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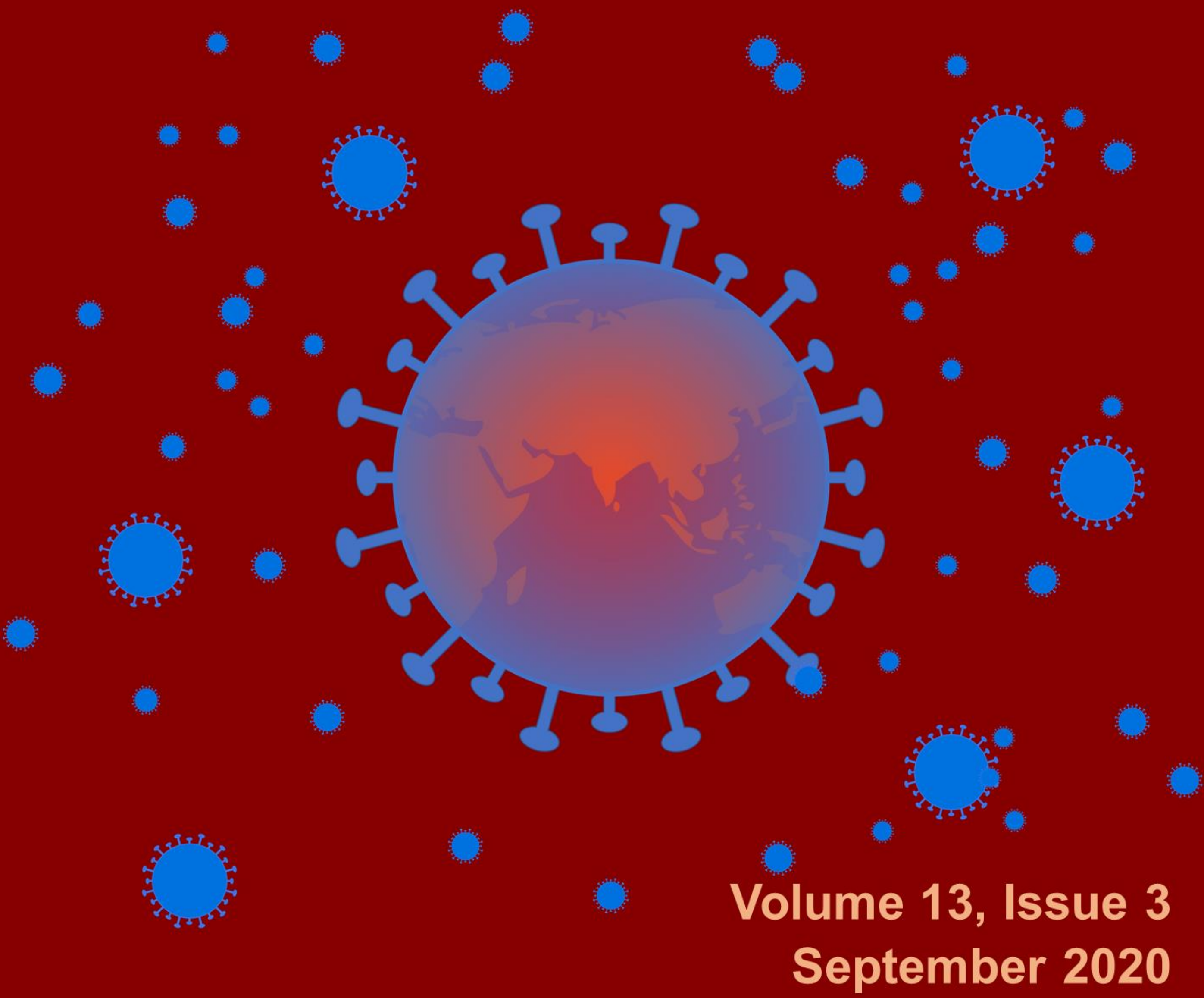

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Editorial

Thailand's Response to the COVID-19 Pandemic

Tanarak Plipat, Deputy Director-General of the Department of Disease Control

On 31 Dec 2019, the World Health Organization received a report of a cluster of 27 cases of pneumonia with unknown etiology from Wuhan Municipal Health Commission.[1] On 3 Jan 2020, the Thai Department of Disease Control activated the Emergency Operations Center (EOC) and its surveillance system. The first case of coronavirus disease (COVID-19) in Thailand was detected at the airport on 8 Jan 2020 and was later confirmed on 13 Jan 2020. This patient was the first confirmed case of COVID-19 outside China.[2]

The number of reported cases remained low throughout February. In early March, Thailand saw a sharp increase of the number of reported cases as a result of several clustering events in many night clubs and Thai boxing matches in Bangkok and the return of the Muslim pilgrims from Malaysia.[3] The number of new reported cases peaked on 22 Mar 2020. The number of new confirmed cases gradually reduced throughout April and May.[4] As of 31 Aug 2020, Thailand reported 3,412 confirmed cases of COVID-19 with 58 deaths.

Thailand was one of a few countries in the world that were successful in controlling the outbreak of COVID-19. This article aims to discuss on Thailand's public health emergency program and epidemiological capacities which are the critical success factors that makes Thailand pass through the difficult situation.

Strong Epidemiological Program

One of the crucial public health workforce development tasks is the field epidemiology training program which was initiated in 1980. The program trains many cadres of epidemiological workforce, including 2-year field epidemiologists, 1-year field epidemiologist, members of the communicable disease control units, and the surveillance staffs at the national and the provincial levels. To date, Thailand has more than 200 well-trained field epidemiologists and 1,000 communicable disease control units that can perform outbreak investigation and contact tracing when necessary.[5,6]

The program has been the backbone of Thailand's public health response. The alumni of the program served in many important positions in Thailand's Centre for COVID-19 Situation Administration and Department of Disease Control's Emergency Operations Centers. During the COVID-19 pandemic, Thailand's epidemiological workforce was able to effectively implement many important public health measures, including prevention of new infections among vulnerable populations, early detection of cases, isolation of cases, and identifying and tracing of contacts.[7,8]

Comprehensive Public Health Emergency Management and Health Security Program

Thailand has actively strengthened the country's International Health Regulation 2005 (IHR 2005) capacities since 2006.[8,9] It initiated a public health emergency management program in 2007 and put in place the incidence command system in 2013.[10,11] Thailand also joined the Global Health Security Agenda (GHSA) in 2014 and it is currently one of the steering member countries and will be the Chair of the steering member countries for GHSA in 2021.

With agile organization, good business continuity plan, surge capacity plan and well-trained health workforce with competent skills to work within the incidence command system, the Thai Department of

Disease Control was able to activate the EOC in a timely manner and was able to scale up the response quickly enough to address the health threats from COVID-19. At the peak of the situation, the Department had more than 1,000 staff members working in COVID-19 EOC, about a quarter of the total staffs in the Department.

Conclusion

Since its emergence in Wuhan in late December last year, COVID-19 has been rapidly spreading throughout the globe. Thailand's response to COVID-19 was designed based on its pre-existing public health emergency management infrastructure and epidemiological capacities.

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Factors Associated with Preventive Behaviors towards Coronavirus Disease (COVID-19) among Adults in Kalasin Province, Thailand, 2020

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Abstract

Coronavirus disease (COVID-19) is a pandemic disease that has caused devastating morbidity and mortality worldwide. Social stigmatization in rural communities of Thailand prevented effective response to the pandemic. This study aimed to determine factors associated with preventive behaviors towards COVID-19 in Kalasin Province, Thailand. An analytic cross-sectional study was conducted among 556 local residents aged at least 15 years old. The questionnaire was developed based on Predisposing, Reinforcing and Enabling Constructs in Educational Diagnosis and Evaluation (PRECEDE) and media perception theories. Most of the residents were female (61.3%) and aged 15-70 years old (mean 37.9 years old, SD 11.7). All of the risk perception, severe perception, benefit perception, media perception, attitudes, and preventive behavior scores were at a good level whereas knowledge on COVID-19 was at a moderate level. Income (β 0.10, p 0.003), risk perception on COVID-19 (β 0.20, p<0.001), media perception (β 0.41, p<0.001), and attitudes toward COVID-19 (β 0.24, p<0.001) were associated with preventive behaviors. These findings provide predicting factors of preventive behaviors towards COVID-19. Definite health education programs, especially for increasing accessibility on COVID-19 prevention, and effective policies should be implemented, particularly for low-income groups.

Keywords: coronavirus disease, preventive behaviors, Kalasin, Thailand

Introduction

Coronavirus disease (COVID-19) has caused devastating morbidity and mortality worldwide.[1] As of 1 Sep 2020, more than 25 million confirmed COVID-19 cases have been reported globally with almost 848,255 deaths.[2] In Thailand, the national Centre for COVID-19 Situation Administration (CCSA) reported that the accumulatively confirmed COVID-19 cases up to 1 Sep 2020 was 3,417 cases with 58 deaths.[3]

With no specific treatment or a vaccine available, behaviors to prevent COVID-19 are necessary to be explored.[4,5] The Thai Ministry of Public Health (MOPH) has implemented five key measures for limiting the COVID-19 outbreak, including a country-wide lockdown, social distancing, mandatory wearing of face masks, observing hand hygiene and the regular cleaning of frequently touched surfaces with an antiseptic soap or detergent. However, a few barriers have prevented the adoption of these behaviors by some members of the Thai community including dissemination of fake news, poor knowledge about the disease, social stigmatization, and the high cost of face masks and hand sanitizers.[6]

In Kalasin Province, there were three confirmed cases of COVID-19 that had been isolated in the hospital longer than stated in the COVID-19 treatment guidelines of Thailand.[7] Of the three cases, one was refused to return to the community and was sent to live in another province. This phenomenon revealed that stigmatization of COVID-19 was present in Thai society.[6] This was despite the CCSA in Kalasin Province updating the COVID-19 situation daily via Facebook by three key sectors including the governor, provincial chief medical officer and provincial hospital director. This provided true information and empowered the Kalasin citizens, including high-risk groups, to participate with COVID-19 prevention and control measures in the province.[8]

The Predisposing, Reinforcing and Enabling Constructs in Educational Diagnosis and Evaluation (PRECEDE) behavioral model states that being healthy and/or having healthy behaviors results from predisposing factors including knowledge, attitudes, beliefs, values, and perceptions. Media perception, a crucial health communication method, is very important to develop knowledge and health protection skills of people, especially during the recent COVID-19 pandemic.[9] Reinforcing factors help support the desired health behaviors, such as warning, praise, and encouragement.[10] Finally, enabling factors, skills or physical factors such as availability and accessibility of resources, or services that facilitate the correct health behaviors.

