THE EFFECTIVENESS OF CROSS BORDER DISEASE CONTROL SYSTEM COMPLIED WITH COMMUNICABLE DISEASE ACT B.E.2558(2015)

Voravit Payungkiatbawon, Somkiat Wattanasirichaigoon, Prush Sa-nga-ngam*, Yod Sukamongkol and Supaporn Kiattisin

Technology of Information System Management Division, Faculty of Engineering, Mahidol University, Thailand

ABSTRACT

The Cross Border Disease Control (CBDC) system was developed as a prototype system in response to surveillance of transboundary patients in foreign countries possibly leading to emerging and reemerging diseases in Thailand. To be practical with lesser data space, the information exchange technique (Message Queue) will be used for data sync from the hospital operating system called Hospital Information System (HIS). HIS consists of diagnostic results, patient information, and real-time patient tracking system, allowing the Department of Disease Control to acquire data from the hospital to process statistical data for prognosis. The information will be exchange with health quarantine to inform them to acknowledge the disease situation of health hazards occurring in the quarantine area, as well as, international tourist from the infectious zone screen and tracking. The effectiveness of the Cross Border Disease Control System (CBDC) is based on a systematic assessment, the statistics information system and preliminary analysis. This assessment can be used with both quantitative and qualitative methods with lesser time spent. The primary objective of this research is to comprehensively evaluate the effectiveness of the Cross Border Disease Control (CBDC) system. Specifically, the study aims to: Evaluate the accuracy, speed, and reliability of data synchronization between CBDC and HIS, ensuring timely disease surveillance and Examine the CBDC system's impact on transborder disease prevention and control, particularly in identifying and managing emerging diseases. The results of the research will develop public health actions on disease prevention and control in the digital system for future.

Keywords: cross border, public health, disease control, Thailand disease control

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1. INTRODUCTION

Thailand was a member of World Health Organization (WHO) since June 15th, 2007 [1]. The Cabinet approved the Ministry of Public Health (MOPH) to request WHO for an evaluation of compliance with International Health Regulations (IHR) by using Joint External Evaluation (JEE) tool. Mae Sai, Chiang Khong and Chiang Saen are the northern districts of Chang Rai Province in northern Thailand, where border crossing between Thailand, Myanmar and Lao located. In 2019, the average number of travelers is in between 80,000 – 90,000 people per day and vehicle usage is around 600-700 units per day. This is the reason why International Health Regulations (IHR) was regulated in Mae Sai, Chiang Khong and Chiang Saen borders as the point of entry requirements to develop the capacity in compliance with the regulations and to evaluate the development in accordance with WHO.

Globally, tuberculosis (TB) incidence rate in South East Asia, such as Myanmar, Lao, Cambodia, and Thailand, is decreasing but still needed more to reach the milestone of the WHO's End TB strategy [2]. From 2015 to 2019, mean value of tuberculosis incidence (per 100,000 people) in Myanmar is 355.6, Lao PDR is 168.4, and Thailand is 156.4 [3]. Correspondingly, risk of TB infectious factors is also from migrant workers from neighbouring countries who come across to work in Thailand. Lao PDR and Myanmar have a higher risk to be more prevalent than Thailand since the Golden Triangle boundary with these countries is connected. Firstly, Myanmar's Tachileik Province is next to Mae sai. Secondly, Lao PDR's Bo Kaeo Province is next to the Chiang Khong border. Lastly, the area of Ton Phueng in Bo Kaeo Province connects to Chiang Saen's border. These areas create a trade labour migration from Lao PDR to work in Thailand, especially in Chiang Khong and Chiang Saen districts, causing the border in areas to spread more tuberculosis. Therefore, it is an appropriate area to conduct this study.

Cross Border Disease Control System: CBDC was created since 2018. To collect tourists' data and migrant patients from the neighbor countries, such as Myanmar, Lao PDR, Cambodia and Malaysia, the different alphabet and personal identification have been required for Thailand entry according to Joint External Evaluation (JEE) of the

International Health Regulations (IHR) since June 2017. However, Thailand has some concerns in priority public health risks and resources are mapped and utilized where it shows no capacity although the quarantine stations provide survey T8 paper form and medical logbook to keep the suspected cross-country data collection. Regarding this incidence, many data are misguided by languages boundary and human errors. This inaccuracy affects health screening system and the success of cross-country-spreading disease prevention. Therefore, quarantine stations and local hospitals in the north and north-east area of Thailand are nominated as special economic zones for real time health border data exchange using digital form of CBDC.

