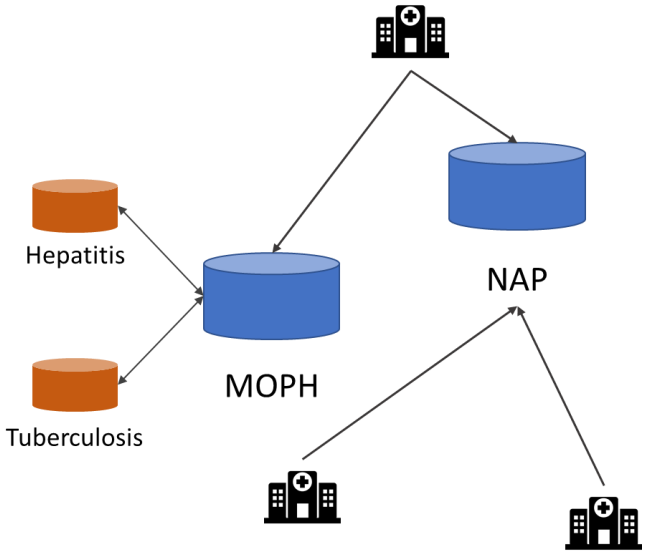


Figure 60 Current Bangkok problem. Some hospitals only submit data to NAP while some hospitals submit data to both systems.

The complicated change request process

Several small BMA affiliated hospitals that had migrated recently to a new EHR were under "Single HER policy". The policy was to make all change requests by one hospital also applied to other hospitals allowing the request to be pooled, reducing EHR variability and cost. However, the policy also slows down the EHR modification process to suit each hospital workflow as the request needed to go through the joint committee and forward it to the vendor. In addition to the fact that small hospitals barely could modify an EHR on their own, further slowing down the process.

"The process takes so much time for our change suggestion to be made and deployed in our EHR"- IT Personnel at secondary care level hospital

"We feel that we did not receive much attention from the vendor as the vendor team at this hospital could not apply much change for us, unlike the larger hospital that can develop and deploy their change" – IT Personnel at secondary care level hospital

Moreover, ARV medications were found in the same category with non-ARV medication (e.g. dyslipidemia medication) across a newly deployed EHR in three hospitals but not among their mature counterpart EHR. The finding supported hospital IT staffs' response that their EHR was much less mature compared to the counterpart in a larger hospital and needed more resources to overcome technical challenges for deploying the MOPH reporting system. Having an ARV medication group in the non-ARV medication may cause errors in data submission to MOPH.

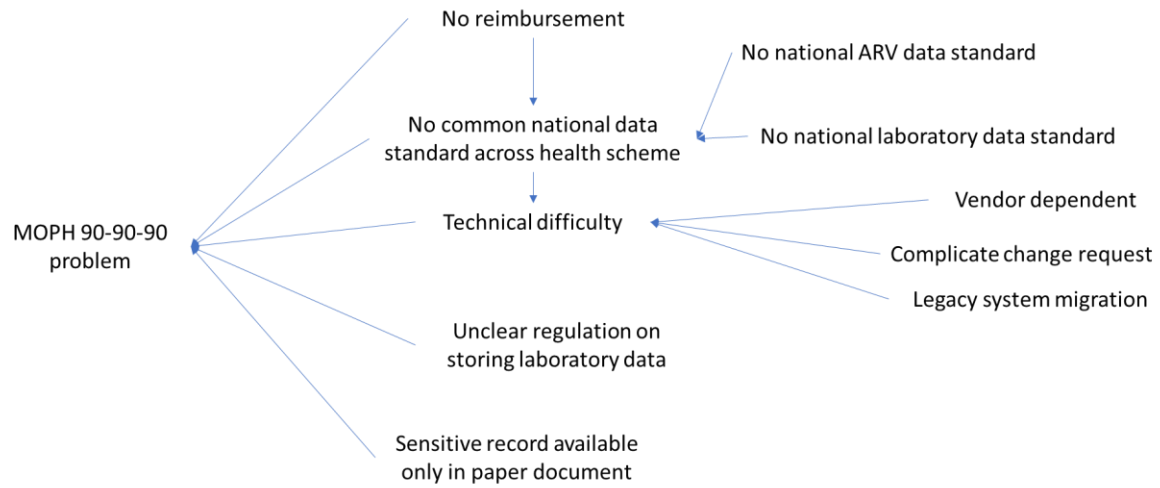


Figure 61 the MOPH Challenges thematic map

Discussion

Overall Thailand HIV progress

Thailand's progress in UNAIDS 90-90-90 indicators in 2018 was 105%, 72%, and 83% for the 90-90-90 respectively. Even though Thailand did not achieve all 90-90-90 indicators, the progress was slightly higher than the aggregated value of 79%, 78%, and 86% according to the UNAIDS report from 60 countries in 2018 (38).

The majority of HIV patients in Thailand were older than 50 years old. The age group proportion was consistently higher than 20% across the NAP and MOPH database and higher than the UNAIDS projected number for developed countries of 21% in 2020 (37). A similar finding was reported from several Low-Middle Income Countries (LMICs) since 2000 and was expected to continue through 2020 (37). As ARV treatment allows patients to have a similar life expectancy to normal people, the demographic findings supported that the Thailand HIV program and service have made progress in improving patient life-expectancy.

However, one remarkable finding was the first 90-90-90 indicators that were higher than 100%, much higher than the highest value reported in the UNAIDS 2019 estimation of 92%. We doubt the first indicator might not be accurate as Thailand still face the HIV stigma problem causing several HIV patients to not visit hospitals, as reported by the literature as a major challenge of HIV care access in Thailand (39-41). A similar finding of HIV stigma was also reported from India as one of the important barriers to achieving the 90-90-90 indicator goals (42).

As the first 90-90-90 indicator was based on a model estimation (AEM for Thailand), using a 90-90-90 indicator to monitoring HIV intervention directly depended on the reporting quality and the model itself. For example, duplicated records or not excluding dead patients can overestimate the indicator. Also, underestimation from the model overestimates the indicator. A similar finding was reported from UNAIDS Report in 2019, as a result, several countries have recognized the data quality impact on the indicators and started improving reporting data quality. However, only a few reports regarding the impact of data quality improvement activities to 90-90-90 indicators were available (43).

AEM Modeling estimation was also an important concern to be considered as Cambodia has been using the same model for their HIV patient's estimation. Any changes to the model in Thailand may also impact Cambodia. However, model validation was not within the scope of this dissertation as the Thai MOPH had a dedicated division for modeling, the concerns, and recommendation of model validation and revision was provided to MOPH modeling division.

Therefore, in the study, we focused on exploring reporting quality gaps in selected relevant data elements, especially the second and third 90-90-90 indicators that did not use the AEM estimation for calculating the indicators.

The first data element, “Patient Living with HIV (PLHIV)” as a nominator for the first 90-90-90 indicator and denominator for the second indicator was obtained from the HIV reporting system. There were two HIV reporting systems in Thailand, NAP, and MOPH. While both data sources had different reporting mechanisms, their data input was from hospitals. Therefore, at the beginning of the study, we expected both databases report numbers to be very close.

According to our findings, the total Thailand PLHIV number from two data sources was remarkably close as expected to cause the first 90-90-90 indicators difference between two data sources to be narrow. However, we identified two important concerns regarding the interpretation of the number.

First, the Bangkok HIV report number was remarkably low from the MOPH database. The number was illogical low given the fact that Bangkok was the capital city of Thailand hosting approximately more than 10% of Thailand population. Second, the NAP report number was far higher than MOPH in Bangkok causing the two data sources difference between them to be the highest in Thailand. The two data sources difference were large enough to identified Bangkok as an outlier.

For the second 90-90-90 indicators, the gaps were remarkably wider between the two data sources. Bangkok was the only province without the second 90-90-90 indicators from the MOPH database from lacking the ARV data, a numerator for the calculation of the indicator.

The problem was furthermore remarkable for the third 90-90-90 indicators as VL data were not available at all from MOPH causing the third 90-90-90 indicators calculation to be not possible. We also explored the potential associated factors to two data source differences including the PEPFAR funding and the bed capacity. Initially, both factors showed a statistically significant positive association. However, removing an outlier (Bangkok) changed all associations to non-statistically significant. We also explored a possible association between hospital class and the two data sources difference. However, only a few Bangkok hospitals were available in the database. Thus, while we

found Public non-MOPH hospitals had a statistically significant association with two data source differences, the finding only applied for non-Bangkok provinces.

The finding, in addition to the first and second 90-90-90 indicators, confirmed the abnormality and importance of Bangkok's contribution and warranted a field visit for exploration. Therefore, Bangkok was selected along with two provinces for the field visits.

Besides from the illogical value of the first 90-90-90 indicators, the large drop in the second 90-90-90 was also important to explore.

Loss-follow-up or dropped-out patients

The second 90-90-90 indicators suffered a large drop from 105% to 72%. The larger drop resulted from the loss-follow-up patients that contribute 28% of total HIV patients. Lost follow-up patients did not receive ARV causing the drop in the second 90-90-90 indicator.

The loss follow-up percentage was far higher than reported from seven ARV programs in Asia (8.95%) (44). This was important as the loss-follow-up patients' mortality rate was much higher and at more risk of developing drug-resistance (45). Therefore, loss-follow-up patients were a particularly important challenge from achieving 90-90-90. Reducing the loss-follow-up patients were prioritized by several countries including in Sub-Saharan Africa, Georgia, and Thailand to achieve the 90-90-90 goal (46, 47) (48). The intervention to address loss-follow-up patients was tracking and recruiting back to HIV care service by a cell phone call or home visit. The intervention effectiveness was supported by a meta-analysis study concluding that care retention was higher with tracking and recruitment activity (44).

There were four categories of loss-follow-up patients; “death”, “alive without ARV”, “silently transfer to other clinics”, and “still receiving ARV without being reported”. Each category required different interventions. Three out of four categories of interventions were related to improving the quality of the reporting system. Alive without ARV was the only category that required personnel intervention (home visit and recruiting).

According to a systematic review consisted of 9 studies across Sub-Saharan Africa, only 1,094 of 7,377 loss-follow-up (14.8%) were still alive without ARV (46). However, recruiting patients back to the care system by conducting home visits and phone calls tracing methods were not efficient as there were only 14.8% alive patients among loss-follow-up to be recruited. Allocating resources on tracking and recruiting patients were not feasible in developing countries with constrained resources. Therefore, providing personnel with a tool that could identify alive patients from a loss-follow-up pool can improve the recruiting process overall.

Data Quality Improvement (DQI) Tools

To provide a shortlist of "alive loss-follow-up" patients for recruiting, integration of multiple data sources across NAP, MOPH, and hospital EHR were needed. However, several legal authorization documents were required to obtain access permission to all databases. After all data sources were obtained, additional data management skills were also required for preprocessing before integration. The additional skill and workload were not feasible for the already overwhelmed HIV clinic nurses and other local personnel in Thailand.

To streamline the data management process and minimize the burden on local personnel, a DQI Tools application was jointly developed by MOPH and Thailand-MOPH-US-CDC collaboration (TUC). The application aimed to integrate multiple data sources and generate recruiting lists for HIV personnel while minimizing additional workload. The application also generates a summary report of service and data quality for stakeholders to improve their service.

The "loss-follow-up" lists were generated based on four loss-follow-up categories ("loss-follow-up", "dead", "silently transfer to another hospital" and "regularly follow-up") and two additional categories that were not previously referred in the literature were added: "Need HIV verification result" and "Misdiagnosed". Both additional categories were created as Thailand had reported of misdiagnosis HIV patients in the past (49). To our extent of knowledge, we could not find any report from other countries containing categories of "Need HIV verification result" and "Misdiagnosed" from the literature search.

The initial deployment of the DQI Tools alone was able to reduce the number to nearly half of those reported from NAP initially. According to the DQI Tools report, approximately half of loss-follow-up reported from NAP were true loss-follow-up (53.8%), dead (0.85%), silently transfer to other hospitals (4.94%), and regularly follow-up without ARV (<0.1%). The percentage of loss-follow-up was cut by half making the Thai loss follow-up percentage lower than those of Sub-Saharan Africa without any additional intervention nor investment.

However, the proportions were completely different from Sub Saharan Africa report of 31.8%, 21.8%, 14.8%, and 22.6% respectively. A large gap represents a unique characteristic of the HIV reporting system of Thailand and it addresses the importance of the loss-follow-up problem as the Thai number is much higher despite having better resources and infrastructure.

Moreover, there were patients with misdiagnosis and several of those who needed HIV laboratory results confirmation. The decision had to be made at the policy level as to what extent they should be excluded from the indicator calculation and if any intervention might be necessary.

After the patient lists were generated and forward to the HIV personnel, this personnel have to verify, update, recruit, and submit the updated data back to us on the follow-up "lessons learned" meeting. In this study, 1,488 patients were reviewed, corrected, traced, and recruited back to HIV care by the local personnel. Unfortunately, most patients from the generated list (1,133 of 1,488 or 76.15%) were unreachable.

Among those unreachable patients, most of them had the last visit date longer than 5 years ago and longer than 10 years for the diagnosis date. Searching the medical record and patient identification was very difficult for patients having last hospital visits longer than 5 years as several old records were discarded. Therefore, the decision should be made at the policy level on whether to excluded unreachable patients from the indicator calculation.

While the DQI Tools were able to reduce loss-follow-up patients' number, the tools did not have much impact on the number of patients having a viral suppressed level, and the third 90-90-90 indicators. These findings were explored further in the qualitative result section.

To our extent of knowledge, our study was the first in initiation the deploying of the tools that integrate several data sources at local health providers to give informative insight to every level of stakeholders ranging from local hospital personnel, national-level decision-makers to an international organization. The closet report was “KenyaEMR”, a Kenya customized version of OpenMRS with DHIS2 for submitting reports to national aggregation. Uganda HIV reporting quality was improved from deploying DHIS2 (50).

However, the Kenya and Uganda report focuses on streamlining the reporting process for improving the data quality, not patient tracking, and recruiting process. Moreover, as hospitals in Thailand had been using EHR from several vendors without national data standard coding, the interoperation problem was prominent. Moreover, hospitals could not modify EHR on their own, the modification request was required to submit to vendors with an additional charge. Therefore deploying an automatic reporting system from EHR directly was not feasible for Thailand at this stage (51).

Weiskopf’s data quality framework

At this state, we addressed Weiskopf’s data quality framework in terms of concordance, plausibility, and timeliness dimensions. The concordance was straight forward on comparing the two data sources on patients count on each category and the 90-90-90 indicators. Timeliness and plausibility were discussed on whether the patients who loss-follow-up length longer than 5 years were excluded with the assumption of death based on HIV survival literature and current data management practice.

Cohen’s kappa and data sources agreement were also calculated to assess the concordance dimension regarding Weiskopf’s framework. Both parameters allow us to gain insight into tho the two data sources difference. We found that, despite the fact of having a very large difference in certain hospital types, their agreement and kappa were very high and higher than those with less two data sources difference. This implies the systematic factor that causing one database to be reported more than another among those hospitals. Possible systematic factors were different regulation, policy, and specific administration structure which will be discussed later in the study.

Loss-follow-up patients were also representing timeliness dimension considering the criteria of not visiting the hospital for longer than 180 days. Local healthcare personnel was expected to reach and recruit loss-follow-up patients back to the care system or update their current status, the activity facing a challenge and, overburdened as discussed.

A large proportion of loss-follow-up patients was found to be unreachable or outdated. As a reason, we considered loss-follow-up patients as a proxy to assess concordance, plausibility, and timeliness of the reporting system in this study.

We did not exclude the possibility that the loss-follow-up patients might represent the local personnel practices rather than the data and reporting system. However, assessing their HIV practices without resolving the challenges of reporting systems was not possible and not within our study objectives.

MEASURE Data Quality Assessment (DQA) Tools

The UNAIDS MEASURE DQA score difference between hospitals was narrow in every section regardless of hospital type and provinces. Hospitals in this study obtained the highest score on the links with the national reporting system section of the MEASURE DQA Tools. This is expected as the tools' section focused on using national data tools for data collection. Both MOPH and NAP were considered as national tools causing the score in this section to be remarkably high.

On the contrary, the lowest score was in the data management process section as the MEASURE DQA focus on the existence of the written data backup procedure and duplicate record identification. All hospitals in our study use the automated back-up procedure on the cloud server. While the activities were automatically stored in the cloud server log, there was no written document decreasing the score of this section in all hospitals. Despite having the back-up system in place, the hospital's score was low.

While the tools focus on assessing the hospital practice, it did not capture the national tools' problem. Without taking the national tools problem into account, the hospitals were achieving high scores even though several problems of both MOPH and NAP were identified in this study.

In summary, while the MEASURE DQA tools provided an overall framework for guiding our approach to reporting quality assessment in this study, the tools did not provide specific information enough for the stakeholders to take action. This is an important issue to our study feasibility as our one-day visit needed to provide useful information and recommendations to the hospital personnel while able to provide recommendations at the national and international levels to maintain hospital cooperation.

We believed the DQI Tools were able to provide more specific guidance for the HIV clinic personnel on whom should they verify, and recruit in Thailand settings allowing personnel to work more effectively and efficiently. Having addressed the Thailand settings, we believe the tools could easily scale up the approach as reported to facilitate success in 90-90-90 achievement in the future (52).

What was the province with the highest two-data sources difference?

The province with the highest two-data sources difference was Bangkok. The difference was remarkable enough to classified Bangkok as an outlier even though Bangkok was one of 300 fast-track cites that participated in the 2016 United Nations Political Declaration on Ending AIDS by 2030 (53). Moreover, Bangkok is the only province lacking ARV prescription data in the MOPH database. As Bangkok 90-90-90 was still available from NAP, the remarkable two-data sources difference implies the problem in the reporting system to MOPH.

In other words, the data were available but were not submitted to MOPH.

The finding was supported by the MEASURE DQA scores that hospitals in Bangkok hospital data management practices were similar to non-Bangkok. This is an important matter as Bangkok covered more than 8.2 million population or 12% of the Thailand population. Lacking Bangkok data alone could distort the overall situation at the national level. For example, we identified bed capacity and

PEPFAR funding as having a statistically significant association with two data sources difference at the provincial level, both associations lost their statistical significance after excluding Bangkok from the analysis.

Bangkok unique hospital management structure

In Thailand, most hospitals were MOPH affiliated and were bound to submitting data to the MOPH. This was not the case in Bangkok where hospitals were not affiliated with MOPH as Bangkok is a special authority province (54).

Most Bangkok public hospitals were affiliated with the Bangkok Metropolitan Administration (BMA), a special authority governing the Bangkok city under the Ministry of Interior. The MOPH had no direct authority on BMA hospitals and were categorized as Public non-MOPH hospitals.

The majority of hospitals in Bangkok were private hospitals. They have different challenges from the government hospitals as hospitals under MOPH and BMA tends to use the same EHR vendors, private hospitals use different EHR vendors from each other causing the change made to EHR not applicable to other hospitals.

Deploying the MOPH data submission system required the hospital to negotiate and make changes with the vendor. The processes were challenging as several small hospitals lack negotiation power compared to larger tertiary care hospitals. As MOPH and BMA affiliated hospitals use similar EHR vendors, pooling their change together, and negotiate with vendors. This was not the case for private hospitals.

As private hospitals did not submit data to MOPH before the A.D. 2015 regulation was enacted, they had to start deploying the MOPH reporting system from scratch. Deploying the MOPH reporting from scratch had more technical challenges requiring a huge amount of resources without any incentive nor reimbursement in return.

Patients privacy was more concerned in a private hospital as compromising patients' private directly impact private hospital revenue and reputation. The concern was more intense among the vulnerable population, HIV patients.

Besides, most private hospital patients used private insurance or pay from their own pockets. Because of that the hospitals did not need reimbursement from NAP and did not submit data to both databases. As a result, cooperation from private hospitals was very limited in this study.

Lacking data submission from several affiliations in Bangkok to MOPH caused the large two-data source difference in Bangkok. The gaps were reported in many non-HIV public health surveillance systems (e.g. Non-communicable diseases, Dengue), therefore addressing the gaps will also improve the effectiveness of the surveillance system for other diseases in Bangkok.

What was the problem on the MOPH side?