Worldwide, there have been many surveys on behaviors towards prevention of the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). One study revealed that a threat and coping appraisal and intention were associated with preventive behaviors towards COVID-19, while another showed that older age (40 years old and over) and higher education (holding a diploma degree) were also associated with good practices.[11,12] Other studies found that frequency of watching COVID-19 news media and sources of media influenced risk perception and media perception, and older age and media watching were associated with knowledge.[12,13] However, a large survey in Hubei, China, revealed that knowledge was significantly associated with negative attitudes and preventive practices toward COVID-19.[14] Preventive behaviors have been defined as any activity undertaken by a person who believes himself to be healthy for the purpose of preventing COVID-19. Currently, behavioral intervention studies and exploration of factors associated with preventive behaviors in Thailand are limited. These findings in a local setting could provide support in developing guidelines for effective preventive behaviors towards COVID-19 in Thailand. The objective of this study is therefore to determine the factors associated with preventive behaviors towards COVID-19 among adults living in Kalasin Province, Thailand.

Methods

Study Design

This analytic cross-sectional study was conducted during May to June 2020 to examine the predisposing, reinforcing and enabling factors versus preventive behaviors on COVID-19 among adult residents in Kalasin Province.

Study Setting

Kalasin Province is a rural province located in the central area of the Northeastern part of Thailand. There were 983,550 populations, 18 districts, one provincial hospital, 17 community hospitals and 156 health centers.[15] We purposively selected this province because all COVID-19 patients experienced difficulty in returning to their home communities. Therefore, some social determinants influencing preventive behaviors might be identified and are able to be applied to other similar areas that will be affected by future COVID-19 epidemics.

Participants and Sample Size

All adult residents aged more than 15 years old were the target population of the study. The sample size was calculated using an equation to approximate the exact population size. We assumed the standard deviation of risk perception to be the same as towards MERS-CoV equaling 1.15 to calculate a sample size of 560, including a 10% increase to account for non-responders.[16]

Sampling Methods

To select the sample, we systemically selected one family member out of every five households who visited any of the 17 community hospitals, 30 people per hospital and 50 people from the Kalasin Provincial Hospital.

Data Collection

The questionnaire was developed from the PRECEDE model, media perception and other related studies.[6,9,13,14,17,18] All participants were interviewed face-to-face using a structured questionnaire. There were eight sections: (i) general questions containing 19 items including demographic characteristics, family structure, environmental questions and access to resources, (ii) knowledge of COVID-19, which comprised 10 items including cause of disease, signs and symptoms, incubation periods, and route of transmission, (iii) risk perception, which had 9 items, (iv) severe perception, which had 7 items, (v) benefit perception, which had 7 items, (vi) media perception, which had 22 items including media sources and types and COVID-19 infections news, (vii) attitudes towards COVID-19, which had 17 items including discrimination, effects of disease, feelings on control about government measures, disadvantages and advantages of COVID-19 outbreak, and (viii) preventive behaviors towards COVID-19, which had 16 items including hand hygiene, wearing face masks, social distancing, cleaning, consumption, exercise and media activities. Knowledge questions elicited a "yes/no" response. Perceptions were measured on a four-point Likert scale as "disagree", "slightly agree", "moderately agree", or "strongly agree". Attitudes were measured as "never", "sometimes", "often", or "usually".[19]

Average scores for attitudes and preventive behaviors were classified into 3 levels as low (1.0-2.0), moderate (2.1-3.0) or good (3.1-4.0) according to the criteria of Best and Kahn.[20] The questionnaire was validated by three experts and the Cronbach coefficient was 0.90. Data were collected by a researcher and trained local healthcare workers in each district. At least one meter of social distancing was maintained during each interview and face masks were worn by all interviewers.

Statistical Analysis

We used descriptive statistics, frequency and percentage, to describe demographic data, knowledge on COVID-19, risk perception, severe perception, benefit perception, media perception and attitudes. Preventive behaviors were presented by the mean and standard deviations.

We analyzed knowledge, perception, attitude, and behaviors towards COVID-19 by independent t-test and Chi-square test as appropriate. Multiple linear regression analysis was performed using all demographic data, knowledge, risk perception, severe perception, benefit perception, media perception and attitude scores as independent variables and the preventive behavior score as the outcome variable. Predictive factors were determined by backward elimination of non-significant variables. Unstandardized regression coefficients (β) were used to determine the associations between independent variables and outcomes at the statistical significance level of 0.05. Statistical analysis was conducted using Stata version 13.0.[21]

Ethical Issues

The study was approved by the research ethical committee of Kalasin Provincial Health Office, Thailand MOPH (KLS.REC53/2563). All participants gave verbal consent before they were interviewed.

Results

Socio-demographic Data

Of the 556 participants in the study, 341 (61.3%) were female and the age range was 15-70 years old (mean 37.9, SD 11.7). More than half (52.9%) were married. Bachelor degree was achieved by 226 (40.7%) participants while 155 (27.9%) had completed high school. Government officer was the most common occupation (33.5%) while incomes were generally uniformly spread between 5,000 baht and 25,000 baht per month. Most participants reported no underlying disease (82.7%), no alcohol consumption (84.9%), and no history of smoking (89.9%). Family members ranged from 1–10 people, including children aged less than 5 years old (52.7%) and elders aged older than 60 years old (59.5%) (Table 1).

Table 1. Demographic and family data among adult residents living in Kalasin Province, Thailand, 2020 (n=556)

Characteristics	n	Percentage
General information		
Gender		
Male	215	38.7
Female	341	61.3
Age (years)		
15-25	79	14.2
26-35	185	33.3
36-45	130	23.4
46-55	117	21.0
56-65	42	7.6
>65	3	0.5
(Mean 37.9 , SD 11.7, Range 15 - 70)		
Marital status		
Single	223	40.1
Married	294	52.9
Divorced	39	7.0
Education		
Uneducated	3	0.5
Elementary school	70	12.6
High school	155	27.9
Diploma degree	67	12.1
Bachelor degree	226	40.7
Higher than bachelor degree	35	6.3
Occupation		
Student	12	2.2
Contractor	47	8.5
Agriculturist	67	12.1
Business owners	42	7.6
Private company employee	73	13.1
Government officers	186	33.5
Others	129	23.2

Table 1. Demographic and family data among adult residents living in Kalasin Province, Thailand, 2020 (n=556) (Con't)

Characteristics	n	Percentage
General information		
Income (Baht per month)		
<5,000	54	9.7
5,001–10,000	128	23.0
10,001–15,000	106	19.1
15,001–20,000	82	14.8
20,001–25,000	58	10.4
≥25,000	128	23.0
Underlying disease		
No	460	82.7
Yes	96	17.3
Alcohol consumption		
No	472	84.9
Yes	84	15.1
Tobacco consumption		
No	500	89.9
Yes	56	10.1
Family information		
Number of family member		
<5 people	449	80.8
≥5 people	107	19.2
(Mean 4.4 , SD 1.49, Range 1-10)		
Have children age <5 years old in household		
No	263	47.3
Yes	293	52.7
Have elders age >60 years old in household		
No	225	40.5
Yes	331	59.5

Characteristics of Households and COVID-19 Resource Accessibility

In households, most participants (87.8%) slept in separate bedrooms, ensured good air-circulation (95.7%), and about half (48.7%) used air-conditioners. Most people could access to face masks for their family (89.9%) and soap or alcohol gel for hand washing (88.1%).

Knowledge and Perception

The overall average scores of knowledge, risk perception, severe perception, benefit perception, media perception, attitudes, and preventive behaviors towards COVID-19 were in the good level except knowledge on COVID-19 was in a moderate level, especially for the understanding that the cured patients can transmit the SARS-CoV-2 to others was in low level (52.3%) (Table 2).

Media Perception

The most common sources of media during the outbreak were family members (98.8%), followed by colleagues (98.4%), public health officers (97.7%) and the daily mass media release from the CCSA, Kalasin Province (97.7%) (Figure 1). The favorite media types were mobile phone or tablets (98.7%), television (96.8%), Facebook (94.2%) and LINE application (91.4%) (Figure 2).

Attitudes

Most of the attitude's questions were scored as 'Good'. Two were scored as 'Moderate': some respondents felt that 14 days of self-quarantine was too long and felt insecure when the government established a quarantine place close to their households. The participants agreed that social distancing, lock down, and wearing face masks could prevent a COVID-19 outbreak and they were satisfied with the national and provincial control measures (Table 3).