With the accordance of the development plan, the point of entry must develop the data base system for identifying and developing the integrated network, the surveillance, detection – interception, and cross-country screening as well as data exchange with stakeholders such as the Immigration Bureau. Immigration Bureau has responsibility for real-time database and data exchange system, which can be effective to the international infectious disease surveillance proactively complied with Communicable Disease Act 2015 [4]. The objective of this work is to assess the effectiveness of the Cross Border Disease Control (CBDC) system prototype, which was developed to enhance surveillance of transboundary patients and potential emerging diseases in Thailand. We aim to measure the efficiency of the data synchronization process from the Hospital Information System (HIS) using the Message Queue technique, evaluate the CBDC system's ability to acquire and process diagnostic results and patient data for disease prognosis, and assess its communication capabilities with health quarantine authorities for timely response and international tourist tracking. The assessment will employ a systematic approach encompassing quantitative and qualitative methods to gauge the system's performance, efficiency metrics, statistical analysis, user feedback, and time-effectiveness, with the ultimate goal of informing digital public health actions for future disease prevention and control efforts, this research applies pulmonary tuberculosis case study to monitor the system by studying its database, real-time notification, and medical treatment from tuberculosis patients and monitoring TB treatment. TB treatment in the study includes TB prevention during treatment and how to respond to dangerously serious TB diagnostic.

2. LITERATURE AND RELATED WORK

Thailand has developed the public health system according to the National Public Health Development Plan under the 4th National Economic and the 12th Social Development Plan (1977-1981) by establishing a comprehensive health work structure from district level up to national level. Each level plays an important role in the surveillance system to enhance disease control and to prevent health hazards from avian influenza, such as SARS, including to analyze the incidence as another lesson of disease prevention. SARS occurred in 2003 when health personnel at that time had worked with an aim to strengthen disease prevention and control by developing a surveillance system in the form of a fast-moving team. Working with other agencies to supervise public works to meet international standards, Cabinet approved the announcement of the International Health Regulations (IHR) in June 15th, 2007. To administrate the IHR, the Ministry of Public Health works as a coordinator with the relevant departments of the various ministries, where the committees have been appointed. International Health Regulations (IHR) was published on September 8th in 2015. The Communicable Diseases Act 2015 was established from the Gazette Government on March 6th in 2016. This is when IHR and the Diseases Act 2015 were both implemented by the Government. The Communicable Diseases 2015 required public health operations. Entry and exit regulation was one of crucial public health operations authorized in 18 countries and the competency must be developed according to the International Health Regulations 2005.

In this research, the quantitative attribute is conducted by searching and reviewing medical records from National Tuberculosis Information Program (NTIP) based on the surveillance system tuberculosis with gold standard and comparing the data with CBDC. CBDC is an organization published medical research. One of related topic is Finding Sensitivity of the CBDC System, Positive Predictive Value, Data Quality of CBDC System, representation, and timeliness from 1st January to 31st December in 2019. The research methods use 2 by 2 table[5] to calculate the data sensitivity, data coverage and positive predictive value. The CBDC massage exchange system used RabbitMQ, a powerful tool and easy, to manage queue.

3. METHODOLOGY

This study is a participatory action research by collecting both qualitative and quantitative method to focus on the accuracy, speed of information exchange, and the data utilization of information divided into 3 issues.

3.1 First Issue: Analyze CBDC system technology.

CBDC system technology will be analyzed using software acceptance checklist and software technique document.

3.2 Second Issue: Find out the effectiveness the data utilization of CBDC system.

Quantitative feature: The quantitative attribute is conducted by searching and reviewing medical records from National Tuberculosis Information Program (NTIP) based on the surveillance system Tuberculosis at Chiang Khong Crown Prince Hospital, and Chiang Saen Hospital. The issue studies on the sensitivity finding of the CBDC system, positive predictive value, data quality of CBDC system, representation, and timeliness.

Analysis Methods: 2 by 2 table to calculate the data sensitivity, data coverage and positive predictive value.