The public non-Bangkok hospital challenges were different as they were bound to submit data to MOPH regularly. Public non-Bangkok hospitals were using the EHR from a few selected vendors providing hospital personnel with a large and mature community to seek help.

Even of that, a large amount of missing data of ARV prescription and VL results were missing from the MOPH database. Two problems were responsible for the missing data.

Regulation problem

There was a statement from the Thailand Medical Technology Standard: 2017 4.2.4. “Outside laboratory results must be stored inside the database without any edit or copy.” (55). We believed the “copy” statement is unclear and the user may understand that “copy” includes re-entering data into the hospital database. The finding was reported from all non-laboratory center hospitals indicating a national level problem that needs to be escalated and to issue an official announcement.

Therefore, as most hospitals could not conduct CD4 and VL tests, they had to send a specimen to the outside laboratory center. Returned results were stored in the database in PDF/Image format that could not submit to MOPH. The procedure applied to all non-HIV laboratory results that were

conducted by a laboratory outside the hospital which was utilized in several public health surveillance systems.

Lacking unified single national data standard coding

Before the A.D. 2015 act was enacted, Thailand reimbursement was based on DRG (UC) and fee-for-service (CSMBS). DRGs used the ICD-10 code for reimbursement in the UC health scheme. As Thailand did not have a national data standard coding for medication, and laboratory, hospitals create their local code for internal use. However, when CSMBS announced in 2015 their medication data coding standard, the Thai Medical Terminology (TMT), hospitals were forced to adopt and deploy the TMT coding system to receive reimbursement from CSMBS. MOPH coding received lower priority from lacking incentive and reimbursement.

Moreover, the MOPH laboratory data coding standard was revised from 2 digits to 7 digits system in 2017 causing several failures in laboratory data submission to MOPH. Frustration and technical problems arose and were discussed by several hospital IT personnel (56, 57). Revising data standard coding also compromised historical data.

Only 21 laboratory results were supported by the 2 digits system. The support laboratory results were mostly Non-communicable disease (NCD) related (See Appendix). No HIV laboratory was supported until the 7 digits system was deployed in 2017.

As the HIV laboratory code was not supported by the 2 digits system, all HIV laboratory data before 2017 were missing entirely from the MOPH database. Even after the 7 digits system was implemented in 2018, HIV laboratory data were still poorly available from implementation lag-time.

Lacking a single unified data standard of historical data, in addition to the fact that the MOPH reporting system was initiating in 2015 severely limiting our ability to obtain historical data.

Why don’t we just use a NAP?

NAP was established under NHSO with the purpose of UC health scheme reimbursement only. NHSO/NAP functions were similar to the Center for Medicare and Medicaid Services (CMS) in the

United States. Their function, capacity, and organization structure were designed to accommodate reimbursement functions.

The MOPH functions in Thailand were similar to the Department of Health and Human Services and US-Center for Disease Control and Prevention (US CDC) in the United States, the main authority for an epidemiology study, and implementing public health interventions.

While directly under MOPH function and responsibility, the MOPH database and reporting system suffered several problems and could not be used as a primary source for HIV 90-90-90 indicators calculation as discussed in the previous section.

NAP was a better source for 90-90-90 indicators calculations from having a better reporting quality. The main reason was, NAP provides reimbursement while MOPH did not. MOPH submission solely depended on the A.D. 2015 Communicable Diseases regulation.

When the national data sources were not reliable, other stakeholders started developing and deployed their separated reporting systems and their results in several data silos. Similar findings were reported in South-African from their failure of DHIS-based reporting system implementation (35).

However, using a NAP as a primary source in the long term was questionable as it may cause conflict among two organizations functions and decrease efficiency. NAP was established for reimbursement purposes but had to allocate resources for non-reimbursement tasks. The situation was similar to US-CDC asking CMS to also do US-CDC jobs.

In the long run, after the MOPH reporting system was more mature, the primary data source for indicator calculation had to be shifted back to MOPH to alleviate NAP from non-reimbursement tasks and improve Thailand's HIV reporting efficiency. Also, NAP had its challenges to overcome.

What causes the NAP problem?

As NAP was centralized data entry, it did not suffer data standard problems like MOPH. NAP challenges were more on management and policy issues.

While the system provided reimbursement for UC and laboratory reimbursement for SSO, that cover the majority of HIV patients in Thailand, non-UC patients were not included by the NAP reporting system (e.g. SSO ARV data did not available in NAP). Depending on data entry and not covering non-UC patients were causing data error, inconsistency, and problems of currency in NAP.

However, the NAP did not have the responsibility to integrate and update the patient's data from non-NAP sources. Also, data quality was not under NAP responsibility as hospitals were responsible to enter correct data or not receiving reimbursement.

Solving the problem by NAP alone was not possible as it needs hospital input to verify, update, and cleaning the data. However, the data correction request was complained as too difficult by the hospitals. Without the hospital's active participation, the NAP reporting quality was compromised due to lacking a data validation mechanism as NAP required information from the hospitals to correct those records.

This was important as the historical NAP data suffered from data quality problems from failure migration from NAPHA in 2008. As an example, several "loss-follow-up" patients were in 2008 records or beyond. Having a difficult data correction process might further posing obstacles to the data quality improvement attempt.

While it was understandable that firm pieces of evidence were necessary for data correction in sensitive information like HIV patients records, archiving, and excluding compromised records from the indicator calculation could be an option.

Overall Gaps in-hospital workflow

Regardless of a partial or electronic-based health record system (EHR), the hospitals manually re-enter data to NAP by a clerk or nurse. On the contrary, MOPH submission was extracted by the database administrator or IT personnel and submitted.

We believe the NAP processes were more prone to human error from manually re-entering data. Unfortunately, limited fieldwork time and several of the external factors discussed in the previous

section (e.g. lacks single unified standards for MOPH and failure of the legacy system migration for NAP) prevented us from fully assessed the impact of the hospital workflow on the reporting quality in both systems.

However, the impact of hospital workflow became more prominent when local personnel was requested to verify the patients' HIV status, or the HIV related laboratory by reviewing old medical records.

In a partial paper-based system, most medical records were kept as scanned image files for internal communication or an archive database. Several hospitals kept separate copies of the HIV patients' information in addition to EHR, mostly were in paper-based documents and Microsoft Excel spreadsheet files. The information was kept across several silos risking data loss and violating patients' privacy. Moreover, paper-based documents, images, and spreadsheet files were not searchable making the old medical record searching for reviewing very challenging, time-consuming as the person must go through the records one by one to identify the relevant records.

It was very challenging for hospitals to improve the old medical record data quality. All hospitals in the study were focusing on transitioning to the fully EHR system requiring a huge amount of their resources. Considering the current resource constraints they were facing, allocating resources on maintaining the archive data was not feasible, especially on loss-follow-up patients who did not visit the hospital for several years.

As HIV was a sensitive diagnosis, we believe excluding patients from the analysis and the indicators calculation without record deletion was more feasible. This option allows data analysis and indicators to better represent the current performance without putting much burden on medical records reviewing. The records were archived and still available if necessary.

Recommendations

Hospitals and Provincial Health Office (PHO)

Hospitals and the PHO in this study were encouraged to use the DQI Tool for providing a shortlist of truly loss-follow-up patients to reach out and recruited back to the care system.

For other categories (regularly follow-up at the hospital or other hospital, death, and invalid records) generated from the DQI Tools, we encouraged personnel to take action provided in the hierarchical visualization given by the tools and to submit the data update requests to NAP if required. The visualization was generated in the application in the hierarchical chart as shown in Figure 62. The color-coded represent the action that local personnel has to proceed for each category.

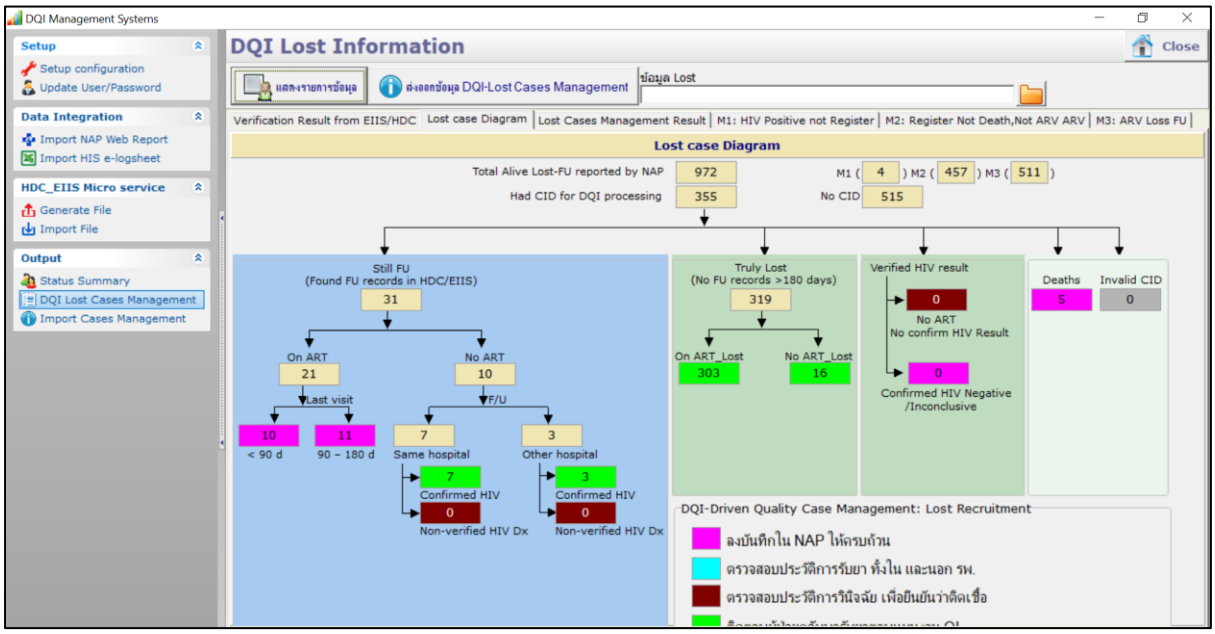


Figure 62 DQI Tools visualization. Violet cells mean personnel must correct data. Brown cell means personnel has to verify patient HIV diagnosis, Green means patients regularly follow-up. Violet color cells represent the need for updated NAP data. Brown color tells the local personnel to verify HIV diagnosis evidence and green color cells are patients that personnel has to recruit back to the HIV care process. The visualization and report can be export in an Excel spreadsheet format.

If retrieving old medical records were not possible, the local personnel should add a remark on the record in the DQI Tools. The remarked records were excluded from the Tools' processes but were archived and still are accessible.

Revising Asian Epidemic Model (AEM), 2019

In the previous section, we discussed the possibility of overestimating the first 90-90-90 indicator of 105%. The indicator level was expected to be less than 100% as HIV patients were less likely to visit the hospital because of stigmatization thus receiving less report number (nominator) to NAP and MOPH while the AEM estimation (denominator) addressed those population not seeking care.

Considering the time constraint and logistics difficulties, the recommendation was provided to the MOPH modeling department at the beginning of the study in parallel to our data collection and field visit. The revision was concluded in November-December 2019 with a 14.3% increase in HIV estimation compared to the original AEM estimation as shown in Figure 63.

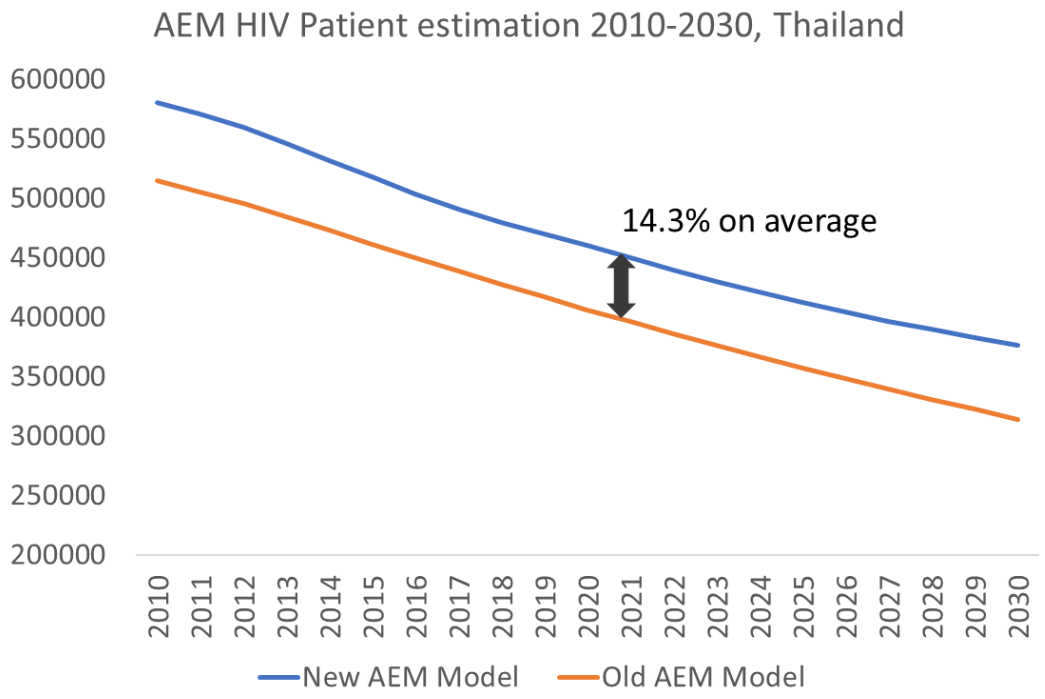


Figure 63 Old and New (Revised) AEM comparison 2010-2030 estimation.

The revised AEM reduces the 2018 first 90-90-90 indicator from 105% to 94%. The DQI Tools further reduced the first 90-90-90 indicator to below 90%. The distribution of Thailand's first 90-90-90 indicator remains unchanged as described in Figure 64. The indicator value decreased in general without any specific pattern.

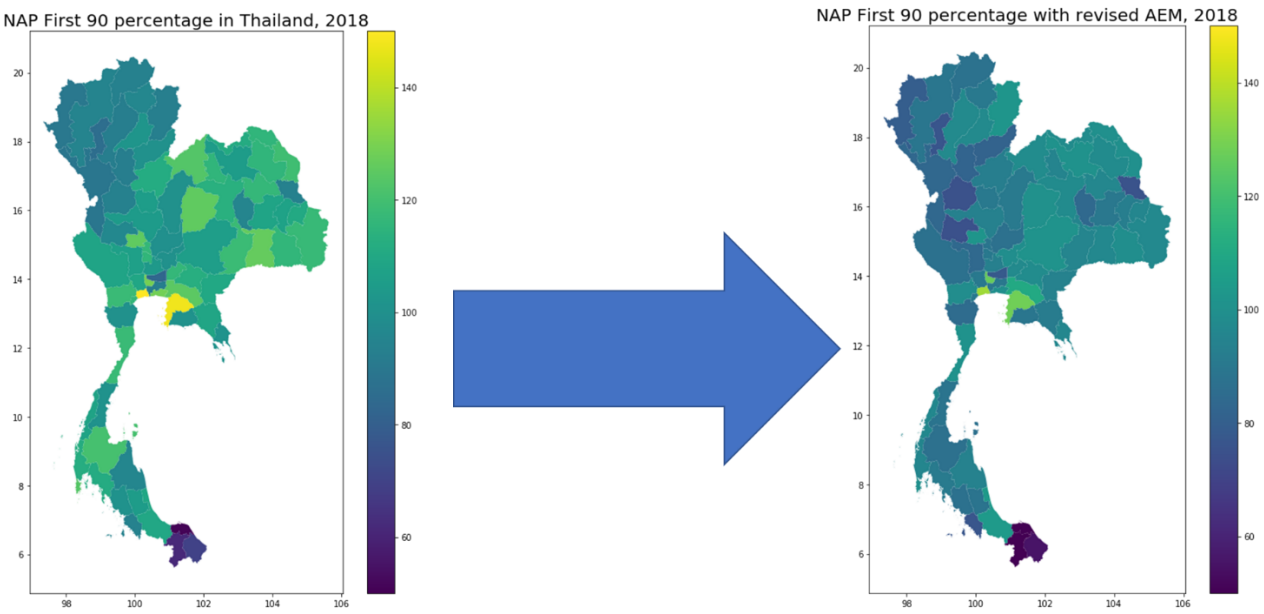


Figure 64 NAP First 90-90-90 indicator at the provincial level distribution between old and revised AEM estimation

Policy Recommendations

The DQI Tools did provide important information for analysis and insight into the current reporting gaps and facilitate local personnel works. To solve the gaps, the interventions need to be provided according to their findings, incorporating also the qualitative findings and proposing them to the national level, especially to NAP.

We analyzed and discussed the insight obtained from the DQI Tools results during the "lesson learned" session with the hospitals that participated in this study to propose the recommendations to relevant stakeholders.

Recommendation for intervention regarding the loss-follow-up category in NAP

We summarized the findings and recommendations for each of the loss-follow-up patient categories identified by the DQI Tools. The recommendations were expected to be proposed in the stakeholder meetings to achieve the 90-90-90 indicators goal level. As NAP was a data source for 90-90-90 indicators, this section focused on the loss-follow-up in the NAP database.

1. Patient without HIV result evidence

Most patients in this group were diagnosed more than 5-10 years ago causing the recruiting and gathering of their evidence incredibly challenging. Despite the effort done by the local personnel, most patients were unreachable.

Taking into account the loss-follow-up and unreachable patients for the calculation of the indicator severely underestimated the current situation in Thailand and the current performance of the hospitals, strongly disincentivizing the local personnel.

Therefore, while the current recommendation was to initiate a better NAP database update request by allowing the hospital to directly corrected patient records from the current NAP data entry system to encourage hospitals to update the current patients status, we proposed that the Thailand archive excluded patients without HIV laboratory evidence for the calculation of the HIV-related indicator to better represent the Thailand situation and the local personnel performance. Those excluded were to be archived and are obtainable if the evidence were recovered in the future.

2. Invalid /duplicated SSN

It was not possible to identify records with invalid SSN, causing the recruitment of patients back to the HIV care system not possible. We recommended invalid SSN records to be excluded from the calculation of the HIV related indicators.

For duplicated SSN records, as NAP could not make a decision on which record to be kept and how to merge them, the decision had to be made by the hospitals and the local personnel. Therefore, for duplicated SSN records, hospitals had to decide on whether to keep or combine the record. Discarded records were archived and excluded from the HIV-related indicator calculation. All records were to be archived without any deletion.

3. Receiving ARV without VL result

In Thailand, as the reimbursement was maintained and oversee by NAP, it was unlikely that patients with VL results did not have ARV prescribed. Even in the case of ARV adverse effects or severe allergic reaction when patients were tested for VL but did not prescribe ARV, the patients were still

follow-up regularly with the physician. The patients remained in the care system and satisfied the indicator purpose of assessing the follow-up.

Therefore, if the ARV prescription date were not available in the database, the VL results report date could be used for the calculation of the indicator instead.

4. Lost-follow-up but regularly follow-up at other hospitals

Patients receiving care at other hospitals without a referral command from the origin were classified as lost-follow-up in NAP. Unlike the data correction process, it was possible to update by the origin hospitals. The origin hospitals, however, needed information on the current follow-up patients and the current hospital location to proceed.

Therefore, a collaboration network among hospitals was necessary to initiate the referral process. A possible solution was to establish a notification system to detect the patient receiving care at other hospitals without a proper referral process. A notification and patient list were generated and sent to both hospitals (senders and receivers) to fulfill the proper referral process. One of our recommendations for Bangkok, the Bangkok Smart Monitoring System (BSMS), was an example of the collaboration network and could be deployed in other provinces.

5. Loss-follow-up length exclusion criteria

Many patients were lost-follow-up for a long time and unable to recruited back. Also, we need to consider the fact that the survival of patients not receiving ARV was low at 5 years and of the data management practice in several hospitals that discarded loss-follow-up records older than 5 years. Taking long-time loss-follow-up patients into the indicator calculation did not represent the current Thailand HIV progress and may put an unnecessary burden on the health personnel. Retaining this patient group also impacts the local personnel activity as they could not focus on constrained resources on whom to recruit back as pointed out by the DQI Tools report that able to reduce the recruiting list in half.