Preventive Behaviors and Associated Factors

Most of the preventive behaviors scores were also scored as 'Good'. Two were scored as 'Moderate': eating and sharing sticky rice with bare hands and having meals with colleagues. The participants cleaned their hands with soap or alcohol gel every day (81.3%) and wore face masks when they were outdoors (89.2%) (Table 4 and 5).

The average score of preventive behaviors towards COVID-19 were statistically different for education, occupation, income, alcohol consumption, and using an air-conditioner in the household ($p<0.01$) (Table 6).

Multiple linear regression analysis showed that income (β 0.10, p 0.003), risk perception (β 0.20, $p<0.001$), media perception (β 0.41, $p<0.001$), and good attitudes on COVID-19 (β 0.24, $p<0.001$) were positively associated with good preventive behaviors towards COVID-19 (R^2 0.39) (Table 7).

Discussion

This is the first study using the PRECEDE model on COVID-19 in the rural province of Thailand. We found that factors associated with preventive behaviors towards COVID-19 were income, risk perception, media perception, and attitudes.

Table 2. Levels of knowledge, perceptions, attitudes, and preventive behaviors toward COVID-19 among adult residents in Kalasin Province, Thailand, 2020 (n=556)

Variables	Range of scores		n (%)	Mean (SD)	Level
	Possible	Actual			
Independent variables					
Knowledge	0.0-10.0	3.0-10.0	314 (56.5)	7.8 (1.12)	Moderate
Risk perception	1.0-4.0	1.9-4.0	439 (79.0)	3.4 (0.39)	Good
Severe perception	1.0-4.0	2.0-4.0	427 (76.8)	3.3 (0.47)	Good
Benefit perception	1.0-4.0	1.1-4.0	442 (79.5)	3.4 (0.39)	Good
Media perception	0.0-3.0	1.0-3.0	284 (51.1)	2.5 (0.56)	Good
Attitude	1.0-4.0	2.2-4.0	463 (83.3)	3.4 (0.35)	Good
Dependent variable					
Preventive behavior	1.0-4.0	1.63-4.0	467 (84.0)	3.4 (0.39)	Good

Knowledge, age, severe perceptions, and benefit perceptions were not associated with preventive behaviors toward COVID-19. These findings are important for developing policies, guidelines, and programs to effectively combat COVID-19. The preventive behaviors that were at a moderate level were eating sticky rice with bare hands and having meals with colleagues at work. This is due to the culture of people in the Northeastern part of Thailand and showed a close relationship with family members, friends, and colleagues. Moreover, as people in rural communities became elderly in the same trend of Thailand that has to adjust to be senior society, more and more elderly people were left in the rural areas.[22] The elderly may have difficulty accessing hand sanitizers or may simply forget to wash their hands. Thus, caregivers should remind them to wash their hands, especially before eating or after touching dirty equipment or surfaces and provide them with hand-washing facilities that are easily accessible.

Adequate income is an enabling factor of the PRECEDE model that allows people to comfortably or easily access resources that may influence their health behaviors.[17] In this study, income was one of the factors associated with preventive behaviors towards COVID-19. A study by Abdelhafiz et al recommended that salaries should be provided during business closures.[23] People with higher incomes can easily access protective equipment such as face masks, alcohol-based gel and liquid hand soap, and other disinfectants, in addition to receiving knowledge. The COVID-19 outbreak led the Kalasin government to issue related control measures such as a mandate

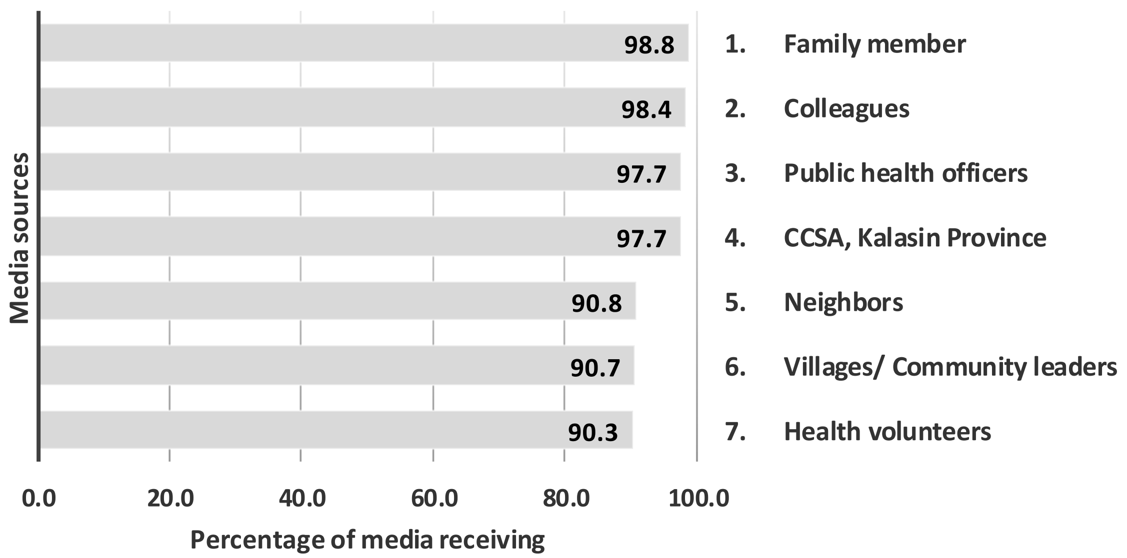

Figure 1. Percentage of media sources received during COVID-19 outbreak in Kalasin Province, Thailand, 2020 (n=556)

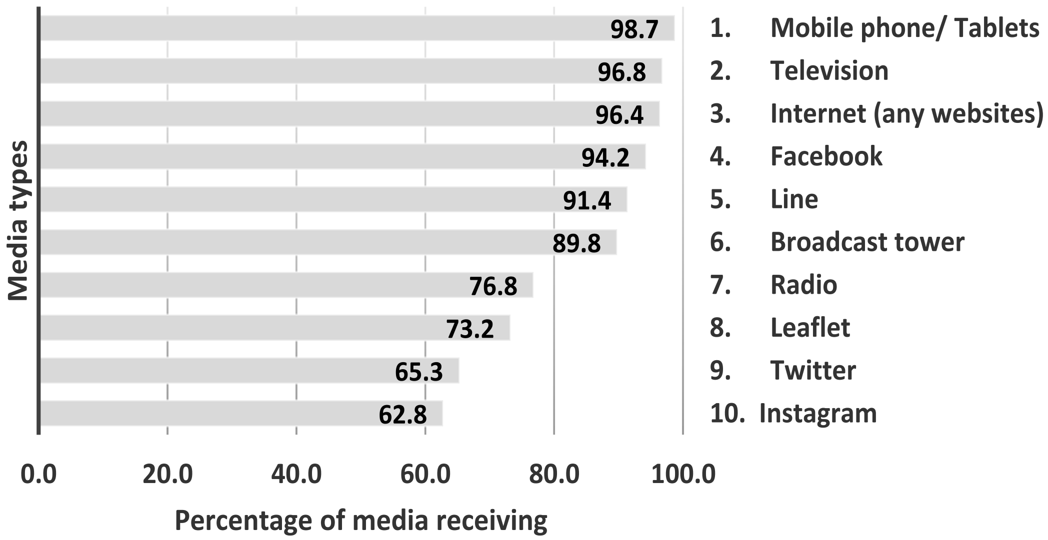

Figure 2. Percentage of media types received during the COVID-19 outbreak in Kalasin Province, Thailand, 2020 (n=556)

that everyone should wear a face mask outdoors or in crowded areas, and owners of public buildings should prepare alcohol gel for customers to clean their hands before entering the building.

A good level of risk perception about COVID-19 influenced preventive behaviors in this study, similar to the finding of Karasneh et al that risk perception was high among pharmacists in Jordan.[13] In this study, the highest score of risk perception was seen for the statement "Not wearing face masks in the community or crowded area increases the risk of infection (3.9/5)" and "Frequently washing hand with soap or alcohol gel could decrease a chance of infection (3.9/5)". Other studies revealed that the threat and coping mechanisms motivated COVID-19 preventive behaviors among hospital staff in Iran and more than 87% of Egyptians had concerns about the risk of COVID-19 infection.[11,23]

In this study, although the average score of attitudes was good, negative attitudes were still present. Participants who refrained from travelling or stayed at home during the outbreak felt uncomfortable or stressful (2.9/5) and felt insecure when the government established a quarantine place close to their houses (2.4/5). These attitudes led to social stigmatization, an uncomfortable feeling about the government's quarantine location. One confirmed case was refused to return to his community by a neighbor and was forced to live with a relative in another province.