Sensitivity (coverage) = A/(A+C)
Positive Predictive value = A/(A+B)

	+	-	
CBDC	A	B	A+B
NTIP	C	D	C+D
	A+C	B+D	

Figure 1. 2 by 2 table

Where A = Number of the confirmed communicable disease patients in CBDC system that links with HIS
B = Number of the confirmed communicable disease patients in CBDC system that not links with HIS
C = Number of the confirmed communicable disease patients in NTIP that links with HIS
D = Number of the confirmed communicable disease patients in that not link with HIS

A+C=Number of aliens cross the border TB case and data links with HIS TB

3.2 Third Issue: This research utilized a questionnaire through the Google Form platform. The questionnaire design concept aimed to evaluate user satisfaction in utilizing the Cross Border Disease Control (CBDC) system for patient surveillance across borders.

The target population for this study comprises all personnel working at the international disease prevention and control checkpoints, totaling 2 checkpoints. The study area for evaluation includes international border entry-exit points and border types where the Cross Border Disease Control (CBDC) system has been implemented. Additionally, the CBDC system has been installed in hospitals near the entry-exit points, totaling 2 hospitals. The two selected entry-exit points are Chiang Khong-Huay Xai Friendship Bridge Checkpoint and Chiang Saen Port Checkpoint. The data for the study is collected through questionnaires from a total of 18 respondents.

This approach was undertaken to confirm the system's operational effectiveness. In this testing phase, the Black Box testing method was employed, focusing on specific aspects such as Functional Requirement Test, Functional Testing to assess the accuracy of system operations, Usability Test, and Security Test. The scoring scale used was a 5-level Likert Scale, following the Likert scale measurement framework. After expert assessments, statistical processes were employed by calculating the average scores in each aspect. The interpretation of the results determined the level of effectiveness according to the 5-level criteria outlined by Best (1997) [6].

Research area: Chiang Khong Crown Prince Hospital, and Chiang Saen Hospital in Chiang Rai Province.

Research data period: 1st January 2019– 31st December 2020

4. RESULTS

4.1 Analyze CBDC System Technology.

Cross Border Disease Control System: CBDC was designed and developed as showed in Figure 1. CBDC system is a real-time data exchange platform that will automatically transmit dataset from hospital information system, HIS, to CBDC system by using application programming interface to API and message broker called RabbitMQ technique.

At the point of entry, the quarantine station inputs the CBDC system interface screening, and the data of the suspected will be transmitted to the CBDC system immediately. The medical record department at the hospital will verify the personal data before providing service. After medical service, the diagnosis data will be automatically gathered with the previous quarantine data and consolidated into data visualization.

Suspected visitor's data will be monitored by control room at the emergency operations center of Department of Disease Control (DDC), Office of Department of Disease Prevention and Control (OPDC) and Provincial Public Health Office (PPHO) to take an action under Communicable Disease Act 2015 illustrated in Figure 1.

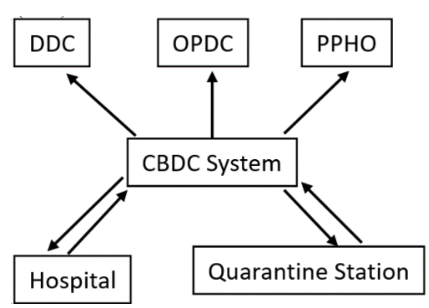


Figure 2. System of Data Exchange Regarding Cross Border Disease Control

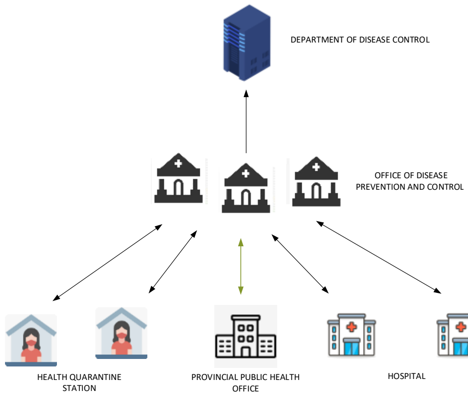


Figure 3. System Overview

4.1.1 Programing Script Technology

CBDC System had develop by Java version 8, spring boot version 2.0.2 framework and Spring data JPA framework version 2.0.2 for database connection by dividing the working system into parts with the accordance with usage part.