However, removing loss-follow-up patients also negatively impact the first 90-90-90 indicators. Removing too many loss-follow-up patients might reduce Thailand's first 90-90-90 indicator to below 90%. Therefore, we applied our DQI Tools findings from the study sites to the national level into 4 possible scenarios for the decision-makers, for excluding loss-follow-up patients from the indicator calculation in the next section.

DQI Tool's data correction scenario on loss-follow-up patients

In this section, we applied our four loss-follow-up scenarios (DQI Corrected 1-4) using the study findings back to the national level to assess their impact on Thailand's 90-90-90 indicators and in the interaction with the Revised AEM 2018 estimation in Table 60, Figure 65, and Figure 66.
When taken the revised AEM 2018 into account, the DQI-Corrected 2 and 4 scenarios reduced Thailand's first 90-90-90 indicators to below 90% due to excluding too many patients from the nominators (loss-follow-up patients) and with the increased denominator from the revised estimation.

Therefore, our suggestion was to deploy the DQI-Corrected 1 scenario with a revised AEM 2018 estimation. Deploying the first scenario was easier to deploy, requiring minimal workload from local personnel while maintaining Thailand's first 90-90-90 indicators above 90%.

With the AEM estimation at the beginning of the study in 2018 of 427,526, 450,548 were reported to NAP (105% of the first 90-90-90 indicator). The DQI-Corrected-1 scenario reduced the nominator (PLHIV) by 1.13% to 445,447 (104.19% of the first 90-90-90 indicators). DQI-Corrected-2 reduced the nominator by 4.50% to 420,290 (100.65%). DQI-Corrected-3 reduced the nominator by 3.22% to 436,055 (1020%) and DQI-Corrected-4 reduced the nominator by 6.6% to 420,898 (98.45%).

However, the revised AEM estimation increased the total number of HIV patients to 479,652 causing a large reduction in Thailand's first 90-90-90 indicator from 105.38% to 93.93%. This change also impacted all four DQI-Corrected scenarios as described in Figure 65. With the revised AEM, only the DQI-Corrected 1 and 3 were able to achieve the 90% percent level first 90-90-90 indicators, as described in Table 60.

The second 90-90-90 indicators were increased in all DQI corrected scenarios. Patients receiving ARV were only increased by 31% in the DQI-Corrected-1 scenario and remained stable in other scenarios. On the contrary, the denominator (PLHIV) was decreasing in scenario 2-4 raising Thailand's second 90-90-90 indicators from 71.83% to 74.84%-79.21%.

The third indicator was minimally improved from 82.89% to 83.65% in the DQI-Corrected 1 scenario and remained stable as described in Figure 66. As the second and third 90-90-90 indicators did not use the AEM estimation for calculation, the AEM revision has no impact on both indicators.

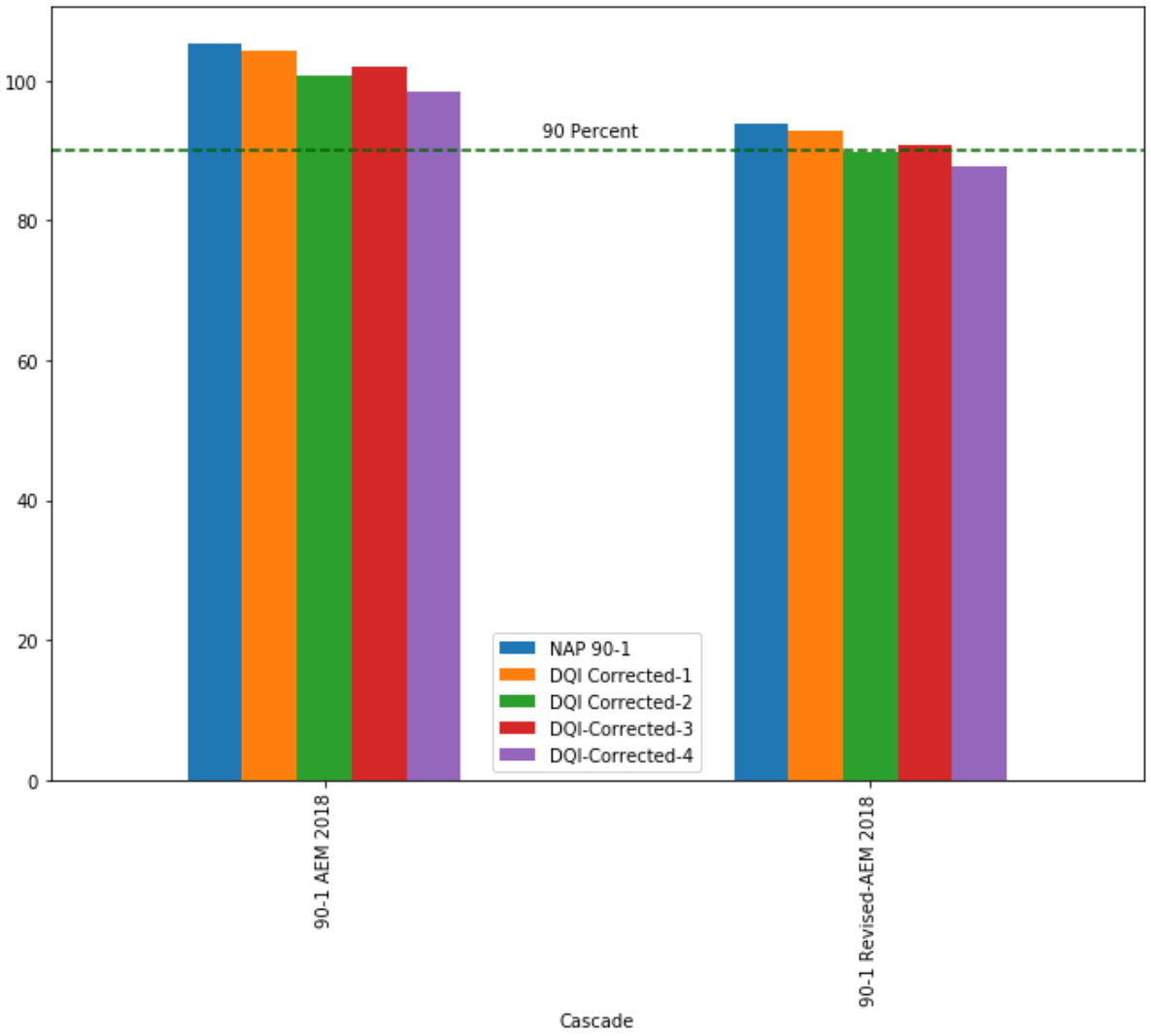


Figure 65 First 90-90-90 indicators comparison across four DQI-Corrected scenarios, by AEM and revised AEM inference at the national level

Table 60 PLHIV, AEM, Revised AEM and 90-1 calculation across four DQI-Corrected scenarios, Thailand, 2018

Cascade	NAP	DQI Corrected-1	DQI Corrected-2	DQI-Corrected-3	DQI-Corrected-4
PLHIV	450,548	445,456.8	430,273.3	436,040.4	420,901.9
AEM 2018	427,526	427,526	427,526	427,526	427,526
AEM Revised 2018	479,652	479,652	479,652	479,652	479,652
90-1 AEM 2018	105.38%	104.19%	100.64%	101.99%	98.45%
90-1 Revised-AEM 2018	93.93%	92.87%	89.71%	90.91%	87.75%
Receive ARV	323,637	333,378.47	333,378.47	333,378.47	333,378.47
90-2	71.83%	74.84%	77.48%	76.46%	79.21%
VL Suppressed	268,256	278,878.94	278,878.94	278,878.94	278,878.94
90-3	82.89%	83.65%	83.65%	83.65%	83.65%

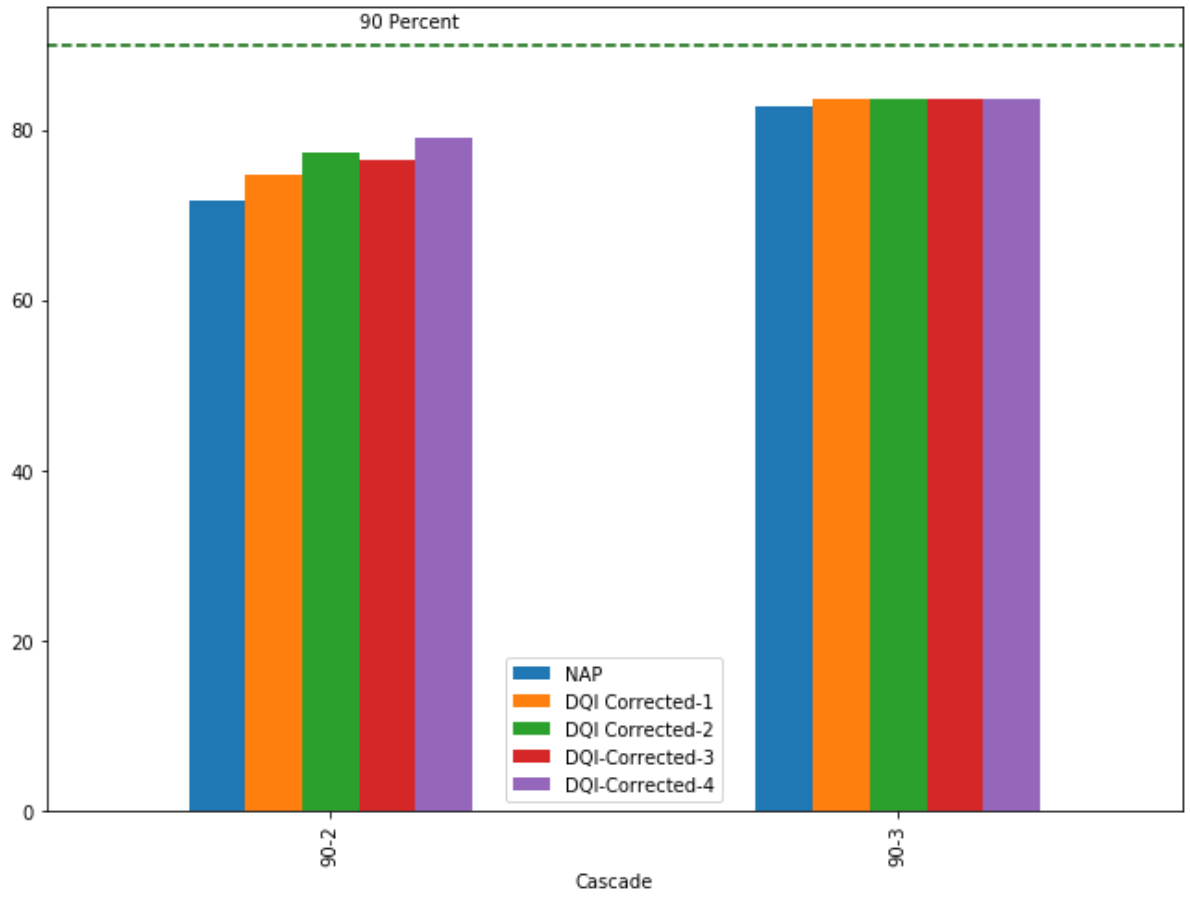


Figure 66 The second and third 90-90-90 indicators comparison across NAP and four DQI Corrected scenario inference at the national level

Time threshold for loss-follow-up exclusion

Another consideration was to determine the time threshold lost-follow-patients to be excluded from the calculation of the indicator.

The important finding was that there were no additional patients receiving care at other hospitals, and patients recruited back to the care system on 4-5 years brackets and above (Table 51).

The finding is consistent with a study reporting the survival rate among patients without ARV/HARRT was 26% for 4 years and 18% of 6 years period (32). Another possible reason was the availability of old medical records. While there was no exact duration on how long the hospitals should keep the medical records, many hospitals disposed of medical records of patients that did not visit hospitals for 5 years or above (58, 59). Some hospitals even discarded medical records after 3

years (60). The report from Sub-Saharan also used the threshold of 4 years duration threshold to take action for loss-follow-up patients (46).

Therefore, we propose 5 years as a cut-off threshold as there was no additional evidence or patients to be recruited back after 3-4 years brackets. The results had been supported by TUC HIV experts and were presented to a stakeholder meeting in 2020 to make the final decision. We also recommended all patients compatible with these categories to be excluded from HIV related indicator calculation only, archiving the records without any deletion.

Deploying DQI Tools at the nation level

As discussed in the previous recommendation, the DQI Tools were able to provide information for relevant decisions and to support decision making that has a direct impact on the national HIV indicators without intensive investment while generating a useful report to the front-line personnel. Therefore, we recommended expanding the application to non-study sites to generate more impact and to follow the achievement of the 90-90-90 indicators.

The national deployment plan was proposed as a centralized web-based application on the MOPH infrastructure. Having a centralized web application could streamline the deployment processes by skipping the installation process and software compatibility issues. The centralized system also will allow MOPH and NAP to have more control and to monitor to ensure satisfying the security and privacy levels. System maintenance was also easier to manage in the long term.

As of February 2020, the DQI Tools phase 2 proposal was approved by stakeholders. The phase 2 target sites included 74 more hospitals (99 hospitals in total) across 35 provinces. The phase was expected to be initiated in early-August 2020.

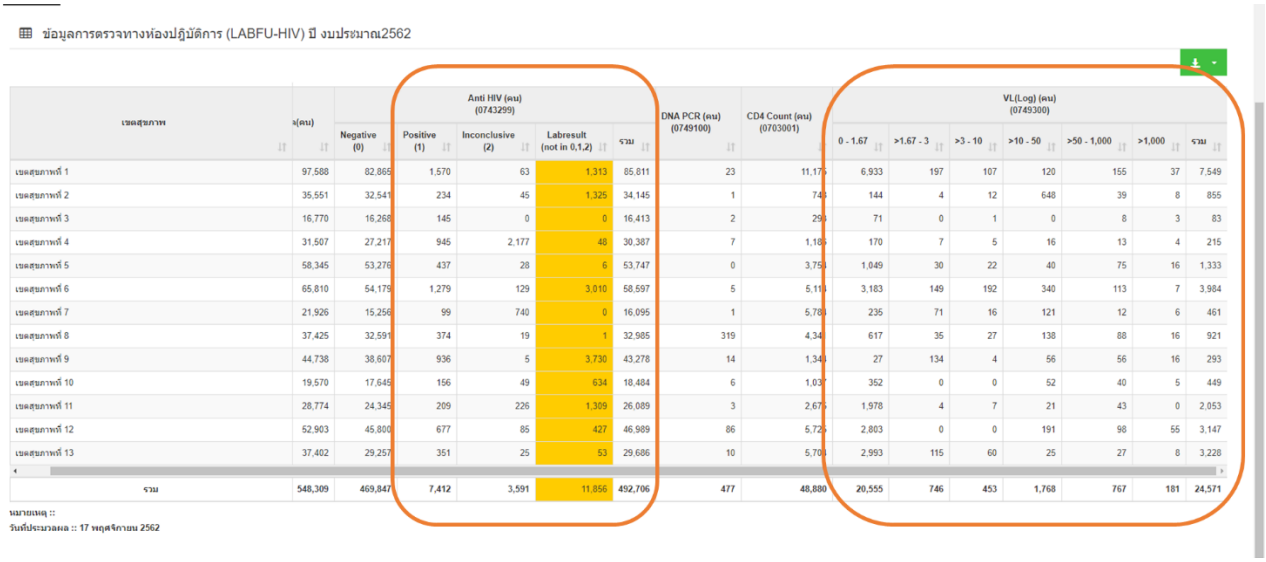
MOPH database improvement initiative

The study findings and local feedbacks regarding the MOPH reporting system were forwarded to the MOPH and received a well-support from the MOPH. The newly developed dashboard database system was developed and deployed in November 2019. Figure 67 describes the improved MOPH

dashboard with the stratified results of Anti-HIV and VL. The VL submission had increased to 24,571 records, much better than 5,537 records before the intervention.

Of 1,128 hospitals under the MOPH HIV database, 62 hospitals had submitted VL results in 2018. The number had increased to 139 in 2019 as of November 2019. There were 24,571 VL results submitted to MOPH, with 23,623 records achieving the VL-suppressed level (96.14%).

Unfortunately, MOPH ARV data will not be available until mid-2020. Thus, assessing the improvement on the MOPH side is not possible until late 2020. However, we expect the number to rapidly increase as the data were already in hospital databases to be extracted and submitted when the MOPH side was ready.


ข้อมูลการตรวจทางห้องปฏิบัติการ (LABFU-HIV) ปี งบประมาณ2562

เขตสุขภาพ	ม(คน)	Anti HIV (คน) (0743299)					DNA PCR (คน) (0749100)	CD4 Count (คน) (0703001)	VL(Log) (คน) (0749300)						
		Negative (0)	Positive (1)	Inconclusive (2)	Labresult (not in 0,1,2)	รวม			0 - 1.67	>1.67 - 3	>3 - 10	>10 - 50	>50 - 1,000	>1,000	รวม
เขตสุขภาพที่ 1	97,588	82,865	1,570	63	1,313	85,811	23	11,179	6,933	197	107	120	155	37	7,549
เขตสุขภาพที่ 2	35,551	32,541	234	45	1,325	34,145	1	749	144	4	12	648	39	8	855
เขตสุขภาพที่ 3	16,770	16,268	145	0	0	16,413	2	294	71	0	1	0	8	3	83
เขตสุขภาพที่ 4	31,507	27,217	945	2,177	48	30,387	7	1,189	170	7	5	16	13	4	215
เขตสุขภาพที่ 5	58,345	53,276	437	28	6	53,747	0	3,750	1,049	30	22	40	75	16	1,333
เขตสุขภาพที่ 6	65,810	54,179	1,279	129	3,010	58,597	5	5,110	3,183	149	192	340	113	7	3,984
เขตสุขภาพที่ 7	21,926	15,256	99	740	0	16,095	1	5,780	235	71	16	121	12	6	461
เขตสุขภาพที่ 8	37,425	32,591	374	19	1	32,985	319	4,340	617	35	27	138	88	16	921
เขตสุขภาพที่ 9	44,738	38,607	936	5	3,730	43,278	14	1,340	27	134	4	56	56	16	293
เขตสุขภาพที่ 10	19,570	17,645	156	49	634	18,484	6	1,037	352	0	0	52	40	5	449
เขตสุขภาพที่ 11	28,774	24,345	209	226	1,309	26,089	3	2,675	1,978	4	7	21	43	0	2,053
เขตสุขภาพที่ 12	52,903	45,800	677	85	427	46,989	86	5,724	2,803	0	0	191	98	55	3,147
เขตสุขภาพที่ 13	37,402	29,257	351	25	53	29,686	10	5,706	2,993	115	60	25	27	8	3,228
รวม	548,309	469,847	7,412	3,591	11,856	492,706	477	48,880	20,555	746	453	1,768	767	181	24,571

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Figure 67 Improved MOPH HIV Dashboard. Notice the orange box shows the VL result and Anti-HIV results were stratified by their results and level. With this, calculating the third 90-90-90 indicator is now possible. Noted that the Anti-HIV results are for newly tested only not a cumulative number while the VL must be tested annually.

Regulation issues

Four regulation issues were requiring the MOPH to clarify and to take action: storing laboratory results from the outside laboratory, mandate VL and CD4 results submission, strengthen the Communicable Disease A.D. 2015 Act enforcement, and working with NAP to improve data correction processes.

First: As discussed, the terms “copy” in the Thailand Medical Technology Standard 2017 was responsible for the confusion of not able to store results from an outside laboratory. Personnel was not sure whether they could store laboratory results from the laboratory center inside their LIS/EHR in text/numeric format. As a result, several laboratory data were unable to submit and were difficult to utilize as they were stored in PDF or Image file format. The MOPH had to confirm that storing data inside LIS/EHR as numeric and text was legit but with a remark that the results were from laboratories outside of the hospitals.

During the field visit, the research team discussed with local personnel whether storing laboratory results from laboratory centers was possible with the remark as ‘outside laboratory result’ to not violating Thailand Medical Technology Standard 2017 and it was acceptable. While most hospitals' responses were acceptable, the concern of increasing the data entry workload remained.

Second: The concern led to the second regulation issue as Thailand Communicable Disease Act 2015 did not state clearly whether to only report the case or including follow-up laboratory VL and CD4. Therefore, the MOPH should clarify with the hospitals on whether the Thailand Communicable Disease Act 2015 mandate VL and CD4 submission.