COVID-19 is a novel disease and there is limited information on its incubation period, route of transmission and immunity.[1] Fake news and false knowledge were found in Thai society during the COVID-19 outbreak and it produced various types of media backlash.[6] Positive effects of media included early detection, isolation and treatment that could lead to preventive behaviors. For example, Karasneh et al revealed that frequency of watching media and source of information influenced both risk perceptions and media roles among pharmacists.[13] As Thailand was the first country outside China to report a confirmed case of COVID-19, Thai society was alert and interested in reading any news reported by all types of media, whether it was based on facts or otherwise.[6] Dissemination of misleading information led to negative effects; such as rumors, false knowledge, fear, disguised history of exposure with risk groups of COVID-19, and social stigma.[6] These negative effects caused panic in society rather than raising people's awareness of practices to prevent further infection in the community.[24] Nowadays, everyone consumes various forms of media. People can exchange both positive and negative information on COVID-19 via multiple types of social media. Therefore, the mass media and social media perceptions greatly affect the way people deal with the response to the COVID-19 pandemic.[25,26]

Knowledge was not associated with preventive behaviors. This result is in contrast with a study among Chinese residents in Hubei where knowledge was significantly associated with attitudes and preventive practice towards COVID-19.[14] Kebede et al revealed that knowledge could predict hand washing and avoidance of hand shaking.[18]

Age, severe and benefit perceptions on COVID-19 were not associated with preventive behaviors toward

Table 3. Attitudes towards COVID-19 among adult residents in Kalasin Province, Thailand, 2020, classified by question items (n=556)

Attitude towards COVID-19	Strongly agree n (%)	Moderately agree n (%)	Slightly agree n (%)	Disagree n (%)	Mean (SD)	Level
1. Feel 14 days self-quarantine is too long	85 (15.3)	109 (19.6)	114 (20.5)	248 (44.6)	2.9 (1.12)	Moderate
2. Satisfy that government asked to stay at home to reduce infection	342 (61.5)	160 (28.8)	37 (6.7)	17 (3.1)	3.5 (0.75)	Good
3. Feel unsafe due to government set quarantine place near your residence area	143 (25.7)	185 (33.3)	105 (18.9)	123 (22.1)	2.4 (1.09)	Moderate
4. Satisfy with government and provincial outbreak control measures	304 (54.7)	193 (34.7)	43 (7.7)	16 (2.9)	3.4 (0.76)	Good
5. Think that Thailand and Kalasin Province can control COVID-19 outbreak	401 (72.1)	130 (23.4)	19 (3.4)	6 (1.1)	3.7 (0.60)	Good
6. Wear mask can prevent COVID-19	350 (62.9)	174 (31.3)	25 (4.5)	7 (1.3)	3.6 (0.64)	Good
7. Good hand hygiene can prevent COVID-19	384 (69.1)	150 (26.9)	17 (3.1)	5 (0.9)	3.6 (0.59)	Good
8. Social distancing can prevent COVID-19	395 (71.0)	137 (24.6)	19 (3.4)	5 (1.0)	3.7 (0.59)	Good
9. Clean surfaces frequently can prevent COVID-19	368 (66.2)	156 (28.1)	31 (5.6)	1 (0.2)	3.6 (0.60)	Good
10. City lock down can prevent COVID-19	360 (64.7)	145 (26.1)	35 (6.3)	16 (2.9)	3.5 (0.74)	Good

COVID-19. In contrast to our study, Olum et al reported that age more than 40 years old and holding a diploma degree were associated with good practices towards COVID-19.[12] However, in another study, older age was negatively associated with hand washing and avoidance of shaking hands in greetings, that could lead older aged people to not practice some preventative behaviors.[18] The lack of association for severe and benefit perceptions could be because COVID-19 is a novel disease. Although a number of preventive behaviors, including social distancing, wearing face masks, and hand hygiene have been

Table 4. Level of preventive behaviors towards COVID-19 among adult residents in Kalasin Province, Thailand, 2020 (n=556)

Level	Range of mean	Preventive behaviors n (%)
Good	3.1-4.0	467 (84.0%)
Moderate	2.1-3.0	84 (15.1%)
Low	1.0-2.0	5 (0.9%)
Overall	Mean 3.4, SD 0.39	

Table 5. Preventive behaviors towards COVID-19 of adult residents in Kalasin Province, Thailand, 2020, classified by question items (n=556)

Preventive behaviors towards COVID-19	Frequency of preventive behaviors					
	Usually n (%)	Often n (%)	Sometimes n (%)	Never n (%)	Mean (SD)	Level
Hand cleaning with soap or alcohol gel	452 (81.3)	84 (15.1)	19 (3.4)	1 (0.2)	3.8 (0.50)	Good
Avoid using unclean hand when touching mouth, nose, or eyes	361 (64.9)	140 (25.2)	46 (8.3)	9 (1.6)	3.5 (0.72)	Good
1-2 meters social distancing when talking with others	359 (64.6)	146 (26.3)	43 (7.7)	8 (1.4)	3.5 (0.70)	Good
Cleaning frequently touched surfaces such as doorknobs	339 (61.0)	142 (25.5)	61 (11.0)	14 (2.5)	3.4 (0.79)	Good
Wearing a face mask outside at all times	496 (89.2)	47 (8.5)	11 (1.9)	2 (0.4)	3.9 (0.42)	Good
Avoiding leaving home to high-risk areas	406 (73.0)	115 (20.7)	26 (4.7)	9 (1.6)	3.7 (0.65)	Good
Eating fresh or cooked food and use a personal spoon	428 (77.0)	98 (17.6)	27 (4.9)	3 (0.5)	3.7 (0.58)	Good
Eating sticky rice with bare hands	65 (11.7)	118 (21.2)	171 (30.8)	202 (36.3)	2.1 (1.02)	Moderate
Having meals with colleagues	78 (14.0)	176 (31.7)	147 (26.4)	155 (27.9)	2.3 (1.03)	Moderate
Separate personal belongings from family members and colleagues	298 (53.6)	141 (25.4)	84 (15.1)	33 (5.9)	3.3 (0.92)	Good

Table 6. Comparison of attitude and preventive behavior scores by demographic and family variables towards COVID-19 among adult residents in Kalasin Province, Thailand, (n=556)

Characteristics	n (%)	Preventive behaviors		
		Mean	SD	t/F
Gender				0.052
Male	215 (38.7)	3.4	0.40	
Female	341 (61.3)	3.4	0.39	
Age (year)				0.560
15-25	79 (14.2)	3.4	0.40	
26-59	462 (83.1)	3.4	0.39	
≥60	15 (2.7)	3.4	0.35	
Marital status				0.705
Single	223 (40.1)	3.4	0.39	
Married	294 (52.9)	3.4	0.39	
Divorced	39 (7.0)	3.4	0.41	
Education				<0.001**
Lower than bachelor degree	295 (53.1)	3.4	0.41	
Bachelor degree and over	261 (46.9)	3.5	0.36	
Occupation				<0.001**
General populations	370 (66.5)	3.4	0.41	
Government employee	186 (33.5)	3.5	0.35	
Income (Baht per month)				<0.001**
≤15,000 ($500)	288 (51.8)	3.3	0.41	
>15,000 ($500)	268 (48.2)	3.5	0.36	

*Note: * p<0.05, ** p<0.01, *** p<0.05 (Bonferroni)*

Table 6. Comparison of attitude and preventive behavior scores by demographic and family variables towards COVID-19 among adult residents in Kalasin Province, Thailand, (n=556) (Con't)

Characteristics	n (%)	Preventive behaviors		
		Mean	SD	t/F
Underlying disease				0.810
No	460 (82.7)	3.4	0.40	
Yes	96 (17.3)	3.4	0.40	
Alcohol consumption				0.008**
No	472 (84.9)	3.4	0.38	
Yes	84 (15.1)	3.3	0.43	
Tobacco consumption				0.098
No	500 (89.9)	3.4	0.37	
Yes	56 (10.1)	3.3	0.52	
Have children age less than 5-years old in family				0.925
No	263 (47.3)	3.4	0.40	
Yes	293 (52.7)	3.4	0.39	
Have elders age more than 60 years old in family				0.333
No	225 (40.5)	3.4	0.39	
Yes	331 (59.5)	3.4	0.39	
Separated bedroom in household				0.402
No	68 (12.2)	3.4	0.39	
Yes	488 (87.8)	3.4	0.39	
Air circulation in household				0.412
Not good	24 (4.3)	3.5	0.36	
Good	532 (95.7)	3.4	0.39	
Used an air-conditioner in household				0.004*
No	271 (48.7)	3.4	0.42	
Yes	285 (51.3)	3.5	0.36	
Have sufficient face mask for family				0.056
No	56 (10.1)	3.3	0.46	
Yes	500 (89.9)	3.4	0.38	
Ever received alcohol gel and face mask from government agencies				0.002*
No	136 (24.5)	3.3	0.47	
Yes	420 (75.5)	3.4	0.36	
Have enough soap or alcohol gel for hand washing				0.833
No	66 (11.9)	3.4	0.40	
Yes	490 (88.1)	3.4	0.39	

*Note: * p<0.05, ** p<0.01, *** p<0.05 (Bonferroni)*

suggested, it was not known how protective these measures were, leading to self-protection concerns resulting in negative social and mental effects.[6]

There were some limitations in this study. First was the lack of diversity in the study sample with one third of participants being government officers. This was somewhat unavoidable since general people feared about being infected with COVID-19 and stayed at home during the lock down measure, thus the majority of people visiting our study hospitals were government officers who had been allowed to work outside. Second, as there were no standardized tools to determine attitudes and preventive behaviors towards COVID-19 in Thailand, the questionnaire and measurement tools were developed based on literature review, the PRECEDE model, and media

Table 7. Factors associated with preventive behaviors towards COVID-19 among adult residents in Kalasin Province, Thailand, 2020 (n=556)

Variables	b	SE *(b)*	Beta	t	p
Income	0.08	0.03	0.10	3.01	0.003
Risk perception on COVID-19	0.21	0.04	0.20	5.71	<0.001
Media perception on COVID-19	0.32	0.03	0.41	11.84	<0.001
Attitudes towards COVID-19	0.26	0.04	0.24	6.36	<0.001
Constant = 1.13		0.15	-	7.44	<0.001
R^2 0.39, $F_{(4, 551)}$ 88.17, p<0.001					

perception theories and the reliability and validity might have limitations. Third, this study was purposively conducted in Kalasin Province, a small the province in Northeastern Thailand with its own unique ethnic group and culture; therefore, participants may not be representative of all residents of Thailand. Therefore, factors associated with attitudes and preventive behaviors towards COVID-19 found in this study may not be generalizable to other parts of Thailand.