4.1.1.1 Data Input

Data form Health Quarantine Station will be sent via HTTPS to personal computer and will later be transferred to database server at the Office of Department of Disease Prevention and Control (OPDC) every 5 minutes. There are OPDC system setup in 9 regions of Thailand and this research will focus only one from The Office of Department of Disease Prevention and Control in Chang Mai. If the data is sending, the record will change form number “0” in to “1”. In case of record data is “0”, it means that there is a new record or there is one data modification. The data will later be resent to OPDC database server in the next 5 minutes in state of SQL Code. SQL Code is used when is “send = 0”. This is when sending data from the checkpoint to post-server API with JSON format via HTTPS web (HTTP + SSL) to inquiry data during transit using basic authentication. Also, the data will split transmission by 10 records per cycle to limit the amount of data in each transmission cycle. As show in Figure4, Figure 5 and Figure 6.

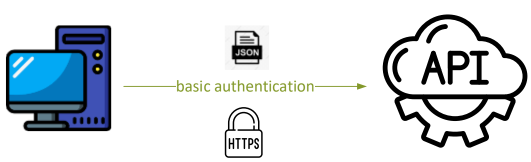


Figure 4. Data Sending and Update from Cross Border Disease Control

```
@RestController
@RequestMapping("/api/receive")
public class ReceiveController {

    @Autowired
    private SyncService syncService;

    @PostMapping("/person")
    public ResponseEntity savePerson(@RequestBody Person person) throws Exception {
        syncService.savePerson(person);
        return new ResponseEntity(HttpStatus.OK);
    }

}
```

Figure 5. Source code; Server site

```
public void sendData() throws Exception{
    final int limit = 10;
    int cnt = personDao.countByIsSend(false);
    int round = cnt / limit;
    if(cnt % limit != 0){
        round++;
    }

    RestTemplate restTemplate = new RestTemplate();
    restTemplate.getInterceptors().add(
            new BasicAuthorizationInterceptor("sync", appProperties.getApiKey()));

    for(int i=0;i<round;i++){
        List<Person> persons = personDao.findAllByIsSend(false, new PageRequest(0, limit));
        for(Person p : persons){
            ResponseEntity<HttpStatus> response = restTemplate.postForEntity(appProperties.getPERSON_POST_URI(), p,
                    HttpStatus.class);
            p.setIsSend(true);
            savePerson(p);
            log.info( Thread.currentThread().getName()+ " : Send person : "+p.getPersonId());
        }
    }
}
```

Figure 6. Source code; Client Site

4.1.1.2 Data Exchange between Health Quarantine Station, Office of Department of Disease Prevention and Control, and Department of Disease Control

This process can be categorized into 2 cases as show in Figure 7 and Figure 8.

- Retrieve the historical data)in 2 days) using the scheduling method. Every 5 minutes, the system will run the GET API from the server by passing the parameter along with the start date and the checkpoint code. The server will process it as the screening data and respond to the checkpoint in JSON format via HTTPS (HTTP + SSL) protocol to encrypt the data in transit using basic authentication.
- Retrieve the historical data)in 30 days) using the scheduling method. Every 6 minutes, the system will run the GET API from the server by passing the parameter along with the start date and the checkpoint code. The server will process it as the screening data and respond to the checkpoint in JSON format via HTTPS (HTTP + SSL) protocol to encrypt the data in transit using basic authentication.

```
@GetMapping("/get/{border}/{date}")
public List<Person> getFromBorder(@PathVariable("border") String border, @PathVariable("date") String date)
        throws Exception {
    return syncService.getFromBorder(border,date);
}

@Query(value = "SELECT p FROM Person p WHERE p.borderId=?1 AND function('date_format', p.arriveDate, '%Y-%m-%d') = ?2 ")
public List<Person> getByCreateDate(String border, String date);
```

Figure 7. Data Exchange between Health Quarantine station and Office of Department of Disease Prevention and Control Source code; Server site

```java
@Scheduled(fixedDelayString = "${task.update.fetch}")
public void updateData() {
    try {
            log.info( Thread.currentThread().getName()+" : start update -->");
            Calendar cal = Calendar.getInstance();
            cal.add(Calendar.DATE,  amount: -2);
            Date maxDate = cal.getTime();
            syncService.updateData(maxDate);
            log.info( Thread.currentThread().getName()+" : end update -->");

    }catch (Exception ex){
        log.error(ex.getMessage());
    }
}
```

Figure 8. Data Exchange between Health Quarantine station and Office of Department of Disease Prevention and Control Source code; Client site