Third: Even though the Thailand Community Disease Act A.D. 2015 had been enacted since 2016, several hospitals were still struggling to comply with challenges reported in this study. The MOPH also needed to provide support in terms of resources and technical assistance to the hospital to comply.

Moreover, while MOPH hospitals were bound to follow the MOPH direction, non-MOPH hospitals may require their authority approval to follow (e.g. BMA for BMA Affiliated hospital). Thus, the MOPH has to agree to follow the A.D. 2015 Act and provide support as needed.

Forth: Reassuring the local personnel to correct data in the NAP database. One of the hospitals was concerned whether correcting NAP data will cause the change in reimbursement and they might be prosecuted. While this was not directly under MOPH authority, the MOPH had to work with NAP on behalf of hospitals to ensure the legitimacy of the personnel’s action.

Bangkok Smart Monitoring System (BSMS)

While hospitals in Bangkok included in this study had good data management practice, they could not submit data to MOPH for several reasons: deploying the MOPH reporting system from scratch was costly and technically difficult, the existence of several stakeholders and affiliation, no incentive available, and privacy concerns. These problems have been causing the reporting gaps in Bangkok across several Thailand Public Health Surveillance systems for a long time. Therefore, addressing Bangkok gaps also will benefit other Thailand Public Health Surveillance systems.

To address the challenges, the Department of Health, Bangkok Metropolitan Administration (BMA) had proposed the idea of creating a Datawarehouse system especially for HIV reporting in Bangkok, Bangkok Smart Monitoring System (BSMS) (Figure 68).

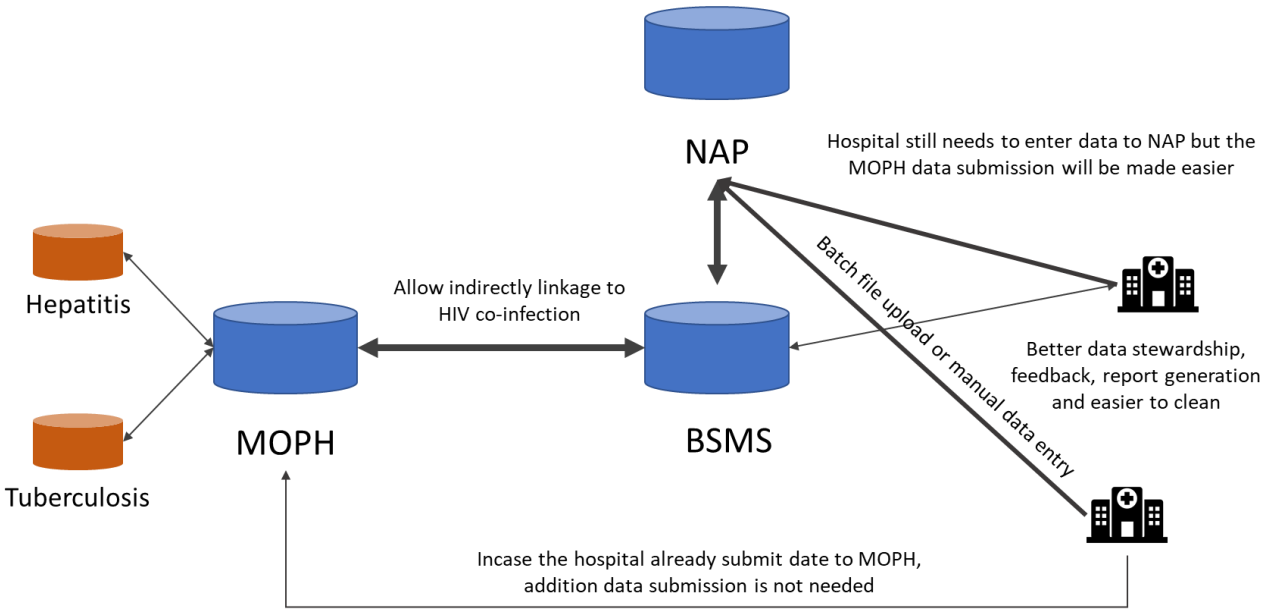

Figure 68 BSMS Dataflow diagram. The BSMS system, under the BMA cloud server, will act as a storage for BMA internal use. (Bangkok Metropolitan Administration or BMA)

The BSMS system was deployed on the BMA cloud server. NAP data were mirrored and integrated with submitted data from BMA hospitals. Non-BMA affiliated hospitals could decide whether to submit a batch data file, manually enter data to BSMS or voluntarily deploy the MOPH reporting system and connect to BSMS. Having these three options available for hospitals could address several of the challenges observed in the study and improve the hospital's cooperation. For example, hospitals

facing the technical difficulty of deploying the MOPH reporting system could instead submit batch files or manually enter data to BSMS. Hospitals with low HIV patient count often preferred to enter data to BSMS directly.

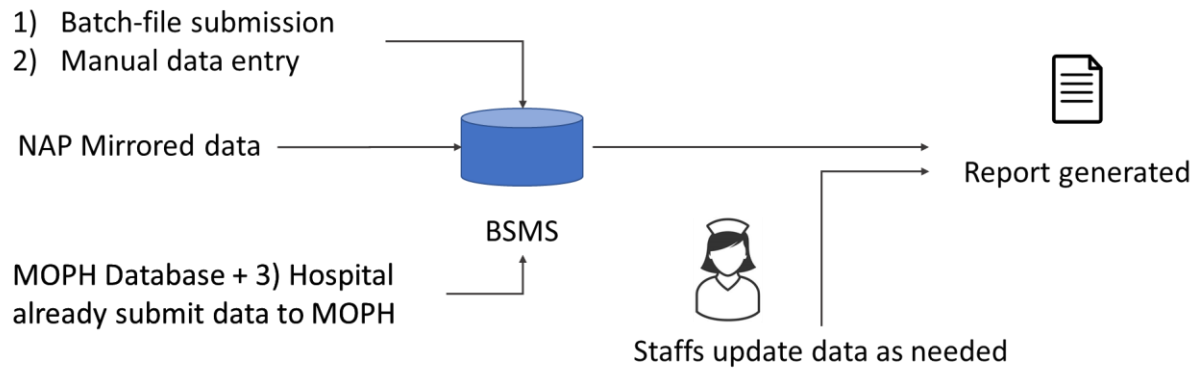

Figure 69 Overall BSMS workflow. Data from NAP, MOPH, and hospital choice of data entry or submission will be integrated. Hospital personnel will update as needed.

Figure 69 described the personnel workflow of BSMS. The system started by mirroring Bangkok NAP data and integrate with hospital data either by batch-file or manual data entry. Hospital personnel only needed to updated new visit data, missing data, SSN data that NAP did not mirror to BSMS, and additional variables required by BMA that did not exist in NAP nor MOPH e.g. Maternal HIV risk factor. At this stage, only patients who have visit data in NAP during the last one-year data were mirrored from NAP to BSMS to not overwhelming personnel with data entry workload, the rest will be mirrored to BSMS in the next phase.

The BSMS allowed BMA to had more control over the data flow and to provide report customization to address hospitals and BMA needs (Figure 69). Hospitals also had more control over their data to ensure that only the necessary data were submitted. This was very important for the private hospitals where customer privacy received priority allowing the BSMS to address the data stewardship conflict between MOPH and BMA by providing data to MOPH and allowing BMA to have control over the data flow.

The control over the data submission in addition to the three available data submission options provides the BSMS system with far greater flexibility for hospitals in Bangkok. The flexibility allows

the BSMS system to address different regulations across several hospital affiliations in Bangkok. Thus, it was more likely to obtain participation from several hospital affiliations.

While entering data to NAP were still required, the system reduced the burden of MOPH reporting and the Thailand Communicable Disease Act 2015 compliance by relieving the technical challenge of deploying the MOPH reporting system from hospitals.

Currently, BSMS only supports the HIV reporting system. Additional support of Sexual-Transmitted Disease (STD) and tuberculosis (TB) were being developed and will be deployed in the next phase. The BSMS also could accommodate other priority diseases of the Thailand Community Disease Act A.D. 2015 in the future, providing potential solutions for filling the Bangkok gaps in several Thailand public health surveillance systems.

The BSMS development was funded by the BMA Health Department of approximately $167,000 U.S Dollars including maintenance contracts for 3 years. As of January 2020, the working prototype software was ready and prepared for field tests before go-live in March 2020 but was temporarily postponed from the COVID-19 pandemic.

As of December 2019, 92 of 155 hospitals in Bangkok agreed to participate in the BSMS (Table 61). The number was much higher from 13 hospitals that were submitting data to MOPH before BSMS. Thirty-seven hospitals were preferring manual data entry and 55 hospitals preferring batch file submission. BSMS data submission interface was shown in Figure 70 and Figure 71.

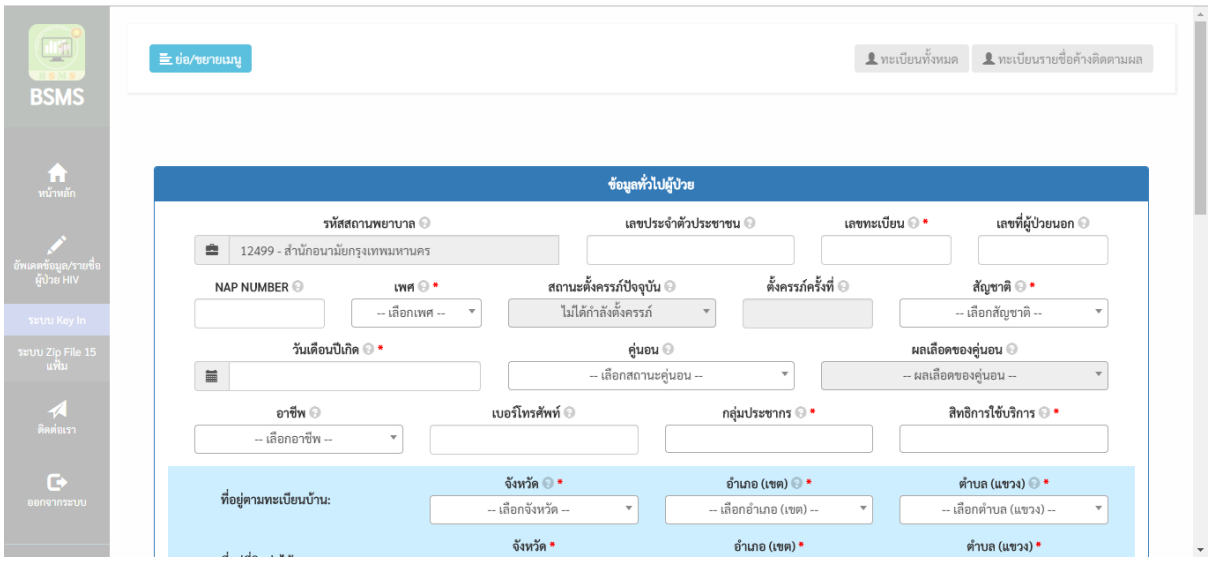

Figure 70 BSMS System data entry user-interface

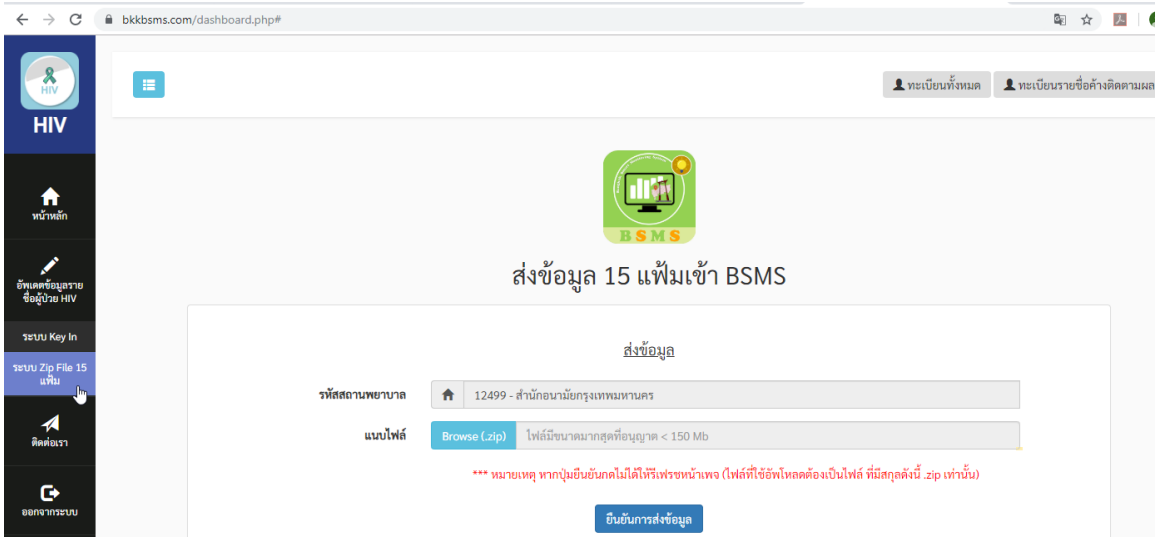

Figure 71 BSMS Batch-file upload user interface

Table 61 Distribution of hospitals that participate in BSMS and percentage of each hospital type

Hospital Type in Bangkok	Total	Participate in BSMS (%)
Private	107	54 (50.47%)
BMA	12	9 (75%)
Non-BMA Hospitals, including MOPH	32	25 (78.13%)
University	4	4 (100%)

Hospitals with manual data entry choice and those already submitting data to MOPH could start using the BSMS immediately. However, hospitals with batch-files submission choice had to submit their data-dictionary and with sample data to the BMA team for data mapping preparation.

In other words, the BMA took the burden of mapping data from the hospitals. As the BMA team relieved the burden of the technical difficulty, cooperation was more likely from the hospitals.

Single unified national data standard for MOPH

Lack of data standard and technical difficulties were reported as an important obstacle to the MOPH reporting system. Ideally, the solution was to announce national data standards that were accepted and widely deployed in Thailand, Thai Medical Terminology (TMT) for medication, and Thai Medical Laboratory Terminology (TMLT). Both standards were developed based on international standards, SNOMED CT and LOINC, and were mapped to support reimbursement in Thailand including CSMBS. Both standards were developed and maintained by the Thai Health Information Standards Development Center (THIS), currently operating under MOPH and NHSO.

The MOPH 24 digits medication coding system did not receive timely updates to support the new medication in Thailand. We identified the code of the main ARV regimen, TEEVIR (Efavirenz 600 mg/ Emtricitabine 200 mg/Tenofovir disoproxil fumarate 300 mg) to be missing from the 24 digits code system. Missing the main ARV regimen severely compromised ARV usage data and the second 90-90-90 indicators from the MOPH database.

The finding was similar to THIS survey across 34 large hospitals in Thailand where 5-10% of medications were missing from the 24 digits system (61). On the contrary, TEEVIR was already available in TMT in EHR. Moreover, the 24 digits system was not an international standard requiring the Thai FDA to maintain and update to support new medications.

Therefore, we recommended MOPH to migrate to TMT to address medication support, reducing technical challenges, and reduce Thai FDA resources spending for maintenance.

We expected the TMT transition in the MOPH database to consume time, resources, and to require the stakeholders' agreement. Therefore, the MOPH could propose a dummy 24 digits code for ARV that were not supported by the 24 digits code to improve ARV data quality in the MOPH database.

Unlike the TMT, TMLT was being developed by THIS and CSMBS to replace CSMBS' current local laboratory coding system. The MOPH could work with CSMBS and THIS to coordinate hospitals deploying TMLT at the national level to prevent the data standard problem in the future.

Limitations

The study faced several challenges. First, only one day of field visits per hospital was allowed. The visit had to cover stakeholder meetings, data extraction, analyze and present results to hospital directors to provide a useful recommendation. The amount of time available was very limited and was spent on solving the technical problems on data extraction and the DQI Tools during the fieldwork leaving little time for the intervention. In addition to logistical challenges, the team was separated into two groups for surveying two hospitals at the same time. A much smaller second team severely faced limited time and logistical constraints and it was not able to conduct the field interviewing to gather qualitative results including the MEASURE DQA Tools. For that reason, qualitative results were only available on 12 from 25 hospitals in this study. Overall, the two data sources' difference between the two hospitals were similar to other hospitals of the same type. Therefore, we believe the 12-hospital selected for the field visits have the representativeness of the hospitals in Thailand. (See Table 62 in Appendix Additional figures section)

Second, HIV information from medical records was considered extremely sensitive data. Hospitals will be held responsible for any data breach occurring from the study. This challenge caused several limitations in accessing the data sources even with stakeholders’ approval further reducing the available visit time and logistics during the study. Therefore, the study was not allowed to explore the demographic characteristics of HIV patients in the hospital's local EHR database.

Third, to have access to the hospitals for the field visits and to be able to obtain data for the analysis, the study team needed special approval from the local authority; BMA for Bangkok Metropolitans Administration and provincial health office (PHO) for the non-Bangkok province. The final decision of the site selection came from the local authority and this might result in some selection bias. However, most sites proposed by the local authority did cover the majority of the HIV patients in the province. Therefore, we do not expect this challenge to have an impact on the overall study's representativeness.

For the Bangkok area, we only had access to the BMA affiliated hospitals which might not represent the situation in other affiliations (e.g. university hospital and non-MOPH government hospital) from logistical challenges. However, for the second phase of the study, 74 additional hospitals were approved including several non-MOPH and non-BMA hospitals.

Forth, the research team had no direct access to SSO VMI and CSMBS databases resulting in HIV patients among both databases being missing. However, we assumed that patient records existed in the hospital EHR database regardless of the health scheme. All patient visits in the hospital medical records were stored in the EHR before entering the designated health coverage protocol, using the EHR as additional data sources in the DQI Tools should provide satisfying coverage to SSO and CSMBS HIV patients in this study.

Fifth, the IRB exemption agreement of the study as a government project did not allow an official interview with voice recording, transcription, directly observing the HIV process, or for taking a photo inside the HIV clinic. This restriction limited our qualitative study results by using “unofficial interviews” and field notes.

Conclusion

In 2018, Thailand's 90-90-90 indicators were unrealistically high given limited credibility among stakeholders. The study was initiated to assess the level of quality in the HIV reporting system to identify main factors for quality problems and to provide recommendations to improve the quality of

the reporting at all levels of stakeholders. We assessed the reporting quality by comparing the two main HIV reporting systems in Thailand, the NAP, and the MOPH. Initially, the first indicator of the 90-90-90 the difference was narrow. However, the difference was remarkable prominent on the second and the third of the 90-90-90 indicators. The third 90-90-90 indicator could not be calculated using the MOPH database due to its lack of VL data. However, not only did we found the MOPH was not suitable for comparison, but the indicator calculation was also not possible considering the absence of a single unified national data standard, the unclear regulation, and several technical challenges. We identified Bangkok, Thailand capital city as the highest two-data source difference that required prompt action.

At this stage, we shift our assessment to review the NAP database. The problem resided in the second indicator, a patient who was receiving ARV treatment as several patients were defined with loss-follow-up causing a huge drop between the first and second 90-90-90 indicators.

Data integration was required to gain insight into the problem, a task not feasible because of the work overburden in the local personnel. Therefore, the DQI Tools that was jointly developed by Thai-MOPH-USCDC Collaboration (TUC) was deployed during the study. We found that the DQI Tools were able to trim down approximately half of the loss-follow-up patients' list who could be needed to be recruited back to the HIV care system improving Thailand's 90-90-90 indicators and the overall system efficiency. In addition to loss-follow-up patients, several reporting issues were also identified including misdiagnosis, deaths, invalid SSN, and lack of HIV test results. We analyzed the DQI Tools report and proposed four scenarios of data correction to the stakeholders to issue a correction policy at a national level.

Several contributing factors to data quality problems were identified on each data source. Among the MOPH reporting system challenges was the technical difficulty, lacking both laboratory and medication data standards, unclear regulation, and lack of incentive for reporting. Among the NAP reporting system challenges were the legacy data migration problems, discourage data correction processes, and not integrating with other data sources. Several recommendations were proposed,

including revising the HIV estimation, establishing national data standards, communicate extensively the regulation, and streamline the NAP data correction process. Scaling-up the DQI Tools at the national level was also recommended.