Conclusion

Income, risk perception, attitudes, and media perception could predict preventive behaviors towards COVID-19. Therefore, these findings are important for developing effective policy and health promotion programs, especially to combat the negative attitude towards those affected by COVID-19. Face masks and alcohol gel should be provided equally for effective prevention of COVID 19. Accurate and trustworthy information about COVID-19 should be broadcast throughout communities to ensure supportive perceptions, attitudes, and preventive behaviors towards COVID-19.

Acknowledgments

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Enhancing Coronavirus Disease (COVID-19) Surveillance System through Information Technology, Thailand, 2020

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Abstract

Coronavirus disease (COVID-19) was designated as a dangerous communicable disease by law in Thailand. However, existing surveillance systems was not timely and accurate. Therefore, we conducted an innovation development research to improve the system. The research comprises two objectives; (i) to describe the existing surveillance system and its challenges, and (ii) to enhance surveillance system through the improvement of information technology. All related stakeholders, from the Department of Disease Control to hospitals, were engaged and communicated to identify the challenges of the surveillance system. Several challenges were reported, for instance, lack of timeliness, overload of verification, inaccessibility of data feedback, and difficulty of cluster identification. To overcome these challenges, five additional features were developed, tested, and implemented. These five features included auto-verification, laboratory reporting, data exporting, data visualization, and integration with the existing event-based surveillance. The system was tested by developers and users and implemented nationwide. The activities were made possible by several communication routes including chat, email, and teleconference. Early engagement of stakeholders, understanding of existing surveillance systems, and utilizing information technologies to solve challenges are substantially crucial. Our study provides a new opportunity for the improvement of the surveillance system during the period of travel restriction in many countries.

Keywords: coronavirus disease, surveillance system, information system, information technology, innovation

Introduction

Shortly after the notification of unknown cause pneumonia cases in China which were later identified as coronavirus disease (COVID-19), on 3 Jan 2020, the Thai Department of Disease Control (DDC), Ministry of Public Health activated emergency operations center to optimize the ability to provide effective and timely outbreak response.[1,2] Several strategies and plans were initiated to mitigate the impact of the disease including specific disease surveillance system which had a direct impact on disease prevention, control, and specific policies implication.[3]

Initially, the COVID-19 surveillance system had been established at the points of entry of the country and hospitals.[2,4,5] The dynamic criteria for identifying a patient under investigation (PUI) including symptoms and specific risk factors were set up and these were changed week by week according to the recent epidemiological characteristics of disease and potential risk factors.[2,6] Besides, laboratory investigation was performed among all PUIs to confirm the diagnosis which could provide opportunities to detect confirmed cases and performed contact tracing.[2,7] Information system had been included in the surveillance system to connect public health decision-makers to appropriate data sources.

Therefore, a reliable and timely disease-specific surveillance system that monitors COVID-19 activity in real-time would help public health institutions deploy timely specific-medication and optimally allocate resources during outbreaks.[8] However, the current information systems in Thailand could not accommodate symptoms, risk factors, cluster of cases data collecting systems, and laboratory reporting system.

In more detail, the current COVID-19 surveillance system could not be applied as a timely and reliable surveillance system due to the complexity of the hierarchical structure of reporting system. Healthcare facilities needed to report PUIs via regional Office of Disease Prevention and Control (ODPC). They could not report the PUI and confirmed case to the surveillance system directly.[2]

At this point, information technology (IT) could be used to support information system of COVID-19 surveillance system.[8,9] Enhancing information system with IT can provide enormous benefits to public health surveillances through improving data quality, data variety, timeliness, ability to understand data and reducing the complex hierarchical structure.[9-15]

However, after February 2020, the situation of COVID-19 had dramatically progressed to become a pandemic. The current COVID-19 surveillance system was not able to handle the massive information which caused several obstacles for DDC response to COVID-19. Thus, DDC decided to design a more comprehensive surveillance system by utilizing information technology.

Therefore, we conducted an innovation development research which consisted of two objectives; (i) to describe COVID-19 surveillance system, focusing on information system during February to April 2020, including roles of stakeholders, and its challenges, and (ii) to redesign and enhance the information system through IT to support COVID-19 surveillance system.

Methods

Operational Definition

SAT: Situation awareness team (SAT) serves as a situation monitoring system. Its main function is to verify, monitor, follow, and evaluate the characteristics and severity of the outbreak, and report such information to the incident commander. The additional heavy task is the verification of PUIs and manually generate SAT code.[2]

PUI criteria: The dynamic criteria for identifying a patient under investigation (PUI) including symptoms and specific risk factors are set up and these are changed week by week according to the recent epidemiological characteristics of disease and potential risk factors.[2,6]

SAT code: The identical number of each PUI who is verified by SAT and compatible with COVID-19 PUI criteria.[2]

Operation team (OP): The team acts as forefront officers to take prompt action against the outbreak which has both roles in the outbreak investigation section and data management section. The data management section gathers information from the outbreak investigation section and summarizes data to the incident commander to ensure the coherence of information.[2]

Strategic response team: The team is responsible for producing applicable operational guidelines for a timely response to COVID-19, based on the state-of-the-art knowledge, considering the strategic directions of the incident commander.[2]

COVID-19 surveillance system: A disease-specific surveillance at the points of entry and hospitals which is established by the Department of Disease Control to monitor, follow, evaluate characteristics and severity of the outbreak.[2]

COVID-19 information system: An information system that is a part of the COVID-19 surveillance system. It gathers information from patients under investigation, case investigation, outbreak investigation, contact tracing, and implications considering the main causal link between information, decision, and action.

Office of Disease Prevention and Control (ODPC): A regional office of the Department of Disease Control, Ministry of Public Health, is responsible for all disease prevention activities within regions. Each ODPC is responsible for 5-12 provinces.

Provincial Health Office (PHO): An identity that is responsible to manage medical resources, prevent and control diseases in their responsible health care facilities in each province. Provincial offices are under the Office of the Permanent Secretary, Ministry of Public Health, Thailand.

Study Overview

An innovation development research consisted of two objectives. Firstly, we conducted a qualitative study to describe the COVID-19 surveillance system, focusing on an information system, roles of stakeholders, and its challenges. Secondly, we redesigned and enhanced information system through IT to support COVID-19 surveillance system.

Describe the Existing System and Identify Challenges

To reach the first objective, we described the existing surveillance system, its information system, and its workflow. All related stakeholders, from DDC to hospitals, were engaged and communicated to identify challenges of the traditional information system. A purposive sampling was conducted to engage stakeholders for each specific setting from DDC and Chonburi Province including ODPC 6, the provincial health office, and the provincial hospital.

We interviewed at least one interviewee from each organization until the results were saturated. For data collecting methods, in-depth interviews with stakeholders through face to face and teleconference were conducted.

Besides, a non-participant observation was performed to observe the activity of the current reporting system. Afterward, we summarized the challenges and workflow of the existing surveillance system.

Identify Solutions, Redesign and Modify Information System

To reach the second objective, we developed the solutions to solve challenges from the first objective. We identified tasks, needed skills of developers, and the number of developers to enhance information systems according to proposed solutions.

Database structures and the hierarchy of data accesses were designed. Each proposed solution was described and transformed into a web-based application. After the information system was enhanced, it was validated by developers and users in the DDC and ODPC 6 to identify more challenges.

We spent one week for a trial period in which we implemented enhanced information system to all ODPCs. After that, the system was re-modified and implemented countrywide. The user supporting team was established to monitor the information system and identify any more challenges in the system (Figure 1).

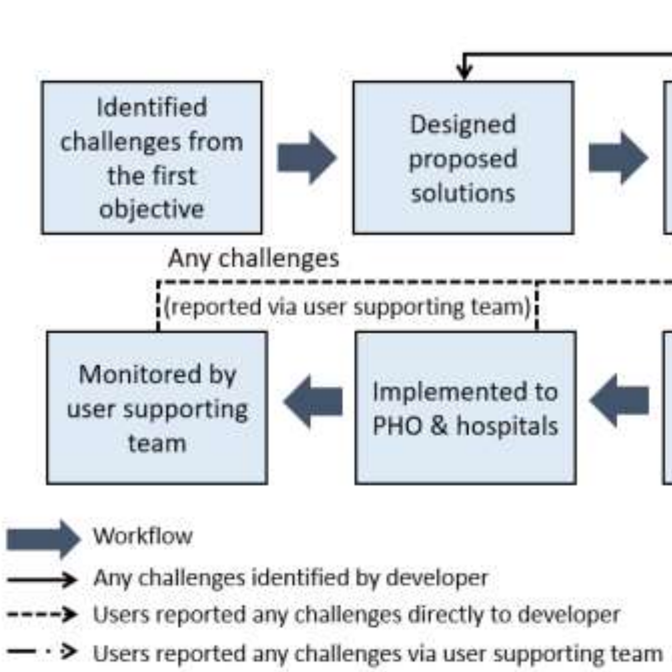

Figure 1. Workflow with the challenges identification process, redesigning process and modification process of the information system

Table 1. Number, roles and types of COVID-19 surveillance system stakeholders

Process	Strategy team	SAT at DDC/ODPC	OP at DDC/ODPC	PHO	Hospitals	Laboratory
1. Create objective and case definition, and identify target population	+					
2. Retrieve patient information		+	+		+	
3. Entry data to system		+	+	+	+	+
4. Extract data from system		+	+	+	+	+
5. Data management and dissemination		+	+			
6. Data usage	+	+	+	+	+	+
Number of stakeholders	3	4	4	2	2	1

Results

Describe the Existing System and Identify Challenges

The COVID-19 surveillance system was designed to be deployed at the national level as disease-specific surveillance, i.e. active, compulsory, and comprehensive surveillance.