4.1.1.3 Data Exchange between Local Hospital and Office of Department of Disease Prevention and Control

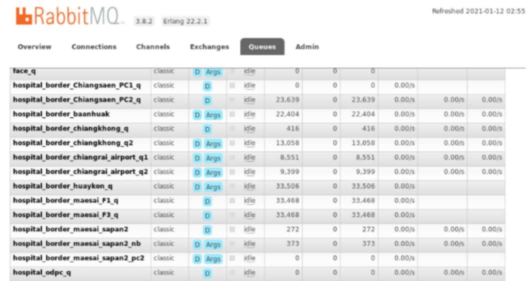
This process is to exchange the migrant patients form Hospital Information System (HIS). CBDC system will set data query every hour to retrieve the historical data)in 8 months) at midnight daily. For the safety of the HIS system and irrelevant data, data exchanges with the CBDC will be not directly connected. Instead, it will be put on the hospital's buffer computer first to extract the data before the exchange, and then will connect to the server of the Office of Department of Disease Prevention and Control, where the data will be turned into "0" to show that there is a new record or turned into "1" if it is an old data or modified data. By using RabbitMQ server at Office of Department of Disease Prevention and Control, data inquiry will limit at 100 rolls per time of sending. This technique does not only make the data most update, but can also help reducing data redundancy as showed in Figure 7, and Figure 8.

4.1.1.4 Data Exchange between Office of Department of Disease Prevention and Control and Department of Disease and Control

Same technique as 4.1.1.3. The information is distributed to the checkpoint queues to the Department of Disease working as a transmission center of information.

4.1.1.5 Queue Management

RabbitMQ can individually control consumer acknowledgements of the disease by allowing it to process multiple messages independently. For example, if there are 100messages at the same time, you can choose to commit or not commit messages that do not cause errors. When RabbitMQ saves the data, the data will disappear because it is consumed and acted. However, there is a case called Kafka. Kafka happens when the data is although it is not influenced. RabbitMQ offers a key exchange with routing, bindings, and facilitating broadcast messages to the desired queue. To pull the data out form RabbitMQ and control transactional risk of missing or losing data during transfer, the system use thread pool technique by setting maximum thread at 60 for more speed of data exchange illustrated in Figure 9,10,11 and Figure 12.



face_q	classic	D Args	idle	0	0	0				
hospital_border_Chiangsaen_PC1_q	classic	D	idle	0	0	0	0.00/s			
hospital_border_Chiangsaen_PC2_q	classic	D	idle	23,639	0	23,639	0.00/s	0.00/s	0.00/s
hospital_border_baanhuak	classic	D Args	idle	22,404	0	22,404	0.00/s	0.00/s	0.00/s
hospital_border_chiangkhong_q	classic	D	idle	416	0	416	0.00/s	0.00/s	0.00/s
hospital_border_chiangkhong_q2	classic	D Args	idle	13,058	0	13,058	0.00/s	0.00/s	0.00/s
hospital_border_chiangrai_airport_q1	classic	D Args	idle	8,551	0	8,551	0.00/s	0.00/s	0.00/s
hospital_border_chiangrai_airport_q2	classic	D Args	idle	9,399	0	9,399	0.00/s	0.00/s	0.00/s
hospital_border_huaykon_q	classic	D Args	idle	33,506	0	33,506	0.00/s		
hospital_border_maesai_F1_q	classic	D	idle	33,468	0	33,468	0.00/s		
hospital_border_maesai_F3_q	classic	D	idle	33,468	0	33,468	0.00/s		
hospital_border_maesai_sapan2	classic	D	idle	272	0	272	0.00/s	0.00/s	0.00/s
hospital_border_maesai_sapan2_nb	classic	D Args	idle	373	0	373	0.00/s	0.00/s	0.00/s
hospital_border_maesai_sapan2_pc2	classic	D Args	idle	0	0	0	0.00/s		
hospital_odpc_q	classic	D	idle	0	0	0	0.00/s	0.00/s	0.00/s

Figure 9. Queue Management by RabbitMQ

```java
public void sendHospitalData() throws Exception{
    final int limit = 100;
    AtomicInteger counter = new AtomicInteger( initialValue: 0);
    int rowNotSend = hospitalDataRepository.countByIsSend("0");
    log.info("detect row : "+rowNotSend);

    Boolean hasMore = true;
    while(hasMore){
        List<HospitalData> data = hospitalDataRepository.findAllByIsSendOrderByRecordDateAsc( isSend: "0",
                new PageRequest( page: 0, limit));
        if(data==null || data.size()==0){
            break;
        }
        send(data,counter);
    }
    log.info("send row : "+counter.get());
}
```