Bangkok's challenges were different from other provinces. Unlike the analyzed situation from the MOPH database, their data management practice was comparable to hospitals in other provinces. This was because of its unique administration status in the health department structure under the Bangkok Metropolitan Administration (BMA). MOPH had no authority in the Bangkok hospitals to mandate for the MOPH data submission. In addition to NAP and MOPH challenges, Bangkok challenges included having several different affiliations of hospitals, a special authority structure, and a data stewardship problem. To address Bangkok challenges, the Bangkok Smart Monitoring System (BSMS) was established with the Bangkok Metropolitan Administration to overcome the unique challenges in Bangkok and for improving the 90-90-90 indicators and for facilitating the data sharing to other public health surveillance systems in the future.

Policy and decision-makers around the world rely on indicators calculated from the reporting data. However, the quality of data can distort the current situation, make the policy ineffective further challenge the already resource-constrained countries. Assessing the data quality did not mean to only address the data themselves to improve the policy, but also reveals gaps in underly processes that provide the opportunity for improvement.

We hope this study demonstrates how assessing the data quality can benefit not only the policy and decision-makers but also the local health care personnel and encourage countries to the same.

Acknowledgment

I’m grateful to my committee members and dissertation readers Dr. Harold Lehmann and Dr. Hadi Kharrazi for supporting the data quality framework, William Weiss for providing and recommend the UNAIDS Tools including the DQA Tool, Edward Bunker for help scoping the data management practice, Dr. Taha E Taha for reading and providing comments regarding the global health impacts,

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Appendix

Field questionnaire (Thai only)

แบบสัมภาษณ์ (สำหรับโรงพยาบาล)

เครื่องมือนี้เป็นแบบสัมภาษณ์ ใช้ประเมินเมื่อมาถึงโรงพยาบาล/สถานพยาบาล **ผู้ตอบแบบสอบถาม ได้แก่ เจ้าหน้าที่ ที่ป้อนข้อมูลเรื่องการให้บริการรักษาด้วยยาต้านไวรัสเชื้อเอชไอวี พยาบาลประจำคลินิกยาต้านไวรัส เจ้าหน้าที่คอมพิวเตอร์ที่ดูแลระบบการลงทะเบียนผู้ป่วย**	
ชื่อโรงพยาบาล	**วันที่**
ผู้สัมภาษณ์	

ส่วนที่ I ข้อมูลทั่วไป

1. แพทย์ประจำคลินิก _____ท่าน
2. HIV coordinator และ พยาบาลประจำคลินิก ARV _____ท่าน
3. ผู้ให้คำปรึกษา _____ท่าน
4. จำนวนผู้รับยาต้านประมาณ_____ ราย
5. จำนวนผู้รับบริการเฉลี่ย _____ ราย/ วัน

ส่วนที่ II ระบบข้อมูลเอชไอวี

1. **ระบบฐานข้อมูลลงทะเบียนให้บริการผู้ป่วย (**Hospital Information System: HIS**)**

1.1 ระบบฐานข้อมูลผู้ป่วยของโรงพยาบาล (HIS) ของท่านมีใช้ระบบปฏิบัติการของบริษัทผู้พัฒนาใด และใช้ version ใด (ตอบได้มากกว่า 1 ข้อ)

❑ HOSxP ❑ Hospital OS ❑ Home C ❑ E-PHIS

❑ JHOS ❑ อื่นๆ ระบุ : _____

Version ที่ใช้.....เริ่มใช้เมื่อ .....

1.2 ระบบฐานข้อมูลผู้ป่วยของโรงพยาบาล (HIS) และข้อมูลการตรวจทางห้องปฏิบัติการ (Laboratory Information System: LIS) ที่เกี่ยวข้องกับการให้บริการรักษาด้วยยาต้านไวรัสเชื้อเอชไอวีได้เชื่อมต่อกันเป็นระบบเดียวกันหรือไม่

❑ ไม่เชื่อมต่อ

❑ เชื่อมต่อ โปรดระบุ ชื่อระบบ LIS _____

❑ แบบ Auto

❑ แบบ Manual ในเรื่องใดบ้าง

การตรวจ HIV	**ผลตรวจ** HIV	**การตรวจ** CD4	**ผลตรวจ** CD4	**การตรวจ** VL	**ผลตรวจ** VL	**การตรวจ** Drug Resistance	**ผลตรวจ** Drug Resistance	**อื่นๆ ระบุ** _____
☐	☐	☐	☐	☐	☐	☐	☐	☐

1.3 โรงพยาบาลของท่านส่งออกข้อมูลรูปแบบ 43 แฟ้ม เข้ากระทรวงสาธารณสุขหรือไม่ อย่างไร

❑ ส่ง ❑ ไม่ส่ง ข้ามไปตอบข้อ **1.6**

1.4 ความถี่ของการส่งออกข้อมูลรูปแบบ 43 แฟ้ม

❑ ทุกวัน ❑ ทุก **2-6** วัน ❑ ทุกสัปดาห์ ❑ ทุก **2** สัปดาห์

❑ ทุกเดือน ❑ อื่นๆ ระบุ: _____

1.5 ข้อมูลอะไรบ้างที่ส่งในรูป **43** แฟ้ม (ตอบได้มากกว่า **1** ตัวเลือก)

❑ การวินิจฉัย ❑ ยา

❑ ผลการตรวจเลือดหาเชื้อเอชไอวี ❑ ผลการตรวจ **Viral load** ❑ ผลการตรวจ **CD4**

1.6 โรงพยาบาลได้เก็บข้อมูล **back up** ไว้หรือไม่

❑ เก็บ ความถี่_____ สถานที่เก็บ **(**เช่น **cloud, internal storage**) _____

❑ ไม่ได้เก็บ

2 **<u>ข้อมูลการให้บริการให้ยาต้านไวรัส</u>** <u>Anti-Retroviral Therapy **(**ARV**)** program data

2.1 โรงพยาบาลของท่านเก็บข้อมูลให้บริการผู้ติดเชื้อฯ ในฐานข้อมูลใดบ้าง (ตอบได้มากกว่า **1** คำตอบ)

❑ ระบบฐานข้อมูลในโรงพยาบาล **HIS**

❑ **National AIDS program (NAP)**

❑ ทะเบียน**อิเล็กทรอนิกส์ (Electronic-based register)** ในรูปแบบ Excel **หรือ** Access

❑ สมุดทะเบียน **(Paper-based register)** เช่น **logbook**

❑ อื่นๆ ระบุ _____

<u>กรณีที่ใช้ระบบฐานข้อมูลในโรงพยาบาล</u> HIS

2.2 โปรดระบุผู้รับผิดชอบในการบันทึกข้อมูลลงในระบบฐานข้อมูลในโรงพยาบาล

เจ้าหน้าที่	**การวินิจฉัย**	**การสั่งยา**	**การสั่งตรวจทางห้องปฏิบัติการ**	**ผลตรวจ** HIV	**ผลตรวจ** CD4	**ผลตรวจ** VL
พยาบาล	❑	❑	❑	❑	❑	❑
เจ้าหน้าที่ห้องตรวจปฏิบัติการ	❑	❑	❑	❑	❑	❑
เภสัชกร	❑	❑	❑	❑	❑	❑
แพทย์	❑	❑	❑	❑	❑	❑
ระบุ	❑	❑	❑	❑	❑	❑

2.3 โปรดระบุความถี่ในการบันทึกข้อมูลเหล่านี้ลงใน **HIS**

	ทุกวัน	ทุก 2-3 วัน	ทุกสัปดาห์	ทุก 2 สัปดาห์	ทุกเดือน
ผลตรวจ HIV	❑	❑	❑	❑	❑
ผลตรวจ CD4	❑	❑	❑	❑	❑
ผลตรวจ VL	❑	❑	❑	❑	❑

2.4 การตรวจสอบคุณภาพข้อมูล HIS (ตอบได้มากกว่า 1 ข้อ)

	การวินิจฉัย	**การสั่งยา**	**การสั่งตรวจทาง ห้องปฏิบัติการ**	**ผลตรวจ** HIV	**ผลตรวจ** CD4	**ผลตรวจ** VL
มีการตรวจสอบข้อมูลก่อนการบันทึกลงใน **HIS**	❑	❑	❑	❑	❑	❑
มีการตรวจสอบความถูกต้อง/ของรายงานที่ออกจาก HIS เช่น ยอดรวมการวินิจฉัย/การสั่งยา/การส่งตรวจ/ผลตรวจทางห้องปฏิบัติการ	❑	❑	❑	❑	❑	❑

ถ้ามี โปรดอธิบายกระบวนการตรวจสอบ เช่น ผู้รับผิดชอบ, ความถี่, เครื่องมือ, วิธีการ)

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.....

.....

<u>กรณีที่บันทึกข้อมูลลงใน</u> <u>NAP</u>

2.5 ตามสิทธิ์การรักษาพยาบาลของผู้ป่วย ท่านมีการบันทึกข้อมูลอะไรบ้างลงใน **NAP**

สิทธิการรักษา	VCT	Registration	VL testing	Follow-up
ประกันสุขภาพถ้วนหน้า	❑	❑	❑	❑
ประกันสังคม	❑	❑	❑	❑
สวัสดิการข้าราชการและรัฐวิสาหกิจ	❑	❑	❑	❑
จ่ายค่ารักษาเอง	❑	❑	❑	❑
ต่างด้าว	❑	❑	❑	❑

2.6 โปรดระบุความถี่ในการบันทึกข้อมูลเหล่านี้ ลงใน **NAP**

	ทุกวัน	ทุก 2-3 วัน	ทุกสัปดาห์	ทุก 2 สัปดาห์	ทุกเดือน
VCT	❑	❑	❑	❑	❑

Registration	❑	❑	❑	❑	❑
VL testing	❑	❑	❑	❑	❑
Follow-up	❑	❑	❑	❑	❑

2.7 โปรดระบุผู้รับผิดชอบในการบันทึกข้อมูลใน **NAP**

เจ้าหน้าที่	**การวินิจฉัย**	**ยาต้านไวรัส**	**การสั่งตรวจทางห้องปฏิบัติการ**	**ผลตรวจ** HIV	**ผลตรวจ** CD4	**ผลตรวจ** VL
พยาบาล	❑	❑	❑	❑	❑	❑
เจ้าหน้าที่ห้องตรวจปฏิบัติการ	❑	❑	❑	❑	❑	❑
เภสัชกร	❑	❑	❑	❑	❑	❑
เจ้าหน้าที่ธุรการ	❑	❑	❑	❑	❑	❑
ระบุ _____	❑	❑	❑	❑	❑	❑

2.8 การตรวจสอบคุณภาพข้อมูล NAP (ตอบได้มากกว่า 1 ข้อ)

	การวินิจฉัย	**ยาต้านไวรัส**	**การสั่งตรวจทางห้องปฏิบัติการ**	**ผลตรวจ** HIV	**ผลตรวจ** CD4	**ผลตรวจ** VL
มีการตรวจสอบข้อมูลก่อนการบันทึกลงใน **NAP**	☐	☐	☐	☐	☐	☐
มีการตรวจสอบความถูกต้องของข้อมูลที่รายงานใน **NAP Web report**	☐	☐	☐	☐	☐	☐

ถ้ามี โปรดอธิบายกระบวนการตรวจสอบ เช่น ผู้รับผิดชอบ, ความถี่, เครื่องมือ, วิธีการ)

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<u>กรณีที่บันทึกข้อมูลลงในรูปแบบอิเล็กทรอนิกส์</u> <u>Excel</u> **<u>หรือ</u>** <u>Access</u>

2.9 ข้อมูลใดบ้างที่ได้มีการบันทึกในรูปแบบอิเล็กทรอนิกซ์ (ตอบได้มากกว่า **1** คำตอบ)

❑ ข้อมูลส่วนบุคคล (เช่น ชื่อ วันเดือนปีเกิด เพศ)

❑ เลขบัตรประชาชน 13 หลัก ❑ **NAP ID** ❑ **HN**

❑ วันที่ติดเชื้อเอชไอวี ❑ วันที่มารับบริการที่คลินิก **ARV**

❑ วันที่มารับยา ❑ ชื่อยา/สูตรยา

❑ วันที่ตรวจ **VL** ❑ ผลการตรวจ **VL**

❑ วันที่นัดมาพบแพทย์ครั้งต่อไป

☐ ประชากรหลัก ได้แก่ ชายที่มีเพศสัมพันธ์กับชาย (MSM), สาวประเภทสอง (TG), พนักงานบริการชาย (MSW), พนักงานบริการสาวประเภทสอง (TGSW), พนักงานบริการหญิง (FSW), ผู้ใช้ยาเสพติดโดยวิธีฉีด (PWID), ผู้ต้องขัง

2.10 โปรดระบุความถี่ในการบันทึกข้อมูลเหล่านี้ ลงใน **Excel/Access**

	ทุกวัน	ทุก 2-3 วัน	ทุกสัปดาห์	ทุก 2 สัปดาห์	ทุกเดือน
ประชากรหลัก	❑	❑	❑	❑	❑
วันที่มารับบริการที่คลินิก	❑	❑	❑	❑	❑
วันที่นัดมาพบแพทย์	❑	❑	❑	❑	❑
ชื่อยา / สูตรยา	❑	❑	❑	❑	❑
วันที่ตรวจ VL	❑	❑	❑	❑	❑
ผลการตรวจ VL	❑	❑	❑	❑	❑

2.10 การตรวจสอบคุณภาพข้อมูลใน **Excel/Access** (ตอบได้มากกว่า 1 ข้อ)

	ประชากรหลัก	**ชื่อยา/ สูตรยา**	**ผลตรวจ HIV**	**ผลตรวจ CD4**	**ผลตรวจ VL**
มีการตรวจสอบข้อมูลก่อนการบันทึกลงใน **Excel/Access**	☐	☐	☐	☐	☐
มีการตรวจสอบคุณภาพของรายงานที่ออกจาก **Excel/Access**	☐	☐	☐	☐	☐

ถ้ามี โปรดอธิบายกระบวนการตรวจสอบ เช่น ผู้รับผิดชอบ, ความถี่, เครื่องมือ, วิธีการ)

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<u>กรณีที่บันทึกข้อมูลในรูปแบบสมุดทะเบียน เช่น logbook</u>

2.11 ข้อมูลใดบ้างที่ได้มีการบันทึกในรูปแบบสมุดทะเบียน เช่น logbook (ตอบได้มากกว่า **1** คำตอบ)

❑ ข้อมูลส่วนบุคคล (เช่น ชื่อ วันเดือนปีเกิด เพศ)

❑ เลขบัตรประชาชน 13 หลัก ❑ **NAP ID** ❑ **HN**

❑ วันที่ติดเชื้อเอชไอวี ❑ วันที่มารับบริการที่คลินิก **ARV**

❑ วันที่มารับยา ❑ ชื่อยา/สูตรยา

❑ วันที่ตรวจ **VL** ❑ ผลการตรวจ **VL**

❑ วันที่นัดมาพบแพทย์ครั้งต่อไป

☐ ประชากรหลัก ได้แก่ ชายที่มีเพศสัมพันธ์กับชาย (MSM), สาวประเภทสอง (TG), พนักงานบริการชาย (MSW), พนักงานบริการสาวประเภทสอง (TGSW), พนักงานบริการหญิง (FSW), ผู้ใช้ยาเสพติดโดยวิธีฉีด (PWID), ผู้ต้องขัง

2.12 โปรดระบุความถี่ในการบันทึกข้อมูลเหล่านี้ ลงใน **logbook**

	ทุกวัน	ทุก 2-3 วัน	ทุกสัปดาห์	ทุก 2 สัปดาห์	ทุกเดือน

ประชากรหลัก	❑	❑	❑	❑	❑
วันที่มารับบริการที่คลินิก	❑	❑	❑	❑	❑
วันที่นัดมาพบแพทย์	❑	❑	❑	❑	❑
ชื่อยา / สูตรยา			❑	❑	❑
วันที่ตรวจ VL	❑	❑	❑	❑	❑
ผลการตรวจ VL	❑	❑	❑	❑	❑

2.13สมุดทะเบียนถูกเก็บในที่ตู้หรือสถานที่ปลอดภัยหรือไม่

❑ ใช่ ❑ ไม่ใช่

2.14การตรวจสอบคุณภาพข้อมูลใน **logbook** (ตอบได้มากกว่า 1 ข้อ)

	ประชากรหลัก	ชื่อยา / สูตรยา	**ผลตรวจ** HIV	**ผลตรวจ** CD4	**ผลตรวจ** VL
มีการตรวจสอบข้อมูลใน **logbook**	☐	☐	☐	☐	☐

ถ้ามี โปรดอธิบายกระบวนการตรวจสอบ เช่น ผู้รับผิดชอบ, ความถี่, เครื่องมือ, วิธีการ)

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<u>ตั้งแต่หัวข้อ 3-4 กรุณาระบุ หน่วยงานที่ลงเข้าเยี่ยม</u>

☐ **CDC** ☐ **USAID (ข้ามไปข้อ 4)**

<u>ใช้กรณีเป็นหน่วยงาน CDC</u>

<u>3. การพัฒนาคุณภาพข้อมูล</u>

3.1 โรงพยาบาลเคยได้รับคำแนะนำเรื่องการบันทึกข้อมูลให้มีคุณภาพเพื่อใช้ประโยชน์ในการติดตามผลการดำเนินงาน หรือไม่

❑ เคย เรื่อง .....โดยใคร_____ ครั้งล่าสุด _____

เรื่อง .....โดยใคร_____ ครั้งล่าสุด _____

เรื่อง .....โดยใคร_____ ครั้งล่าสุด _____

❑ ไม่เคย

3.2 โรงพยาบาลเคยได้รับการเข้าเยี่ยมจากเจ้าหน้าที่กระทรวงสาธารณสุข, สปสช, สสจ, หรือ PEPFAR เพื่อตรวจสอบคุณภาพข้อมูลการให้บริการเรื่องยาต้านไวรัส หรือไม่

❑ เคย ครั้งล่าสุด _____ จากหน่วยงาน .....

❑ ไม่เคย

.....

ใช้กรณีเป็นหน่วยงาน USAID

4. คุณภาพของข้อมูลและการรายงาน

4.1 โรงพยาบาลได้มีการส่งรายงานที่เกี่ยวข้องกับการให้บริการผู้ติดเชื้อฯ และ ARV ให้แก่หน่วยงานใด ด้วยรูปแบบใด และโปรดระบุความถี่

หน่วยงาน	รูปแบบรายงาน	ทุกสัปดาห์	ทุก 2 สัปดาห์	ทุกเดือน	ทุกไตรมาส
NAP	❑ Web application ❑ Excel ❑ ระบุ_____	❑	❑	❑	❑
กระทรวงสาธารณสุข (43 แฟ้ม)	❑ Web application ❑ Excel ❑ ระบุ_____	❑	❑	❑	❑
LINKAGES/FHI 360	❑ Web application ❑ Excel ❑ ระบุ_____	❑	❑	❑	❑
กองทุนประกันสังคม	❑ Web application ❑ Excel ❑ ระบุ_____	❑	❑	❑	❑
Same-day ARV	❑ Web application ❑ Excel ❑ ระบุ_____	❑	❑	❑	❑
กองทุนผู้มีปัญหาสถานะและสิทธิ	❑ Web application ❑ Excel ❑ ระบุ_____	❑	❑	❑	❑
ต่างด้าว (FWF)	❑ Web application ❑ Excel ❑ ระบุ_____	❑	❑	❑	❑
คัดกรอง TB/HIV	❑ Web application ❑ Excel ❑ ระบุ_____	❑	❑	❑	❑
PMTCT	❑ Web application	❑	❑	❑	❑

	❑ Excel ❑ ระบุ_____				
อื่นๆ ระบุ_____	❑ Web application ❑ Excel ❑ ระบุ_____	❑	❑	❑	❑
อื่นๆ ระบุ_____	❑ Web application ❑ Excel ❑ ระบุ_____	❑	❑	❑	❑
อื่นๆ ระบุ_____	❑ Web application ❑ Excel ❑ ระบุ_____	❑	❑	❑	❑

4.2 แหล่งที่มาของข้อมูล (source of data) ของการงานนั้นมาจากแหล่งใดบ้างและเพราะเหตุใดจึงเลือกแหล่งนั้นๆ

แหล่งที่มาของข้อมูลของผู้รับบริการARVทั้งหมด_____

เพราะ_____

แหล่งที่มาของข้อมูลของการจ่ายยา ARV_____

เพราะ_____

แหล่งที่มาของข้อมูลอื่นๆ ระบุ_____

เพราะ_____

4.3 ในรอบ 1 ปีที่ผ่านมา โรงพยาบาล/เจ้าหน้าที่ที่เกี่ยวข้อง เคยได้รับการอบรม/การสนับสนุน/ข้อเสนอแนะเรื่องข้อมูล (เช่น การบันทึกข้อมูล, คุณภาพข้อมูล, การจัดการข้อมูล, การรายงาน, ตัวชี้วัด, เครื่องมือในการบันทึกข้อมูล, ฯลฯ) เพื่อเป็นประโยชน์ในการติดตามผลการดำเนินงาน หรือไม่

❑ เคย

เรื่อง.....โดย_____ครั้งล่าสุด _____

เรื่อง.....โดย_____ครั้งล่าสุด _____

เรื่อง.....โดย_____ครั้งล่าสุด _____

เรื่อง.....โดย_____ครั้งล่าสุด _____

เรื่อง.....โดย_____ครั้งล่าสุด _____

เรื่อง.....โดย_____ครั้งล่าสุด _____

❑ ไม่เคย

4.4 มีเรื่องใดบ้างที่โรงพยาบาล/เจ้าหน้าที่ที่เกี่ยวข้อง ต้องการการสนับสนุนเพิ่มเติมเรื่องข้อมูล

❑ ต้องการ เรื่อง .....โดยใคร_____

เรื่อง .....โดยใคร_____

เรื่อง .....โดยใคร_____

❑ ไม่ต้องการ

4.5 เคยได้รับการเข้าเยี่ยมจากเจ้าหน้าที่กระทรวงสาธารณสุข, สปสช, สสจ, หรือ หน่วยงานอื่นๆ เพื่อตรวจสอบคุณภาพข้อมูลการให้บริการเรื่องยาต้านไวรัส หรือไม่

❑ เคย ครั้งล่าสุด _____ จากหน่วยงาน .....