The system was designed as a centralized web-based application and functioned as a case-based reporting system. Sixteen staffs from various stakeholders were required to operate the system as described in Table 1.

The workflow was initiated by frontline staff. The information was recorded in a paper-based screening form and forwarded to the SAT staff to verify whether patients were compatible with PUI criteria. If compatible, the SAT code was manually generated, assigned, and sent back to the frontline staff.

At the same time, patient specimens were collected and sent to the laboratory. The test results were notified to the SAT team. The SAT was responsible to record laboratory results into the database and notify the frontline staff.

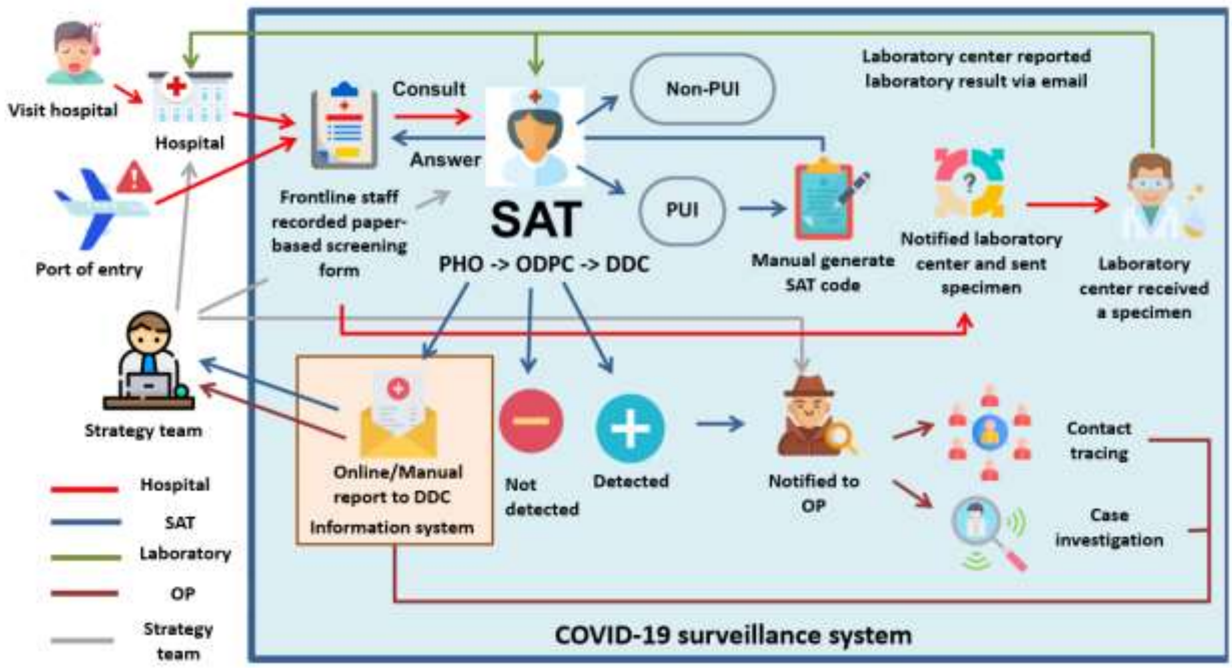

Figure 2. Workflow of the traditional COVID-19 surveillance system reviewed from stakeholders

Note: Blue box illustrates COVID-19 surveillance system; Brown box illustrates information system; Red line illustrates the workflow of the hospital; Blue line illustrates the workflow of the situation awareness team (SAT); Green line illustrates the workflow of the laboratory center; Dark red line illustrates the workflow of the operation team (OP); Grey line illustrates workflow of the strategy team.

Table 2. Summary of challenges and proposed solutions

Challenges	Proposed solutions
1. Overloading of verification processes (SAT code) 2. Time consuming and complexity of verification processes 3. Duplication of record entries by multiple users	SAT code automatic verification system
1. Need to report laboratory result to multiple partners 2. Delayed report and laboratory result 3. Cannot monitor actual number of laboratories tested and new confirmed case (need to check from e-mail)	Laboratory reporting system
1. Cannot identify new confirmed case (need to check from e-mail)	Confirmed case notification feature
1. Cannot monitor real time number and detail of PUI, confirmed case and contact 2. Need to recollect data from lower level (hospitals/PHO)	Data export feature and data visualization
1. Cannot early identify a new cluster of cases 2. Cannot monitor current cluster of cases and event-related patients (active case finding, cluster of cases in local quarantine and state quarantine.	Event-based surveillance system

In case the test result was positive for SARS-CoV-2, the SAT needed to notify the operation team (OP) for investigation and contact tracing. The OP investigation report was also recorded in the database. Lastly, the strategy team extracted data from the information system to support proper policies (Figure 2).

However, several challenges were informed from different stakeholders, for instance, the overburden of verification processes which needed multiple steps of the verification and took a long time, duplication of the patient record, the error of SAT code manually generated, delayed report of laboratory test and confirmed case identification, and difficulty of clustered cases detection and data extraction (Table 2).

Identify Solutions, Redesign and Modify Information System

After challenges were identified, the design team conducted a brainstorming session and proposed the possible solution for each challenge as described in Table 2.

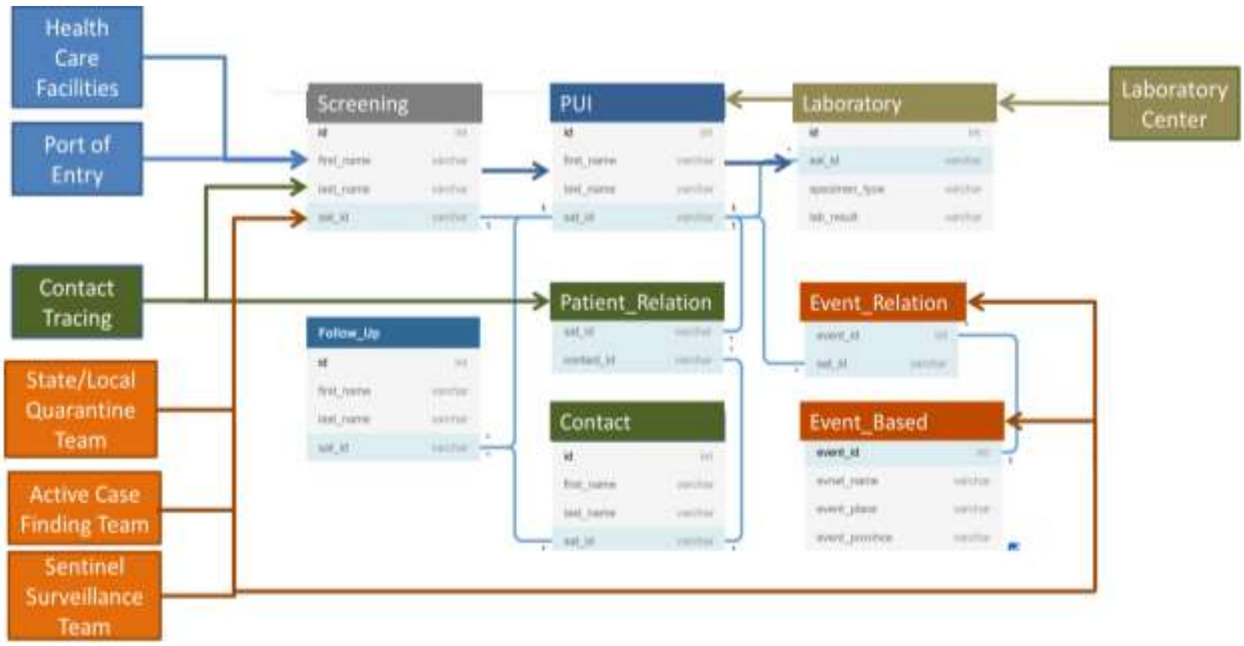

Figure 3. Entity relationship diagram of COVID-19 database structure in COVID-19 enhanced information system

Notes: Blue arrow illustrates data flow from the health care facilities and the port of entry; Green arrow illustrates data flow from the contact tracing team; Brown arrow illustrates data flow from the state quarantine, local quarantine, active case finding team and sentinel surveillance team; Gold arrow illustrates data flow from the laboratory center.