Figure 10. Queue management by RabbitMQ, Source code

```java
@Component
@RabbitListener(queues = {"${config.consumer.hospital}"})
public class HospitalConsumer {

    private static final Logger LOGGER = LoggerFactory.getLogger(HospitalConsumer.class);

    @Autowired
    private HospitalDataDao hospitalDataDao;

    @RabbitHandler
    @Transactional(rollbackOn = Exception.class)
    public void receiveMessage(HospitalData data, Channel channel, @Header(AmqpHeaders.DELIVERY_TAG) long tag)
            throws Exception {
        hospitalDataDao.save(data);
        channel.basicAck(tag,  b: false);
    }
}
```

Figure 11. Data queue management by RabbitMQ, Source code

```java
public void process() throws InterruptedException {
    ExecutorService executor = Executors.newFixedThreadPool(appProperties.getTHREAD());
    int rowLimit = appProperties.getROW_LIMIT();

    // person
    int rows = personDao.countByIsSend(false);
    log.info("person rows : "+rows);

    int pages = rows/rowLimit;
    if(rows!=0) {
        if (rows % rowLimit != 0)
            pages++;

        for (int i = 0; i < pages; i++) {
            int page = i;
            executor.submit(() -> {
                sendPerson(page, rowLimit);
            });
        }
    }
```

Figure 12. Data Queue Management by RabbitMQ, Source code

4.2 The Effectiveness of the Data Utilization of CBDC System.

Chiang Khong Crown Prince Hospital

From January 1st to December 31st in 2019, the number of migrant patient visits are 13,865 times in HIS database and 11,249 times in CBDC database with system usage at 81.13%, showed in Figure 13.

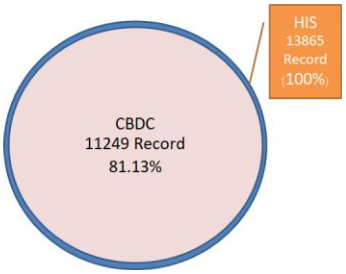


Figure 13. Cross Border Disease Control, CBDC Sensitivity 2019 The Total Number of Migrant Patient Visits at Chiang Khong Crown Prince Hospital.

According to searching and reviewing information from NTIP from January 1st to December 31st in 2019, there were 5 migrant patients with positive results of Tuberculosis and 13 migrant patients with negative results. As for CBDC database, it showed there were 10 migrant patients with positive results of Tuberculosis and 8 migrant patients with negative results in Table1.

The sensitivity assessment of CBDC from January 1st to December 31st in 2019 reported that there were 10 people with the definition of Tuberculosis and 5 migrant patients with Tuberculosis of NTIP. The sensitivity of CBDC in this case is accounted for 66.66 percent.

The Positive Predictive Value evaluation of the CBDC from January 1st – December 31st in 2019 is 55.55 percent.

Table 1. Sensitivity and Positive Predictive Value of Tuberculosis Report. From January 1st to December 31st, 2019

Sensitivity and prophecy	Definition of disease surveillance		Total
	+	-	
CBDC	10	8	18
NTIP	5	13	18
Total	15	21	36

Sensitivity = A/(A+C) = 10/15 = 66.66 %

Positive Predictive Value = A/(A+B) = 10/18 = 55.55 %

Data quality assessment of CBDC medical record and review regarding migrant patient's visit was 18 in number, representing 55.55 percent of overall visit.

Accuracy of the information regarding the address and date of diagnosis record and review of 10 migrant patients are at 100 percent accuracy.

Assessing of NTIP Representation was conducted by comparing number of cases and it showed that CBDC had data 2 times more than NTIP, but 8 records from CBDC were missing from their ER system when the connection with the exchange system was lost.

Timeliness Assessment of CBDC Tuberculosis reported cases will provide immediate notification in form of a dashboard in CBDC system. This works the same as NTIP system.

Chiang Saen Hospital

From January 1st to December 31st in 2019, the number of migrant patient visits are 24,148 times in HIS database and 22,361 times in CBDC database with system usage at 92.60%, showed in Figure 13.