❑ ไม่เคย

5. <u>การให้บริการและการติดตามการรักษา</u>

5.1 โรงพยาบาลมีระบบการรักษาด้วยยาต้านไวรัส รวมถึงระบบการติดตามผู้ป่วย และความถี่ของการนัดหมาย อย่างไร

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_____

5.2 โรงพยาบาลมีเกณฑ์ในการพิจารณาอย่างไรว่าผู้รับยาต้านฯ รายไหนควรกลับมารับยาเมื่อไหร่

_____

5.3 โรงพยาบาลมีเกณฑ์อะไรบ้างที่ระบุว่าผู้รับยาต้านฯ มีอาการคงที่แล้ว

_____

5.4 เกณฑ์เหล่านี้มีเขียนไว้เป็นลายลักษณ์อักษรหรือไม่ (ผู้ประเมินขอดูเอกสารที่เป็นลายลักษณ์อักษร)

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5.5 โรงพยาบาลจะมีการนัดหมายให้ผู้รับบริการกลับมารับยา ที่ 2, 3, 4, 5, หรือ 6 เดือน เนื่องจากเหตุผลใดบ้าง

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5.6 เครื่องมือใดบ้างที่ใช้ในการติดตามผู้รับยาต้านฯ เพื่อให้แน่ใจว่าผู้รับบริการเหล่านี้กลับมารับยา/รับบริการตามนัด (เช่น ใบนัด สมุดลงนัด โปรแกรมบันทึกการนัดหมาย หรือ LINE ฯลฯ) (คำถามนี้เชื่อมโยงกับคำถามการขาดการติดตาม/การไม่มาพบแพทย์ตามนัดนัด)

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5.7 โรงพยาบาลมีเกณฑ์ในการพิจารณาว่าผู้รับยาต้านฯ นั้นขาดการติดตาม (LTFU) (เช่น 28 วัน, 3 เดือน, หรือ 6 เดือนจาก การนัดหมายครั้งล่าสุด หรือกี่วันจากการรับยาต้านฯ) กระบวนการติดตามผู้ที่ LTFU ของโรงพยาบาลเป็นอย่างไร

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_____

5.8 ในทางปฏิบัติ โรงพยาบาลนับผู้รับบริการที่เสียชีวิตแล้วหรือย้ายออกจากสถานพยาบาลโดยไม่บอกกล่าว เป็น "LTFU" หรือไม่ และคุณมีความคิดเห็นอย่างไรในเรื่องนี้

_____

5.9 อะไรคือสาเหตุหลักที่ทำให้ผู้ป่วยไม่มาตามนัด และมีการแก้ไขปัญหานี้อย่างไร

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5.10 ระบบการตรวจ VL ในโรงพยาบาลเป็นอย่างไร (เช่น ตรวจตามระบบการตรวจ VL ของ Lab หรือตรวจตามวันครบกำหนดตรวจ VL ของผู้รับบริการ) และมีการตรวจบ่อยแค่ไหน

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_____

5.11 กระบวนการบันทึกผล VL ในโรงพยาบาลเป็นแบบใด มีการแจ้งและให้ผลการตรวจกับผู้รับบริการหรือไม่

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5.12 ใน 12 เดือนที่ผ่านมา มีผู้รับบริการที่ได้รับการตรวจ VL ร้อยละเท่าไหร่ (จำนวนผู้ที่ได้รับการตรวจ VL ใน 12 เดือนที่ผ่านมา / จำนวนผู้รับบริการที่ได้รับยาต้านฯ มาไม่ต่ำกว่า 6 เดือน ทั้งหมด)
และในกลุ่มนี้ มีร้อยละเท่าไรที่กดไวรัสได้ (จำนวนผู้ที่มีผลตรวจ VL <1000 copies/ml / จำนวนผู้ที่ได้รับการตรวจ VL ใน 12 เดือนที่ผ่านมา)กระบวนการบันทึกผล VL ในโรงพยาบาลเป็นแบบใด มีการแจ้งและให้ผลการตรวจกับผู้รับบริการหรือไม่

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MEASURE DQA Tools questionaire

Question_number	Questions
I - M&E Structure, Functions and Capabilities	
1	There is a documented organizational structure/chart that clearly identifies positions that have data management responsibilities at the M&E Unit.
2	All staff positions dedicated to M&E and data management systems are filled.
3	There is a training plan which includes staff involved in data-collection and reporting at all levels in the reporting process.
4	All relevant staff have received training on the data management processes and tools.
5	A senior staff member (e.g., the Program Manager) is responsible for reviewing the aggregated numbers prior to the submission/release of reports from the M&E Unit.

6	There are designated staff responsible for reviewing the quality of data (i.e., accuracy, completeness and timeliness) received from sub-reporting levels (e.g., regions, districts, service points).
7	There are designated staff responsible for reviewing aggregated numbers prior to submission to the next level (e.g., to districts, to regional offices, to the central M&E Unit).
8	The responsibility for recording the delivery of services on source documents is clearly assigned to the relevant staff.
II- Indicator Definitions and Reporting Guidelines	
9	The M&E Unit has documented and shared the definition of the indicator(s) with all relevant levels of the reporting system (e.g., regions, districts, service points).
10	There is a description of the services that are related to each indicator measured by the Program/project.
The M&E Unit has provided written guidelines to each sub-reporting level on ...	
11	,,, what they are supposed to report on.
12	... how (e.g., in what specific format) reports are to be submitted.
13	... to whom the reports should be submitted.
14	... when the reports are due.
15	There is a written policy that states for how long source documents and reporting forms need to be retained.
III- Data-collection and Reporting Forms / Tools	
16	The M&E Unit has identified a standard source document (e.g., medical record, client intake form, register, etc.) to be used by all service delivery points to record service delivery.
17	The M&E Unit has identified standard reporting forms/tools to be used by all reporting levels.
18	Clear instructions have been provided by the M&E Unit on how to complete the data collection and reporting forms/tools.
19	The source documents and reporting forms/tools specified by the M&E Unit are consistently used by all reporting levels.
20	If multiple organizations are implementing activities under the Program/project, they all use the same reporting forms and report according to the same reporting timelines.

21	The data collected by the M&E system has sufficient precision to measure the indicator(s) (i.e., relevant data are collected by sex, age, etc. if the indicator specifies disaggregation by these characteristics).
22	All source documents and reporting forms relevant for measuring the indicator(s) are available for auditing purposes (including dated print-outs in case of computerized system).
IV- Data Management Processes	
23	The M&E Unit has clearly documented data aggregation, analysis and/or manipulation steps performed at each level of the reporting system.
24	There is a written procedure to address late, incomplete, inaccurate and missing reports; including following-up with sub-reporting levels on data quality issues.
25	If data discrepancies have been uncovered in reports from sub-reporting levels, the M&E Unit or the Intermediate Aggregation Levels (e.g., districts or regions) have documented how these inconsistencies have been resolved.
26	Feedback is systematically provided to all sub-reporting levels on the quality of their reporting (i.e., accuracy, completeness and timeliness).
27	There are quality controls in place for when data from paper-based forms are entered into a computer (e.g., double entry, post-data entry verification, etc).
28	For automated (computerized) systems, there is a clearly documented and actively implemented database administration procedure in place. This includes backup/recovery procedures, security admininstration, and user administration.
29	There is a written back-up procedure for when data entry or data processing is computerized.
30	If yes, the latest date of back-up is appropriate given the frequency of update of the computerized system (e.g., back-ups are weekly or monthly).
31	Relevant personal data are maintained according to national or international confidentiality guidelines.
The reporting system avoids double counting people ...	
32	... within each point of service/organization (e.g., a person receiving the same service twice in a reporting period, a person registered as receiving the same service in two different locations, etc).
33	... across service points/organizations (e.g., a person registered as receiving the same service in two different service points/organizations, etc).

34	The reporting system enables the identification and recording of a "drop out", a person "lost to follow-up" and a person who died.
35	The M&E Unit can demonstrate that regular supervisory site visits have taken place and that data quality has been reviewed.
V- Links with National Reporting System	
36	When available, the relevant national forms/tools are used for data-collection and reporting.
37	When applicable, data are reported through a single channel of the national information systems.
38	Reporting deadlines are harmonized with the relevant timelines of the National Program (e.g., cut-off dates for monthly reporting).
39	The service sites are identified using ID numbers that follow a national system.

Thailand codeing standard releated to HIV

MOPH Two Digits Laboratory Coding system

2-digits	7-digits (ICD-10TM)	Remark
01	0531002	01= Fasting Blood sugar
02	0531004	02= Blood sugar without NPO
03	0531101	03=DTX with NPO
04	0531102	04= DTX without NPO
05	0531601	05= HbA1C
06	0546602	06= Triglyceride
07	0541601	07= Total Cholesterol
08	0541202	08= HDL Cholesterol
09	0541402	09= LDL Cholesterol
10	0583001	10= BUN
11	0581902	11=Creatinine
12	0581902	12=Urine microalbumin (0=negative, 1=trace, 2=positive)
13	0581903	13=Urine CREATININE
14	0446203	14=Urine macroalbumin (0=negative, 1=trace, 2=positive)

15	0581904	15= eGFR (CKD-EPI formula)
16	0621401	16= Hb
17	0440205	17=UPCR (Urine protein creatinine ratio)
18	0511402	18= K (CKD stage 3 or ACEI//ARBs) (serum/plasma)
19	0510402	19=Bicarb (CKD stage 3)
20	0511202	20= phosphate (CKD stage 3) (serum/plasma)
21	0614402	21= PTH (CKD stage 3)

Thai FDA ARV medication coding ID

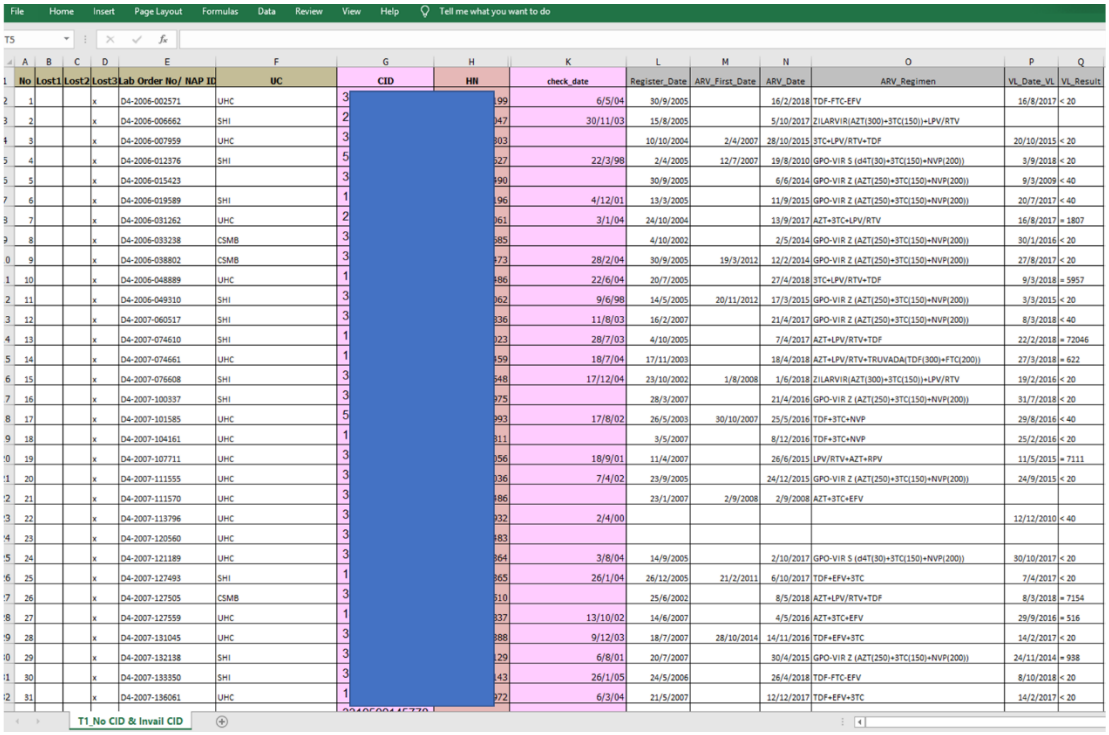
No	**Class**	**Drug Name**	**24 Digits ID (2-11th digit)**	**Abbrevation**
1	NRTIs	Lamivudine	2488400000	3TC
2	NRTIs	Tenofovir	4433449300	TDF
3	NRTIs	Zidovudine	0022800000	AZT
4	NRTIs	Stavudine	2494800000	D4T
5	NRTIs	Didanosine	0130500000	ddI
6	NRTIs	Abacavir	4042028000	ABC
7	NNRTIs	Efavirenz	2291400000	EFV
8	NNRTIs	Nevirapine	2491100000	NVP
9	NNRTIs	Etravirine	4710500000	ETR
10	NNRTIs	Rilpivirine	N/A	RPV

11	NNRTIs	Delavirdine	N/A	DLV
12	PIs	Atazanavir	4368400000	ATV
13	PIs	Darunavir	4603699900	DRV
14	PIs	Indinavir	2420428000	IDV
15	PIs	Lopinavir/Ritonavir	1005011001	LPV/r
16	PIs	Nelfinavir	2491000000	NFV
17	PIs	Ritronavir	2493000000	RTV
18	PIs	Tipranavir	N/A	TPV
19	PIs	Saquinavir	2493500000	SQV
20	PIs	Fosamprenavir	N/A	
21	II	Elvitegravir	N/A	ELV
22	II	Raltegravir	4750900000	RAL
23	II	dolutegravir	N/A	DTG
24	II	Enfuvirtide	4370500000	ENF
25	CRR5	Maraviroc	4692700000	Stavudine
26	FDC	GPO-vir S	1005011004	d4T/ 3TC/NVP
27	FDC	GPO-vir Z	1005011006	AZT/ 3TC/NVP
28	FDC	Emtricitabine / Tenofovir	1005011008	FTC/TDF

29	FDC	Emtricitabine / Tenofovir / Efavirenz	1005011009	FTC/TDF/EFV
30	FDC	Emtricitabine / Rilpivirine / Tenofovir	N/A	FTC/RPV/TDF
31	FDC	Elvitegravir/Emtricitabine/ Tenofovir	N/A	ELV/FTC/TDF
32	FDC	Zidovudine+Lamivudine	1005011003	AZT/3TC
33	FDC	rilpivirine/ Emtricitabine		RPV/FTC
34	FDC	Abacavir/Lamivudine	1005011005	ABC/3TC
35	FDC	Zidovudine/Lamivudine/abacavir	1005011002	AZT/3TC/ABC
36	FDC	Lamivudine+Stavudine	1005011007	3TC/d4T

Additional figures

DQI Tools features



No	Lost1	Lost2	Lost3	Lab Order No/ NAP ID	UC	CID	HN	check_date	Register_Date	ARV_First_Date	ARV_Date	ARV_Regimen	VL_Date_VL	VL_Result
1			x	D4-2006-002571	UHC	3		6/5/04	30/9/2005		16/2/2018	TDF-FTC-EFV	16/8/2017	< 20
2			x	D4-2006-006662	SHI	2		30/11/03	15/8/2005		5/10/2017	ZILARVIR(AZT(300)+3TC(150))+LPV/RTV		
3			x	D4-2006-007959	UHC	3			10/10/2004	2/4/2007	28/10/2015	3TC+LPV/RTV+TDF	20/10/2015	< 20
4			x	D4-2006-012376	SHI	5		22/3/98	2/4/2005	12/7/2007	19/8/2010	GPO-VIR S (d4T(30)+3TC(150)+NVP(200))	3/9/2018	< 20
5			x	D4-2006-015423		3			30/9/2005		6/6/2014	GPO-VIR Z (AZT(250)+3TC(150)+NVP(200))	9/3/2009	< 40
6			x	D4-2006-019589	SHI	1		4/12/01	13/3/2005		11/9/2015	GPO-VIR Z (AZT(250)+3TC(150)+NVP(200))	20/7/2017	< 40
7			x	D4-2006-031262	UHC	2		3/1/04	24/10/2004		13/9/2017	AZT+3TC+LPV/RTV	16/8/2017	= 1807
8			x	D4-2006-033238	CSMB	3			4/10/2002		2/5/2014	GPO-VIR Z (AZT(250)+3TC(150)+NVP(200))	30/1/2016	< 20
9			x	D4-2006-038802	CSMB	3		28/2/04	30/9/2005	19/3/2012	12/2/2014	GPO-VIR Z (AZT(250)+3TC(150)+NVP(200))	27/8/2017	< 20
10			x	D4-2006-048889	UHC	1		22/6/04	20/7/2005		27/4/2018	3TC+LPV/RTV+TDF	9/3/2018	= 5957
11			x	D4-2006-049310	SHI	3		9/6/98	14/5/2005	20/11/2012	17/3/2015	GPO-VIR Z (AZT(250)+3TC(150)+NVP(200))	3/3/2015	< 20
12			x	D4-2007-060517	SHI	3		11/8/03	16/2/2007		21/4/2017	GPO-VIR Z (AZT(250)+3TC(150)+NVP(200))	8/3/2018	< 40
13			x	D4-2007-074610	SHI	1		28/7/03	4/10/2005		7/4/2017	AZT+LPV/RTV+TDF	22/2/2018	= 72046
14			x	D4-2007-074661	UHC	1		18/7/04	17/11/2003		18/4/2018	AZT+LPV/RTV+TRUVADA(TDF(300)+FTC(200))	27/3/2018	= 622
15			x	D4-2007-076608	SHI	3		17/12/04	23/10/2002	1/8/2008	1/6/2018	ZILARVIR(AZT(300)+3TC(150))+LPV/RTV	19/2/2016	< 20
16			x	D4-2007-100337	SHI	3			28/3/2007		21/4/2016	GPO-VIR Z (AZT(250)+3TC(150)+NVP(200))	31/7/2018	< 20
17			x	D4-2007-101585	UHC	5		17/8/02	26/5/2003	30/10/2007	25/5/2016	TDF+3TC+NVP	29/8/2016	< 40
18			x	D4-2007-104161	UHC	1			3/5/2007		8/12/2016	TDF+3TC+NVP	25/2/2016	< 20
19			x	D4-2007-107711	UHC	3		18/9/01	11/4/2007		26/6/2015	LPV/RTV+AZT+RPV	11/5/2015	= 7111
20			x	D4-2007-111555	UHC	3		7/4/02	23/9/2005		24/12/2015	GPO-VIR Z (AZT(250)+3TC(150)+NVP(200))	24/9/2015	< 20
21			x	D4-2007-111570	UHC	3			23/1/2007	2/9/2008	2/9/2008	AZT+3TC+EFV		
22			x	D4-2007-113796	UHC	3		2/4/00					12/12/2010	< 40
23			x	D4-2007-120560	UHC	3								
24			x	D4-2007-121189	UHC	3		3/8/04	14/9/2005		2/10/2017	GPO-VIR S (d4T(30)+3TC(150)+NVP(200))	30/10/2017	< 20
25			x	D4-2007-127493	SHI	1		26/1/04	26/12/2005	21/2/2011	6/10/2017	TDF+EFV+3TC	7/4/2017	< 20
26			x	D4-2007-127505	CSMB	3			25/6/2002		8/5/2018	AZT+LPV/RTV+TDF	8/3/2018	= 7154
27			x	D4-2007-127559	UHC	1		13/10/02	14/6/2007		4/5/2016	AZT+3TC+EFV	29/9/2016	= 516
28			x	D4-2007-131045	UHC	3		9/12/03	18/7/2007	28/10/2014	14/11/2016	TDF+EFV+3TC	14/2/2017	< 20
29			x	D4-2007-132138	SHI	3		6/8/01	20/7/2007		30/4/2015	GPO-VIR Z (AZT(250)+3TC(150)+NVP(200))	24/11/2014	= 938
30			x	D4-2007-133350	SHI	3		26/1/05	24/5/2006		26/4/2018	TDF-FTC-EFV	8/10/2018	< 20
31			x	D4-2007-136061	UHC	1		6/3/04	21/5/2007		12/12/2017	TDF+EFV+3TC	14/2/2017	< 20