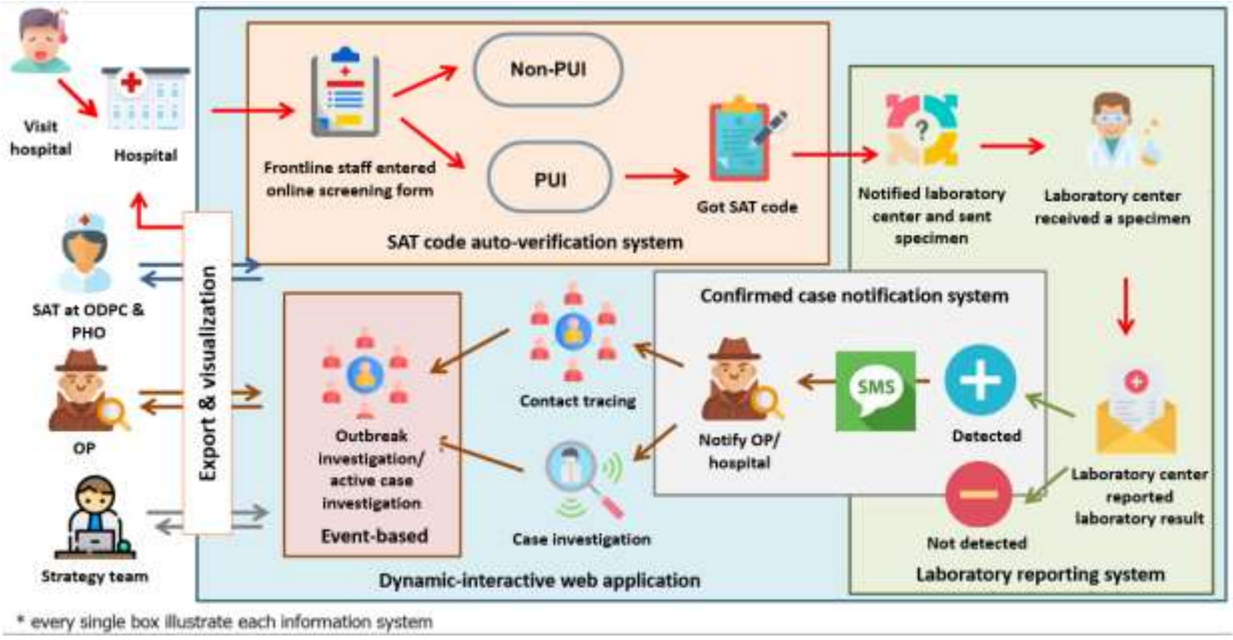

Figure 4. New workflow of the enhanced COVID-19 surveillance system

Note: Blue box illustrates the COVID-19 surveillance system; Red box illustrates the SAT code auto-verification system; Green box illustrates the laboratory reporting system; Gray box illustrates the confirmed case notification system; Dark red box illustrates the event-based reporting system; Red line illustrates the workflow of the hospital; Blue line illustrates the workflow of situation awareness team (SAT); Green line illustrates the workflow of laboratory center; Dark red line illustrates the workflow of operation team (OP); Grey line illustrates the workflow of the strategy team.

In total, 26 staffs and developers from seven different fields of expertise, including two database administrators, six web-application developers, four data analysts, four user supporting staffs, three network and system engineers, one network security consultant, four user supporting staffs and two project managers were recruited to work on the development.

The database was designed based on relational structure and consisted of seven tables including screening, patient, contact, patient contact relation, laboratory, event-based and event-patient relation. (Figure 3).

The user access control (UAC) system was designed based on hospital-level hierarchy. For example, hospital staff could only access their data, the PHO staff could access data of all hospitals under the province authority, ODPC could access data of all provinces under its region and DDC could access national-level data.

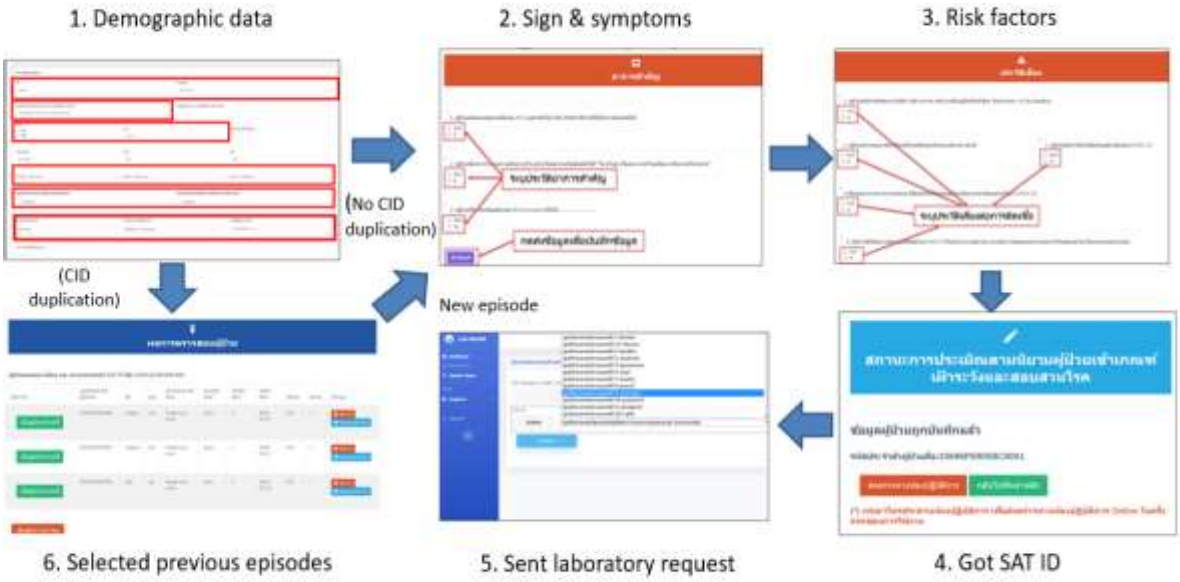

Figure 5. Workflow and example of the user interface of the SAT code verification system

Overall, five additional systems were designed as proposed solutions and were implemented including SAT code automatic-verification system, laboratory reporting system, confirmed case notification system, data export and visualization and event-based surveillance system (Figure 4).

SAT Code Verification System

The system was designed to streamline the SAT verification process. The system received input data from the frontline staff, and categorized patients based on PUI criteria. Patients compatible with PUI criteria were automatically assigned SAT code by the system. Thailand citizen identification number (CID) was required as a master patient index (MPI) across the entire system (Figure 5). Epidemiological linkage and contact tracing were to be identified using the CID of the index cases and contacts (Figure 3).

Laboratory Reporting System

We designed a real-time, electronic-based laboratory reporting system based on two-way communications between frontline staff and laboratory center. After frontline staff get SAT code from the SAT code verification system, they can send laboratory requests to the laboratory center. The specimen status and results will be updated by the laboratory technician through the reporting system.

Confirmed Case Notification System

When the new confirmed case was identified, the notification will be sent to SAT and OP by short message service of the Thai MOPH COLAB application. The notification will be triggered when the laboratory result was updated.

Event-Based Reporting System (EBS)

The event-based reporting system was designed for reporting of clustered events. The system allows the DDC to track the outbreak progress and linkage as one event which can have many patients, and one patient can link with many events. Additionally, the total screening population, confirmed case, and attack rate in those events were automatically calculated.

Data Exporting

We developed a data export feature in which the user could extract data by type of patient and date of the report in Microsoft Excel format according to their hierarchy of data accessibility.

The feature allowed users to export data into Microsoft Excel spreadsheet format. Users can only export data permitted by their level of access and the exporting activity was recorded in the system audit log.

Program Implementation and User Supporting System

A 1-week pilot phase was deployed by trained users via teleconference. An online communication group was provided to gather feedback and for user training. Afterward, the system was deployed to PHO and hospitals. The deployment was supervised by PHO and their networking hospitals. The 24/7 hotline, online chat, and email were established to provide technical assistance during the deployment.

Discussion

The coronavirus disease (COVID-19) surveillance system was designed to be a nation-wide surveillance system aiming to collect all populations related to COVID-19 including PUI, contact, and COVID-19 related signals event. However, several challenges were found in the existing surveillance workflow during the early phase of implementation, January to February. Early engagement with all stakeholders was described as crucial to ensure ownership, increase coordination, and gain a “better understanding of the existing surveillance landscape”.[16-19]

This is important as improving the surveillance is also an opportunity to improve workflow, resource utilization, efficiency of the system and outcome of the diseases which was reported in Sydney, Sierra Leone and several previous outbreaks including acute respiratory syndrome (SARS), Middle East respiratory syndrome, and Ebola virus disease.[19-22]

The COVID-19 surveillance system improvement was implemented nation-wide in early April 2020 which had an impact on both data quality and workflow. Before implementing, the health care facility and port of entry needed to notify SAT and wait for multiple steps of verification which might take a long period. This could increase the risk of infection among frontline staff who had long-time direct exposure to large numbers of infected patients.[23-25] This was because SAT spent the majority of its time on the verification processes and missed some opportunities to monitor the situation as its main function.[2] Therefore, the SAT code auto-verification system could speed up the verification processes, diminish incorrectness of SAT code verification and duplication record, and demolish undue burdened personnel with alarming fatigue.

One of the challenges is that the data could not be used to monitor an actual number of confirmed cases and laboratory tested in a timely manner. The reason was the laboratory results were reported via email causing the delay and missing data which leaded to unreliable surveillance systems. Delay in reporting further compromised timely diagnosis, treatment and case isolation which lead to suboptimal disease prevention and control.[20,21] The possible solution was to migrate the laboratory results to the new reporting system.[26,27] Using an automatically trigger of a notification and short message service when tests are being reported could enhance to detect a new confirmed case.[21]

Reporting timeliness is also important for local health authorities to monitor in order to ensure timely intervention and response, which is the very purpose of the disease surveillance system.[28,29] Therefore, data feedback loops are one of the most important parts of the system to fulfill the surveillance cycle which is associated with data quality improvement.[30] Feedback mechanisms to inform stakeholders regarding the situation and performance monitoring were necessary to sustain staff motivation and cooperation.[31]

In the past, we were unable to link the individual patient record to available clustering information to detect epidemiologic linkage systematically. To address the challenge, the existing EBS was integrated into the COVID-19 surveillance system to become the enhanced information system of individual case linkage to the clustering event. EBS was reported to be important in detecting a large scope of events and guiding outbreak response.[31,32] EBS is a valuable source of data that can strengthen the early warning function of national surveillance systems, if it is integrated into existing surveillance and linked to response structures.[31]

According to travel and mass gathering restriction due to the COVID-19 situation, several technologies had been used to support user training processes including teleconference, chat group communication, and comprehensive electronic user manual. Those technologies allowed the DDC to address the gaps in the system and continuously improved the system despite the travel restriction order in Thailand during the COVID-19 epidemic. This provided a new opportunity for surveillance system improvement as the activity was normally conducted by visiting the field in person. Utilizing new technologies that can support epidemiological surveillance has made a positive difference in performance and data quality.[33] Teleconference provides the ability to deliver training to large numbers of people across multiple locations within a relatively short time with reasonable costs.[34]

Due to the COVID-19 situation and its intense control measures, face to face interviews with local stakeholders and direct observation were not performed during the pilot phase which limited our observation and interaction with users to gather essential feedback. Besides, we could not assess the impact of the improvement made in this study given the current COVID-19 situation. Thus, we recommend conducting the surveillance evaluation to compare the performance of the system before and after the improvement.