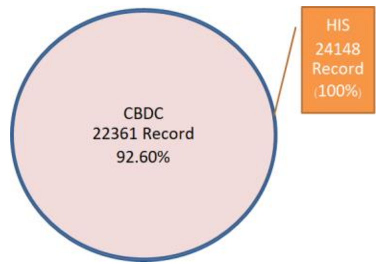


Figure 14. Cross Border Disease Control, CBDC Sensitivity 2019 The Total Number of Migrant Patient Visits in Chiang Saen Hospital.

According to searching and reviewing information from NTIP from January 1st to December 31st in 2019, there were 7 migrant patients with positive results of Tuberculosis and 106 migrant patients with negative results. As for CBDC database, it showed there were 103 migrant patients with positive results of Tuberculosis and 10 migrant patients with negative results in Table 2.

The sensitivity assessment of CBDC from January 1st to December 31st in 2019 reported that there were 106 people with the definition of Tuberculosis and 7 migrant patients with Tuberculosis of NTIP. The sensitivity of CBDC in this case is accounted for 93.63 percent.

The Positive Predictive Value evaluation of the CBDC from January 1st – December 31st in 2019 is 91.15 percent.

Table 2. Sensitivity and Positive Predictive Value of Tuberculosis Report From January 1st to December 31st, 2019

Sensitivity and prophecy	Definition of disease surveillance		Total
	+	-	
CBDC	103	10	113
NTIP	7	106	113
Total	110	116	226

Sensitivity = A/(A+C) = 103/110 = 93.63 %

Positive Predictive Value = A/(A+B) = 103/113 = 91.15 %

Data quality assessment of CBDC medical record and review regarding migrant patients visit was 103 in number compared with 113 people of overall positive Tuberculosis, representing 91.15 percent of overall visit.

Accuracy of the information regarding the address and date of diagnosis record and review of 103 migrant patients are at 100 percent accuracy.

Assessing of NTIP Representation was conducted by comparing number of cases and it showed that CBDC had data recorded more 96 patients than NTIP, but 10 records from CBDC were missing from their ER system when the connection with the exchange system was lost.

Timeliness Assessment of CBDC Tuberculosis reported cases will provide immediate notification in form of a dashboard in CBDC system. This works the same as NTIP system.

4.3 The evaluate user satisfaction in utilizing the Cross Border Disease Control (CBDC) system.

Table 3. Results of Evaluation on Meeting Functional Requirements

Evaluation Items	**Mean ($\bar{x}$)**	Standard Deviation (S.D.)	Evaluation Interpretation
System's ability to store data for analysis	4.33	0.71	Very Satisfied
System's ability to present data relationships	4.33	0.50	Very Satisfied
System's ability to present desired data outcomes	4.22	0.44	Very Satisfied
System's ability to analyze data	4.22	0.44	Very Satisfied
System's ability to support decision-making	4.56	0.53	Very Satisfied
System's ability to generate summary reports	4.33	0.71	Very Satisfied
System's ability to manage the database	4.67	0.55	Very Satisfied
Overall Average	4.38	0.55	Very Satisfied

From Table 3, it is evident that the system's performance in meeting the Functional Requirement Test of the Cross Border Disease Control (CBDC) system is at a very satisfied level. The overall average satisfaction score is 4.38. Notably, the system's ability to store data for analysis and generate summary reports scored a high average satisfaction level of 0.71 on both aspects.

Table 4. Results of evaluation for the system's functional performance (Functional Test)

Evaluation Items	**Mean ($\bar{x}$)**	Standard Deviation (S.D.)	Evaluation Interpretation
Accuracy in data storage	4.67	0.50	Very Satisfied
Accuracy in basic data storage	4.67	0.50	Very Satisfied
Accuracy in data presentation	4.56	0.53	Very Satisfied
Accuracy in data grouping	4.67	0.50	Very Satisfied
Data collection speed	4.56	0.53	Very Satisfied
Accuracy in timely reporting	4.56	0.53	Very Satisfied
Accuracy in data correction	4.67	0.50	Very Satisfied
Accuracy in results presentation	4.67	0.50	Very Satisfied
Overall system functional accuracy	4.67	0.50	Very Satisfied
Accuracy in data transmission	4.56	0.53	Very Satisfied
Overall Average	4.38	0.55	Very Satisfied

Table 4 reveals that the system's performance in terms of functional testing is very satisfying, with an overall average satisfaction score of 4.63. This high satisfaction level is consistent across all evaluation items.