Figure 72 One of the four DQI Lost case reporting tables. The table consisted of the case list of whom their SSN (CID) is invalid. The table variables consisted of NAP ID, SSN (CID), healthcare coverage scheme, laboratory data and result, ARV date and regiment and last visit data

Thailand HIV patients characteristics

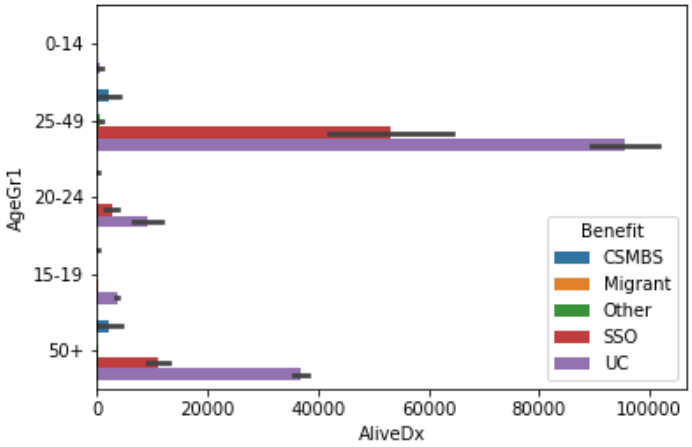


Figure 73 Demographics distribution of HIV patients stratified by Health coverage scheme reported by NAP in 2018, Thailand.

MOPH Patients demographic

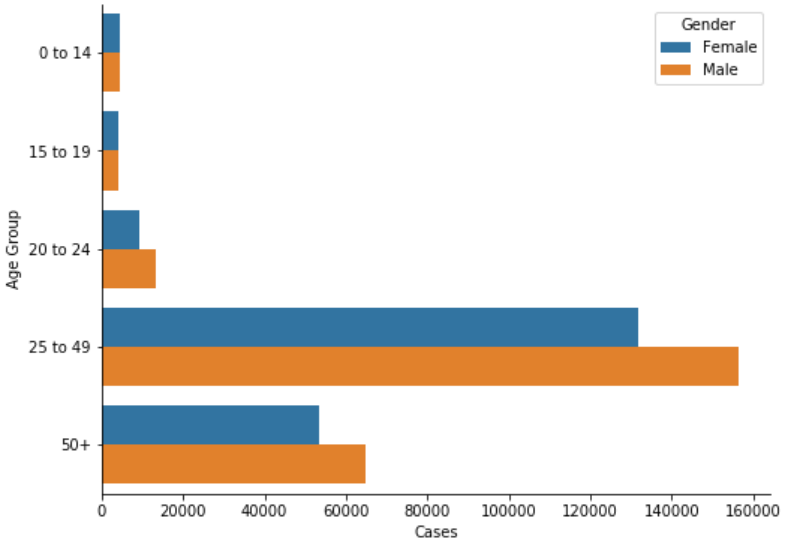


Figure 74 MOPH HIV patients' demographic distribution by age group and gender, 2018, Thailand

NAP patients characteristics

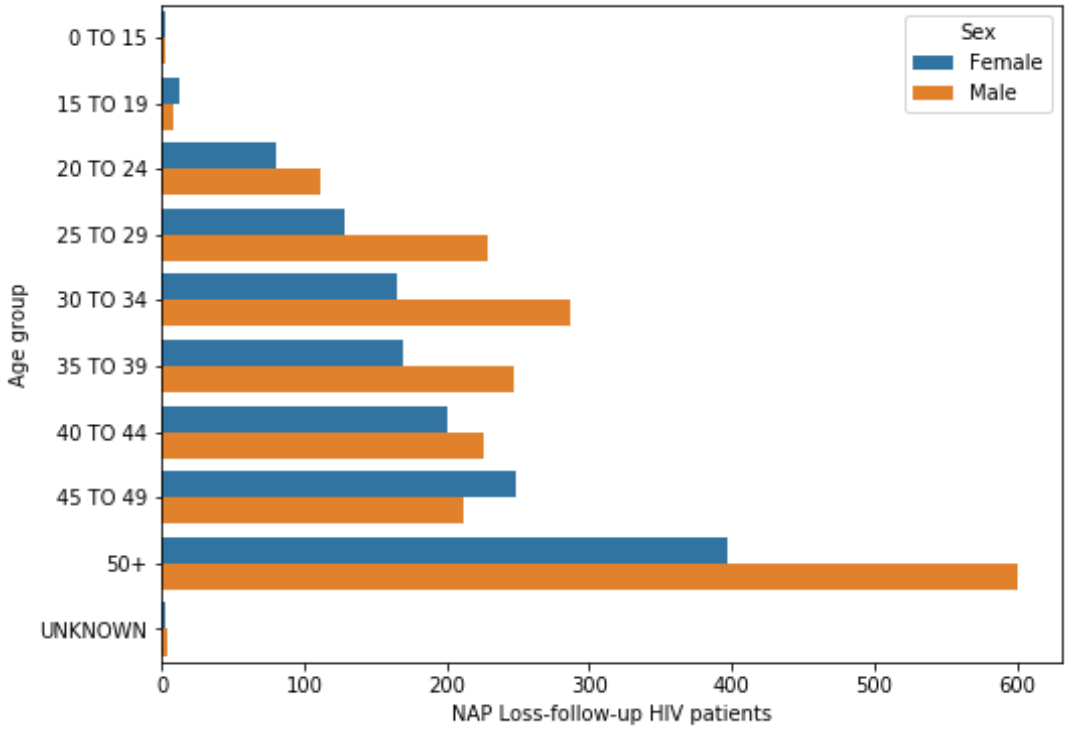


Figure 75 NAP Loss-follow-up HIV patients' demographic distribution among study sites

Two data sources difference among study sites

Table 62 Two data sources difference among all 25 study sites

Hospital Type (n)	Median Absolute Percentage of Two-data sources difference	Median Absolute Difference between two data sources	Median NAP HIV patient count	Median MOPH patient count
Public Non-MOPH hospital (10)	461 (179-1,637)	40.58 % (22.82-1000)	1,665 (196-2,936)	786 (0-2,266)
MOPH Community hospital (MOPH) (11)	155 (7-713)	23.50 % (3.38-212.84)	575 (139-1,294)	533 (167-1,921)
MOPH General hospital (1)	191 (191-191)	6.47 % (6.47-6.47)	2,952 (2,952-2,952)	2,761 (2,761-2,761)
MOPH Regional hospital (3)	1,278 (822-1,845)	32.51 % (19.15-40.47)	4,292 (3,931-4,559)	5,209 (5,114-6,404)

Table 63 Two data sources difference among 12 field visit sites

Hospital Type (n)	Median Absolute Percentage of Two-data sources difference	Median Absolute Difference between two data sources	Median NAP HIV patient count	Median MOPH patient count
Public Non-MOPH hospital (7)	412 (179-698)	43.8 % (22.82-1000)	727 (196 – 2,936)	410 (0-2,266)
MOPH Community hospital (3)	155 (28-627)	22.59 % (5.97 – 48.45)	686 (469 – 1,294)	531 (441-1,921)
MOPH Regional hospital (2)	1,050 (822-1,278)	25.83 % (19.15-32.51)	4,111 (3,931 – 4,292)	5,161 (5,114 – 5,209)

Approval Letters

US-CDC Center for Global Health (CGH)

CGH HSR Tracking #: 2018-352

Request for Project Determination & Approval -- Center for Global Health (CGH)

Use this form to submit proposals to the CGH Office of the Associate Director for Science/Laboratory Science (ADS/ADLS) for research/nonresearch determination and requirements for IRB review/approval.
Approval Chain: Investigator → Branch Chief/Country Director →Division ADS → CGH Human Subjects Mailbox

☐ **New Request** ☒ **Amendment** ☐ **Laboratory Submission**

Project Title: CDC Division of Global HIV and TB Data Quality Assessments in PEPFAR Supported Countries	Project Location/Country(ies): All PEPFAR Supported Countries
CDC Principal Investigator's name and SEV#: Sadhna Patel, SEV#12792	CDC Primary Contact's name and SEV# (Leave blank if same as PI): Brittney Baack, SEV #16942
Division: DGHT	CDC PI or PC Email: sjp5@cdc.gov / Telephone: 404.639.6212
Project start date (mm/dd/yyyy): 01/29/2018	Project end date (mm/dd/yyyy): 11/01/2022

Collaborating Institutions (List other collaborating institutions in the protocol or in a separate document)

☐CoAg ☐Grant ☐contract #:	Original Award Year if CoAg:	Current Budget Year if CoAg:
Title (CoAg, Grant, or Contract):		
Supported Institution Name:		
Supported Institution FWA# (if applicable):	FWA Exp. Date (if applicable):	

Check appropriate category and subcategory

☑ **I. Activity is NOT human subjects research. Primary intent is public health practice or a disease control activity (Check all that apply)**

- ☐ **A.** Epidemic or endemic disease control activity; if applicable, Epi-AID #
- ☐ **B.** Routine surveillance activity (e.g., disease, adverse events, injuries)
- ☐ **C.** Program evaluation activity*
- ☑ **D.** Public health program activityΩ
- ☐ **E.** Laboratory proficiency testing

* Evaluation of a new intervention for effectiveness and comparison of different interventions are research under CDC policy.
Ω e.g., service delivery; health education programs; social marketing campaigns, program monitoring; electronic database construction and/or support; development of patient registries; needs assessments; and demonstration projects intended to assess organizational needs, management, and human resource requirements for implementation.

☐ **II. Activity is research but does NOT involve human subjects (Check all that apply)**

- ☐ **A.** Activity is research involving collection or analysis of data about health facilities or other organizations or units (NOT persons).
- ☐ **B.** Activity is research involving data or specimens from deceased persons.
- ☐ **C.** Activity is research involving unlinked or anonymous data or specimens collected for another purpose.
- ☐ **D.** Activity is research involving data or specimens from animal subjects.§

§Note: Approval by CDC Institutional Animal Care and Use Committee (IACUC) may be required for certain animal research. Institution must also have assurance with the Office of Laboratory and Animal Welfare at NIH.

☐ **III. Activity is research involving human subjects but CDC involvement does not constitute "engagement in human subject research."** CDC employees or agents will not intervene or interact with living individuals or have access to identifiable information for research purposes. Appropriate IRB or ethics committee approval is required prior to approval. **(Check all that apply)**

- ☐ **A.** This project is funded under a grant/cooperative agreement/contract award mechanism.
- ☐ **B.** CDC staff provide technical support that does not involve possession or analysis of identifiable data or interaction with participants from whom data are being collected (No CDC Supportβ).
- ☐ **C.** CDC staff are involved only in manuscript writing for a project that has closed. For the project, CDC staff did not interact with participants and were not involved with data collection (No CDC Support).
- ☐ **D.** Activity is research involving linked data, but CDC non-disclosure form 0.1375B is signed.∞

β See definition of support on page 3.
∞ CDC form 0.1375B agreement is required for all subcategories (A-D) if CDC has access to linked data. This agreement prohibits the release of identifying key to CDC investigators under any circumstances. The purposes of the planned research do not contradict the terms of consent under which the information or specimens were collected, whether that consent was documented or not documented.

☐ **IV. Activity is research involving human subjects that requires submission to CDC Human Research Protection Office (Check one)**α

- ☐ A. Full Board Review (Use forms 0.1250, 0.1370-research partners)
- ☐ B. Expedited Review (Use same forms as A above)
- ☐ C. Exemption Request¥ (Use forms 0.1250X, 0.1370-research partners)
- ☐ D. Reliance¥
  - ☐ 1. Request to allow CDC to rely on a non-CDC IRB (Use same forms as A above, plus 0.1371)
  - ☐ 2. Request to allow outside institution to rely on CDC IRB (Use same forms as A above, plus 0.1372)

α There are other types of requests not listed under category IV, e.g., continuation of existing protocol, amendment, incident reports.
¥ Exemption and reliance request is approved by CDC Human Research Protection Office (HRPO).

CGH HSR Tracking #:_____

Amendment

If this request is an amendment to an existing project determination. Please include a brief description of the substantive change or modification below and attach both clean and marked copies of the amended protocol or project outline.

Updated language added to data management section to clarify that de-identified data may be collected from the sites. Two sentences added to the dissemination section (p.12) indicating that results may be summerized and submitted for peer-reviewed publication, to align with the data use protocol.

Submission: Attach a protocol if one exists. If not, provide a separate project description (See suggested format below) in sufficient detail to justify the proposed category. Submit your request to your branch chief (or country director or designee for country staff).

CGH ADS/ADLS Review	**Date received in CGH ADS /ADLS office:**

[X] **Project does not require human subject research review beyond CGH at this time. Local IRB Exp. Date (if applicable):**

[ ] **Project constitutes human subject research that must be routed to CDC HRPO.**

Comments/Rationale for Determination:

Approvals and Signatures

	Date:	**Remarks:**
Sadhna Patel -S Digitally signed by Sadhna Patel -S Date: 2018.05.01 17:22:24 -04'00' Investigator	05/18/2018	
John Aberle-grasse -S Digitally signed by John Aberle-grasse -S Date: 2018.05.18 13:35:01 +03'00' Branch Chief/Country Director	05/18/2018	
Division Human Research Protection Coordinator Division ADS/ADLS or Director	8/20/18	
Basia Tomczyk CGH Human Research Protection Coordinator CGH ADS/ADLS or Deputy ADS/ADLS	8/22/2018	

Note: Although CDC IRB review is not required for certain projects (categories I,II & III) approved under this determination, CDC investigators and project officers are expected to adhere to the highest ethical standards of conduct and to respect and protect to the extent possible the privacy, confidentiality, and autonomy of participants. All applicable country, state, and federal laws must be followed. Informed consent may be appropriate and should address all applicable elements of informed consent. CDC investigators should incorporate diverse perspectives that respect the values, beliefs, and cultures of the people in the country, state, and community in which they work.

CGH HSR Tracking #:_____

Public Access and Data Sharing

A. Type of data collected or generated: 2. By non-CDC staff, supported with CDC funding

Instructions: From the dropdown list, select the types of data that will be collected that best fits this project. Categories 1, 2, and 3 are data covered by CDC Policy (http: aspnet-mas-iis/Policy Doc policy385.pdf). Categories 4 and 5 are data covered by CDC Policy but release or sharing may be restricted or limited. Categories 6, 7 and 8 are data NOT covered by CDC Policy and no further information is needed under this section. Use the lowest number when the data falls under more than one type. **See Box below for more information on the categories.**

Provide a 2-3 sentences description of the data that will be collected in this project:

The collected data will be tallies or counts of consistency between indicators reported by the site and indicators recreated at the site. These consistency counts will be used for program management; the utility of the data to the public is extremely limited

B. Data ownership: CDC country team

Instructions: Provide the name of the organization that will own the public health data for this project. If there are multiple organizations involved, provide the name of the organization that will retain and provide long-term control over the access and use of the data. Provide data steward's name and contact information if available.

C. Public access level: 3. Non-public – will not be available to the public

Instructions: From the drop-down list, select the data release category that will best fits how data will be available after data availability date.

Justifications: 4. Data has minimal value for public availability (e.g., low utility or value, insufficient quality, small study)

Instructions: From the dropdown list, select the option that best fits the justification for restricted access or unavailability of data.

Provide a brief description (1-3 sentences) if "Other reason" is selected:

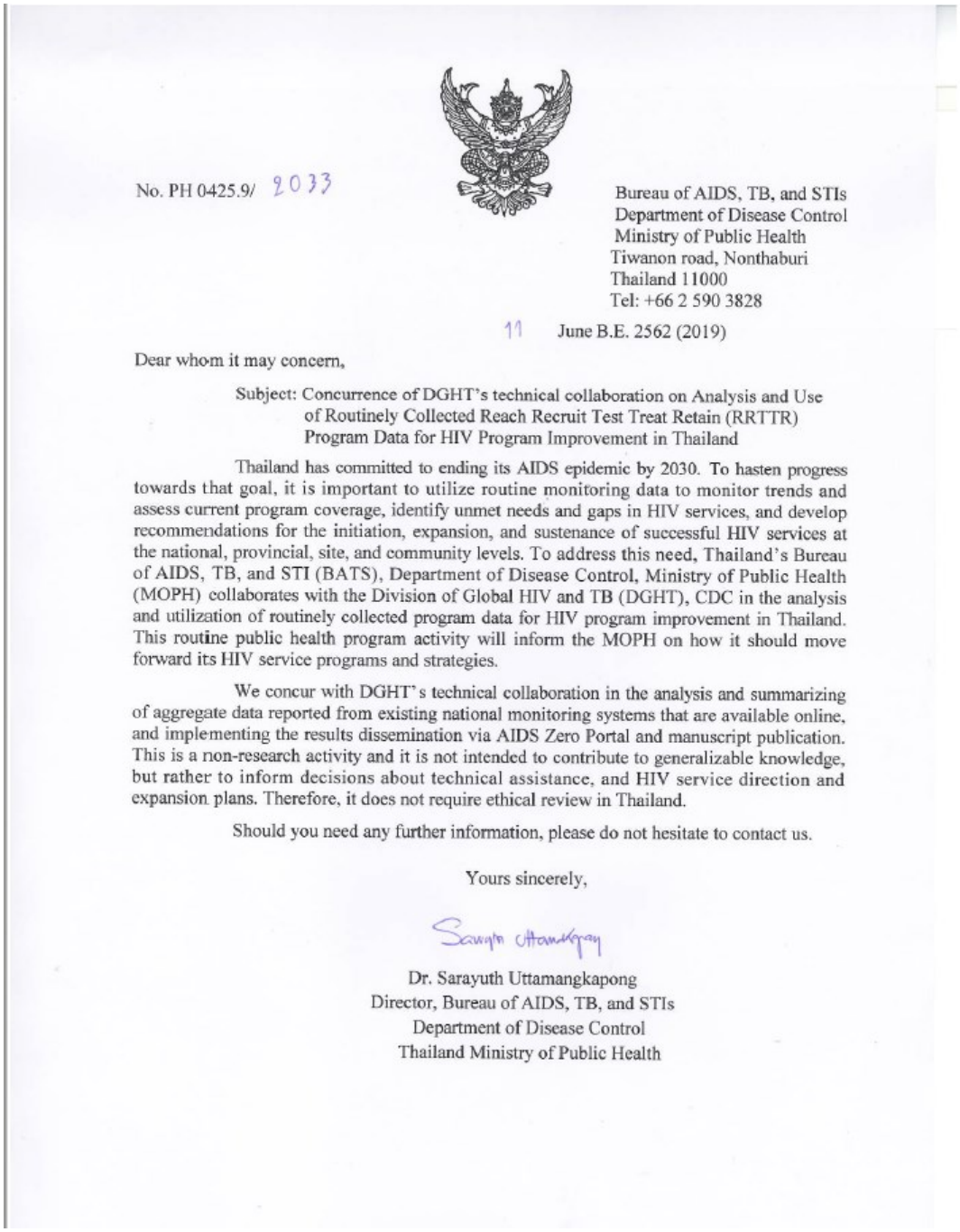
D. Anticipated data availability date (if applicable):

Instructions: Provide the anticipated date (mm/yyyy) that the public health data will become available.