Table 5. Results of the usability test for the system.

Evaluation Items	**Mean ($\bar{x}$)**	Standard Deviation (S.D.)	Evaluation Interpretation
Ease of data addition and deletion	3.89	0.33	Fairly Satisfied
Appropriateness of presenting data outcomes	4.11	0.60	Very Satisfied
Appropriateness of using images in the system	4.11	0.78	Very Satisfied
Overall appropriateness of component arrangement	4.00	0.50	Fairly Satisfied
Appropriateness of data search	4.11	0.78	Very Satisfied
Appropriateness of system design	4.11	0.60	Very Satisfied
Clarity and appropriateness of report presentation	4.33	0.87	Very Satisfied
Overall Average	4.09	0.67	Very Satisfied

Table 5 indicates that the usability of the Cross Border Disease Control (CBDC) system is very satisfying, with an overall average satisfaction score of 4.09. Notably, the clarity and appropriateness of report presentation scored a high average satisfaction level of 4.33, while the lowest satisfaction score was for the ease of data addition and deletion at 3.89.

Table 6 summarizes the results of the security test for the system.

Evaluation Items	**Mean ($\bar{x}$)**	Standard Deviation (S.D.)	Evaluation Interpretation
Appropriateness of user privilege assignment	4.67	0.50	Very Satisfied
Accuracy of system login	4.33	0.71	Very Satisfied
Notification for failed login attempts	4.00	0.71	Fairly Satisfied

Notification for news or usage guidelines	4.11	0.78	Very Satisfied
Overall appropriateness of system security maintenance	4.22	0.67	Very Satisfied
Overall Average	4.27	0.67	Very Satisfied

From Table 6, it is evident that the security performance of the system in terms of the Security Test for the Cross Border Disease Control (CBDC) system is at a highly satisfactory level. Particularly, in the aspect of appropriateness in user privilege assignments in the system, it has a high average rating of 4.67, signifying a high level of satisfaction. Similarly, in terms of notification effectiveness when login failures occur, the average satisfaction rating is relatively high at 4 percent.

5. CONCLUSION

Cross Border Disease Control system is the prototype of real-time data exchange system to improve screening and Tuberculosis prevention from cross-country-spread by providing disease identification and diagnostic confirmation of suspected visitors via data visualized module.

The data from the survey is analysed using “2 by 2 table” to calculate data sensitivity, data coverage, and positive predictive value. Overall, the data sensitivity and data coverage average value is 80.14 percent. The positive predictive value average is 86.14 percent. The satisfaction component has the highest mean value ($\bar{\boldsymbol{X}} = \mathbf{95}\%$). The results show that CBDC system is considered as a prototype concept and technique for surveillance action plan with the aim to develop data exchange system complied with Communicable Disease Act 2015.

The efficiency of the Cross Border Disease Control (CBDC) system in monitoring and managing diseases in cross-border patients is rated as highly satisfactory, with an overall average score of 4.34. Upon evaluating individual aspects, it was found that the Functional Test results, with an average score of 4.63, indicated that the system's performance was notably high. The Functional Requirement Test, measuring the system's adherence to requirements, achieved an average score of 4.38. The Security Test yielded an average score of 4.27, evaluating the system's security aspects. The Usability Test, assessing the system's user-friendliness, received an average score of 4.09. The development of the system focused on simplicity, resulting in an easy-to-understand operational model. Examining specific details, the ease of data input and manipulation received the lowest satisfaction rating, with an average score of 3.89. This may be attributed to the high volume of data entry required, particularly regarding the screening procedures, which contributed to the elevated data input demands.

Research Recommendations:

Based on the research findings, it is recommended to enhance the system by implementing automated data import tools for the Cross Border Disease Control (CBDC) system. Additionally, improvements can be made to the report design, incorporating data imports from related sources such as immigration office records for cross-border individuals and airline passenger data. This enhancement would greatly bolster the comprehensiveness of the system.

To conclude, this evaluation shows that CBDC system expansion project is suitable, but still lacks of migrant cross border screening number. After an observation, there are few of migrant screening information at health quarantine compared with the number of all cross border. To implement CBDC system, it still needs more co-operation form all relate organizations to complete the project.

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