Box: Type of data collected or generated

1. ***By CDC staff, supported with CDC funding*** – **CDC funds the activity and data are collected by CDC staff.**
2. ***By non-CDC staff, supported with CDC funding*** – **CDC funds or co-funds the data collection through mechanisms such as grants, cooperative agreements, contracts, or other funding mechanisms. Data is collected by non-CDC staff. When CDC funds another federal agency, an interagency agreement should indicate who would be responsible for the data.**
3. ***Provided to CDC and becomes part of a CDC data system*** – **Data is reported to CDC by another entity, e.g., by local health departments, that become a part of a CDC data collection system, e.g., CDC surveillance systems.**
4. ***Owned by partner and protected from release by laws or regulations*** – **CDC funds or co-funds the data collection. Data may be collected by CDC or non-CDC staff as in #1 and 2 above, but applicable US or country laws and regulations limit or restrict disclosure of data. Examples of US laws limiting disclosure include: the Privacy Act, Trade Secrets Act, or Section 308(d) of the US Public Health Service Act. When CDC funds activities in other countries, foreign laws and/or regulations may also apply.**
5. ***Not sharable due to potential dual-use research of concern*** – **Dual use research of concern is life sciences research that, based on current understanding, can reasonably be anticipated to provide knowledge, products, or technologies that could be directly misapplied by others to pose a threat to public health, agriculture, plants, animals, the environment, or material (http://intranet.cdc.gov/oadlss/mammals-and-policies/dual-use-research/). Data pertaining to DURC may not be sharable because of the potential threats.**
6. *Owned by partner and shared with CDC, but no CDC funding* – CDC does not fund, collect, or own the data. Data may be shared with CDC.
7. *Owned by partner and has an agreement restricting data sharing* – CDC does not fund, collect, or own the data. Data may be shared with CDC under data sharing agreement.
8. ***By another federal agency*** – **Another federal agency shares data with CDC under restricted terms agreement. The other federal agency is responsible for data release and sharing.**

The Ministry of Public Health, Thailand



No. PH 0425.9/ 2033

Bureau of AIDS, TB, and STIs
Department of Disease Control
Ministry of Public Health
Tiwanon road, Nonthaburi
Thailand 11000
Tel: +66 2 590 3828

11 June B.E. 2562 (2019)

Dear whom it may concern,

Subject: Concurrence of DGHT's technical collaboration on Analysis and Use of Routinely Collected Reach Recruit Test Treat Retain (RRTTR) Program Data for HIV Program Improvement in Thailand

Thailand has committed to ending its AIDS epidemic by 2030. To hasten progress towards that goal, it is important to utilize routine monitoring data to monitor trends and assess current program coverage, identify unmet needs and gaps in HIV services, and develop recommendations for the initiation, expansion, and sustenance of successful HIV services at the national, provincial, site, and community levels. To address this need, Thailand's Bureau of AIDS, TB, and STI (BATS), Department of Disease Control, Ministry of Public Health (MOPH) collaborates with the Division of Global HIV and TB (DGHT), CDC in the analysis and utilization of routinely collected program data for HIV program improvement in Thailand. This routine public health program activity will inform the MOPH on how it should move forward its HIV service programs and strategies.

We concur with DGHT's technical collaboration in the analysis and summarizing of aggregate data reported from existing national monitoring systems that are available online, and implementing the results dissemination via AIDS Zero Portal and manuscript publication. This is a non-research activity and it is not intended to contribute to generalizable knowledge, but rather to inform decisions about technical assistance, and HIV service direction and expansion plans. Therefore, it does not require ethical review in Thailand.

Should you need any further information, please do not hesitate to contact us.

Yours sincerely,

Sarayuth Uttamangkapong

Dr. Sarayuth Uttamangkapong
Director, Bureau of AIDS, TB, and STIs
Department of Disease Control
Thailand Ministry of Public Health

No. 0408.11/458

Division of Epidemiology
Department of Disease Control
Ministry of Public Health
Tiwanon Road.
Nonthaburi 11000, Thailand
Tel: +66 2 590 3831

4 September B.E. 2562 (2019)

Dear Whom It May Concern,

Subject: Concurrence of DGHT's technical collaboration on System Strengthening to Utilize Data from the National Health Information System for HIV Morbidity and Mortality Surveillance, Thailand

Electronic medical records hold great promise for facilitating decision-making and improving program planning to accelerate Ending AIDS at national and subnational levels in Thailand. To address this need, Thailand's Division of Epidemiology (DoE), Department of Disease Control, Ministry of Public Health (MOPH) collaborates with the Division of Global HIV and TB (DGHT), CDC in improvement usage of the national health information system for enhance routine dissemination of HIV-related morbidity and mortality reports, and build capacity of health officers for the interpretation of surveillance results for program planning.

We concur with DGHT's technical collaboration to develop and implement electronic HIV morbidity and mortality reporting system and visualization as well as build capacity for national and sub-national health officers on using surveillance results to monitor HIV related morbidity and mortality. This is a non-research activity and it is not intended to contribute to generalizable knowledge, but rather to inform program quality improvement and policy decisions to end AIDS at national and subnational levels. Therefore, it does not require ethical review in Thailand.

Should you need any further information, please do not hesitate to contact us at ying.thiti@gmail.com

Yours sincerely,

Dr. Thitipong Yingyong, MD
Division of Epidemiology
Department of Disease Control
Thailand Ministry of Public Health

No. PH 0413.9/ 559

Division of AIDS and STIs
Department of Disease Control
Ministry of Public Health
Tiwanon road,
Nonthaburi 11000, Thailand
Tel: +66 2 590 3828

13 August B.E. 2562 (2019)

Dear whom it may concern,

Subject: Concurrence of PEPFAR's technical collaboration on Data Quality Assessment in PEPFAR's supported sites in Thailand

Thailand has committed to ending its AIDS epidemic by 2030. Accuracy of data is essential in ensuring that programs implement with fidelity and are monitored appropriately to achieve the program success. To address this need, Thailand's Ministry of Public Health (MOPH) has included the improvement of data quality is one of the key national strategy. The primary objective is to regularly obtain accurate and reliable service delivery data, and the health providers and public health officers at PEPFAR supported sites are able to use the data for quality improvement services.

We concur that the implementation of the HIV Data Quality Assessment (DQA) will be conducted as a joint collaboration between the DGHT, USAID, Bangkok Metropolitan, Global Fund Thailand and the MoPH. The DQA process will be added to the routine data-driven quality improvement services which has been implemented in high HIV burden sites since 2018. The assessment team made up of USG staff and non-USG staff (e.g., Global Fund) will work alongside with health providers to review patient medical records, determine any discrepancies and provide technical support for data quality improvement process. No any personal data are collected. The DQA is classified as a non-research activity as it's objective is directly indicate the quality improvement actions under the national strategy; therefore, does not require ethical review in Thailand.

Should you need any further information, please contact Mr. Chaisuk Tungvongjulaneum, Chief, Informatics Section, by email chalermchaisuk@hotmail.com.

Yours sincerely,

Sarayuth Uttamangkapong

Dr. Sarayuth Uttamangkapong
Division of AIDS and STIs
Department of Disease Control
Ministry of Public Health

References

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4. Ou CY, Takebe Y, Weniger BG, Luo CC, Kalish ML, Auwanit W, et al. Independent introduction of two major HIV-1 genotypes into distinct high-risk populations in Thailand. Lancet. 1993;341(8854):1171-4.
5. Celentano DD, Bond KC, Lyles CM, Eiumtrakul S, Go VF, Beyrer C, et al. Preventive intervention to reduce sexually transmitted infections: a field trial in the Royal Thai Army. Arch Intern Med. 2000;160(4):535-40.
6. Siraprapasiri T, Ongwangdee S, Benjarattanaporn P, Peerapatanapokin W, Sharma M. The impact of Thailand's public health response to the HIV epidemic 1984-2015: understanding the ingredients of success. J Virus Erad. 2016;2(Suppl 4):7-14.
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13. Celentano DD, Nelson KE, Lyles CM, Beyrer C, Eiumtrakul S, Go VF, et al. Decreasing incidence of HIV and sexually transmitted diseases in young Thai men: evidence for success of the HIV/AIDS control and prevention program. AIDS. 1998;12(5):F29-36.
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19. BATS. Thailand HIV related reimbursement [Available from: http://aidssti.ddc.moph.go.th/contents/view/222.
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23. Theera-Ampornpunt N. Thai Hospitals' Adoption of Information Technology:A Theory Development and Nationwide Survey. Dissertation. Minneapolis; 2011.
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25. UNAIDS. 90-90-90: AN AMBITIOUS TREATMENT TARGET TO HELP END THE AIDS EPIDEMIC 2018 [Available from: http://www.unaids.org/en/resources/909090.
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Curriculum Vitae/Biographical Statement

Supharerk Thawillarp, MD, MS

Personnel information

Workplace

Bureau of Epidemiology, Department of Disease Control, Ministry of Public Health, Thailand

Current positions

Medical Doctor, Professional Level

Preventive medicine specialist

DrPH student, Department of Health Policy and Management

Bloomberg School of Public Health, Johns Hopkins University

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Education

September 2017-Present	DrPH candidate in Public Health Informatics Department of Health Policy and Management Bloomberg School of Public Health, Johns Hopkins University
August 2015-August 2017	Master of Science Division of Health Sciences Informatics School of Medicine, Johns Hopkins University *Thesis: Evaluation of Possible Dengue Outbreak Detection Methodologies for Thailand, which one should be implemented?.*

June 2013- May 2015	Field Epidemiology Training Program (FETP), Bureau of Epidemiology, Ministry of Public Health, Thailand *Capstones* - *Situation of Heat Related Illness in Thailand* - *Situation of Lead Exposure among pre-school Children in Bangkok, Thailand*
June 2004-May 2010	Doctor of Medicine Faculty of Medicine Prince of Songkla University, Songkhla, Thailand

Professional Experience

September 2019-December 2019	Developing HIV dashboard and indicator for monitoring HIV progress in Thailand UNICEF
October 2016-May 2019	Graduate Teaching Assistant PH 315.703 Leading Change through Health IT PH 340.770 Public Health Surveillance PH 340.770 Special Studies in Advanced Public Health Surveillance PH 315.709 Health Sciences Informatics, Knowledge Engineering and Decision Support 340.769 Professional Epidemiology Method Johns Hopkins Bloomberg School of Public Health
April 2015-May2015	Guest Researcher Centers for Disease Control and Prevention (USCDC), Atlanta, Georgia, USA

June 2013-June 2015	Resident (Board of Preventive Medicine) Field Epidemiology Training Program (FETP) Bureau of Epidemiology, Department of Disease Control Ministry of Public Health Thailand
September 2011-June 2013	General Practitioner (Intern) Pua Crown Hospital Nan, Thailand
September 2010-September 2011	General Practitioner (Intern) Nan Provincial Hospital Nan, Thailand

Certificate of Achievement

May, 2016	Certified HL7® V3 RIM Specialist Health Level Seven International
March, 2016	Certified HL7® V2.7 Control Specialist Health Level Seven International
February, 2016	Certified HL7 CDA® Specialist Health Level Seven International
October, 2015	SNOMED CT Foundation course, International Health Terminology Standards Development Organization IHTSDO

November, 2016	SNOMED CT Implementation course, International Health Terminology Standards Development Organization IHTSDO
March, 2017	SNOMED CT Content Development Theory course, International Health Terminology Standards Development Organization IHTSDO
September, 2014	Good Clinical Practices, Clinical Trials Network, National Institute on Drug Abuse (NIDA), Maryland, USA
March, 2014	Epidemiology of Nosocomial infection, Epidemiology unit, Faculty of Medicine, Prince of Songkla University, Songkhla, Thailand
February, 2014	Joint Workshop on Scientific Writing in Field Epidemiology, 2014, Champasak, Laos PDR
August, 2013	Short course in Environmental Medicine, Nopparat Rajathanee Hospital, Bangkok, Thailand
June, 2013	Introductory Courses on Field Epidemiology and Biostatistics, Ministry of Public Health, Nonthaburi, Thailand

Skills

Programs: Stata, Epi-info, Epidata, QGIS,

Computer Languages: R, Java HTML, Python

Publications

International Publication

1. **Supharerk Thawillarp**, Carlos Castillo-Salgado, Harold P Lehmann Evaluation of Early Aberration Reporting System for Dengue Outbreak Detection in Thailand. Outbreak, Surveillance and Investigation Reports (OSIR) December 2018, Volume 11, Issue 4
2. **Supharerk Thawillarp**, Waiyanate N., Chen L., Akechalermkiat S., Srichang S., Ritthidej P., Nagchinta T. Ferry boat injuries and death in Pattaya, November 2013; Its' time for Thailand to reclaim its safe travelling. Outbreak, Surveillance and Investigation Reports (OSIR) December 2014, Volume 7, Issue 4, p.6-11.
3. **Supharerk Thawillarp**, Thammawijaya P., Praekunnatham H., Siriruttanapruk S. Situation of Heat-related Illness in Thailand, and the Proposing of Heat Warning System Outbreak, Surveillance and Investigation Reports (OSIR). September 2015, Volume 8, Issue 3, p.15-23

Thai Publication

1. **Supharerk Thawillarp**, Butkarn C., Taweewigyakarn P. ,Arunothong S. , Thanakitjaroenkul J. , Sankalux B. , Lekcharoen P. , Onsongchan S. , Phupat P., Techaniyom T. , Dejphichai R., Thammawijaya P. Dengue cluster investigation in two districts, Ubon Ratchathani, January-July 2013: Epidemiological characteristics and key vector containers. Weekly Epidemiological Surveillance Report (WESR). September 2015, Volume 46, Issue 6, p.81-88
2. **Supharerk Thawillarp**, Waiyanate N., Karnjanapiboonwong A., Saengaram K., Plaingam M., Yodprasit T. , Klaitabtim T. ,Wongcharoendham B. , Mueangorasert P., Krishna J. Aircraft Turbulence Encounter in Rainy, 2013. Weekly Epidemiological Surveillance Report (WESR). November 2015, Volume 46, Issue 43, p. 673-677.
3. **Supharerk Thawillarp**, Waiyanate N., Chen L., Akechalermkiat S., Srichang S., Ritthidej P., Understanding about Buoyancy Aid and Life Vest, According to an Investigation on Boat Traveling Injury in Chon Buri, November 2013. Weekly Epidemiological Surveillance Report (WESR). November 2015, Volume 46, Issue 44, p. 689-693.
4. Taweewigyakarn P., Kanlayanaphotporn J., Sangsawang C., Arunothong S., **Supharerk Thawillarp**, Boonyapaisarncharoen P., Jansiriyakorn S., Keereesamon T., Rubthongsuksakul K., Sonbalee M., Pittayawonganon C., Influenza A (H1N1) 2009 Dead Cases Investigation, Chiang Dao District, Chiang Mai, Thailand, February 2014. Weekly Epidemiological Surveillance Report (WESR). September 2015, Volume 46, Issue 35, p. 545-552
5. Nitiapinyasakul A, Thaewnongiew K., **Supharerk Thawillarp**, Mungaomklang A., A Matched Case-Control Study to Stratify Mortality Risk Factors in Adult Pulmonary Tuberculosis Patients in Northeast of Thailand, Journal of Health Science, May-June 2018, Volume 27 Issue 3

Other Publications

1. **Supharerk Thawillarp**, Chumkasean P. Summary situation of Brucellosis in Thailand, Annual Epidemiological Surveillance Report (AESR), 2013;83-84

2. **Supharerk Thawillarp**, Siripanij S. Summary situation of Heavy Metal poisoning in Thailand, Annual Epidemiological Surveillance Report (AESR), 2013;154
3. **Supharerk Thawillarp**, Siripanij S., Ungchusak K. Summary situation of Toxic gas and asphyxia in Thailand, Annual Epidemiological Surveillance Report (AESR), 2014;166-167

Manual Production

Ebola Virus Disease Manual for Surveillance and Rapid Response Team (SRRT), Ministry of Public Health, Thailand 2014

- Literature Review
- Co-author of Suspect Case Report Process Chapter
- Co-author of Thailand Situation Summary Chapter
- Co-author of Investigation Process Chapter

Presentation

International conference

Oral presentation

Presented "Fatal Injuries from Boat Travelling in Pattaya, Thailand, November 2013" at The 7th Asian Conference on Safe Communities in Busan, South Korea, 13 May 2014.

Presented "Situation of Heat Related Illness in Thailand, 2013" at the 8th Global TEPHINET Conference, Mexico City, Mexico, 11 Sep 2015.

Thailand conference

Poster presentation

Presented "Dengue cluster investigation in two districts, Ubon Ratchathani, January-July 2013: Epidemiological characteristics and key vector containers" at The 22nd National Epidemiology Seminar, February 2015.

Professional Membership

Epidemiology Association of Thailand (EpiAT)	February 2015-present
Thai Medical Informatics (TMI)	November 2014-present
Field Epidemiology Association of Thailand (FEAT)	December 2014-present
The Medical Council of Thailand	November 2010-present

Professional Service

Project

1. Growing Expertise in e-Health Knowledge (GEEK)
   Ministry of Public Health, Thailand and Centers for Disease Control and Prevention (USCDC)
   - Curriculum Design
   - Instructor
   - Teaching Assistant
2. CBID NEONATAL TEAM 2016 Mortality Busters – Combatting Neonatal Mortality in Kenya, 2016
   The Johns Hopkins Center for Bioengineering Innovation & Design (CBID)
   - Research Design and Methodology Consultant
   - Data analysis
   - Android Application Developer
3. Lead exposure surveillance, prevention and eradication in preschool child committee, 2015, Department of Disease Control, Ministry of Public Health, Thailand
   - Medical Consultant
   - Committee Member
4. Driver license examination revision committee 2015, Department of Land Transport, Ministry of Transport, Thailand
   - Medical Consultant

Surveillance system evaluation

Data analysis and management team leader

1. Food Poisoning Surveillance Evaluation, Chiang Mai, Thailand, 2013
2. Malaria Surveillance System Evaluation, Ubon Ratchathani, Thailand, 2014

Outbreak Investigator

Principal Investigator

1. Explosion in chemical substance warehouse at Samut Prakan, 2014
2. Diphtheria death in Satun September 2013
3. Food Poisoning, Mae Rim, Chiang Mai, February 2014

Co-Principal Investigator

1. The outbreak of Staphylococcus aureus in Neonatal unit, Bangkok, August 2013
2. Vancomycin Resistance Enterococci (VRE) outbreak in Ramathibodi hospital, July 2013
3. An Investigation of Influenza A H1N1 (2009) deaths, Chiang Dao District, Chiang Mai, February 2014
4. Hepatitis A Outbreak in Chon Buri – Rayong, June 2014
5. Food poisoning, Chiang Rai, July 2014
6. Meningococcemia in Prison, Nonthaburi

Teaching Assistance (Short Course and Seminar)

Data analysis workshop, The 22nd National Epidemiology Seminar, 2-3 Feb 2015

- Prepare Assignment and Application
- Help Participant for Technical Problem

Invited instructor

Presented the example of injury investigation to Marine Officers, Kanchanaburi.7th January, 2014

Presented the current project of Ministry of Public Health in controlling Blood Lead Level Project, Kanchana Buri, Thailand, 2014

Introduction to Public Health Informatics, GEEKS training program, Thailand, August,5 2019

Invited speaker

Heat stroke in summer, Good Morning Thailand, People Share, Mono29 channel 17th April 2015

What is Biomedical Informatics?, Prince of Songkla University Update in Medicine Conference, 4 July 2017