Public Health Recommendations

During the early phase of IT development, early engagement and comprehensive communicating with stakeholders, both via face to face and teleconference, are strongly suggested to avoid obstacle as it shows an opportunity to gather feedback and address the gaps in the system without the need for the field visiting.

After obstacles identification, integrating information systems, such as laboratory reporting systems and event-based surveillance systems, are suggested to fulfill gaps in the existing surveillance systems. Appropriated helpdesk services and user support have a crucial role to monitor additional challenges from stakeholders and to improve the surveillance system.

Conclusion

The coronavirus disease (COVID-19) surveillance system was designed to be used nation-wide as an active, compulsive, and comprehensive surveillance system. However, the system suffers several limitations, such as lack of timeliness, overload of verification, inaccessible of data feedback loops, and a cluster of case identification. Stakeholders' engagement was made despite the travel restriction order in Thailand to gather feedback and needs from the users. The activities were made possible with several communication routes including chat, email, and teleconference. As a result, several gaps were identified, and improvements were made. Therefore, our study provides a new opportunity for surveillance system improvement to be possible during the travel restriction as implemented in several countries.

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An Evaluation of the Enhanced Information System for COVID-19 Surveillance in Thailand, 2020: A Pre-Post Intervention Comparison

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Abstract

With information technology, a traditional coronavirus disease (COVID-19) surveillance system was improved with five additional features including auto-verification system, laboratory reporting system, confirmed case notification system, data feedback loops, and integrated event-based surveillance system. We conducted a surveillance evaluation to compare quantitative and qualitative attributes before and after the improvement. Qualitative and quantitative studies were conducted to measure the effectiveness of enhancing the information system according to the US-CDC framework. Qualitative attributes consisting of simplicity, acceptability, accessibility, flexibility, and stability, and quantitative attributes consisting of timeliness and completeness were investigated and compared between pre-enhanced and post-enhanced information system using the chi-square test. During January to April, there were 74,565 patients under investigation reported to the surveillance system. We interviewed a total of 16 health personnel. After the improvement, we observed statistically significant increases of completeness and timeliness from 55 to 66 and 75 to 96 percent, respectively. Almost all stakeholders (15/16) reported that the system was improved significantly. All qualitative attribute scores were increased including acceptability from 57 to 73, simplicity from 43 to 77, stability from 47 to 80, flexibility from 57 to 73, and usefulness from 50 to 80. In summary, all the qualitative and quantitative attributes were improved significantly (*p*-value<0.01 for the chi-square test). Enhanced information system with careful understanding of the existing workflow and stakeholders could improve performance of the surveillance system in both qualitative and quantitative attributes. Surveillance evaluation process could be used to assess the improvement, gather feedback, and identify the gaps.

Keywords: coronavirus disease, surveillance evaluation, information system, information technology, innovation

Introduction

Coronavirus disease (COVID-19) was an emerging infectious disease affecting people worldwide. After received a notification from China, Thai Department of Disease Control (DDC) implemented COVID-19 surveillance system at the points of entry and hospitals since January 2020.[1-3] Public health information systems (PHIS) are major components of public health infrastructure.[4] They have been defined to include a variety of data sources essential to public health action and are often used for surveillance.[4] The COVID-19 surveillance system with the information system was rapidly deployed in February 2020 to

Table 1. Selected variables from COVID-19 screening form and their validity rules

Selected variable	Validity rules
COVID-19 screening form	
Card ID	Must be 13 digits
Sex	Must be Male, Female, Unknown
Age	Must be 0 - 110
Nation	Must be in a valid list of nation codes
Occupation	Must be in a valid list of occupation codes
Address (Sub-district)	Must be a valid sub-district code
Address (Province)	Must be a valid province code
Screening Province	Must be a valid province code
Screening Hospital	Must be a valid hospital code
Screening Date	Must be a valid date format before last update date
Date of Onset	Must be a valid date format before last update date

collect and provide data systematically to all related stakeholders.[1]

Even though the COVID-19 surveillance system was designed to be a passive compulsive surveillance system which could provide rich information to public health authorities, several limitations of the existing surveillance system remained, including reporting delay and poor data quality due to the complexity of the reporting process, and the repetitiveness of multiple stakeholders reporting.[4]

From our previous study, the gap analysis was conducted.[5] Several challenges of the existing surveillance system were identified, including the overburden of case verification, delayed laboratory results, lacking feedback, and case-clustering identification. Therefore, a new electronic surveillance system was designed and deployed in April 2020 by enhancing five important features: (i) auto-verification to verify patient according to screening criteria, (ii) laboratory reporting system which was coordinated with a laboratory center and integrated with the case reporting system, (iii) data exporting, (iv) visualization which was able to fulfill data feedback loops, and (v) integrated event-based surveillance which was developed to address the identified gaps.

To assess the improvement impact, surveillance evaluation was carried out. The surveillance system evaluation is important to promote efficient and effective public health surveillance systems and fulfill the cycle of the surveillance system.[6-7] This could provide opportunities to identify existing difficulties from various stakeholders, access the system effectiveness, monitor data quality, and provide a recommendation to improve the surveillance system.

Therefore, we conducted a surveillance system evaluation to assess the improvement of quantitative and qualitative attributes of the newly designed COVID-19 surveillance system.

Methods

Overview

A mixed method, based on the US-CDC Surveillance evaluation framework, was conducted. All reported Patient Under Investigation (PUI) and confirmed COVID-19 cases in the COVID-19 surveillance system during February to April 2020 were obtained nationally from DDC.

Qualitative Study

Firstly, we briefly summarized the improvement made to the surveillance system. We conducted a qualitative study consisted of six attributes namely, simplicity, stability, flexibility, usefulness, and accessibility during February to March 2020 for pre-improvement and April 2020 after the improvement in Chonburi Province, Thailand.

Using purposive sampling method, related stakeholders were interviewed. They included the operation team who acted as forefront officers to take prompt action against the outbreak, situation awareness team who served as a situation monitoring system, strategy response team who was responsible for producing applicable operational guidelines for a timely response to COVID-19, from DDC and Office of Disease Prevention and Control (ODPC), Provincial Health Office (PHO) staffs, hospital staffs, and laboratory technicians.

An in-depth face-to-face interview was conducted during in-person visits and teleconference. After the

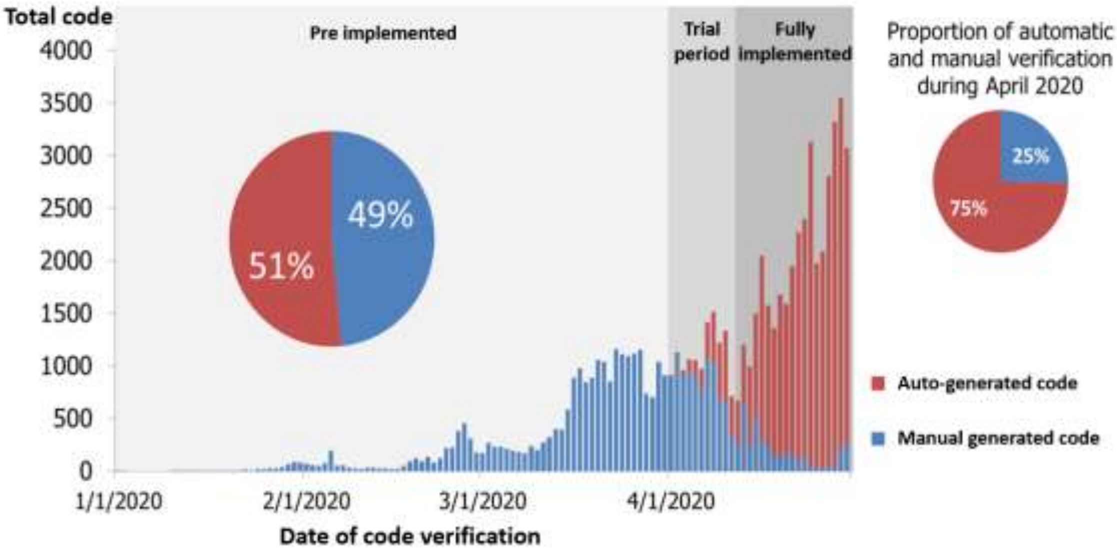

Figure 1. Proportion of the manual and automatic verification system in COVID-19 surveillance system during January to April 2020 (n=74,565)

interview, we asked interviewees to provide a score (0-10) for each attribute. The interview was recorded for coding and transcribe. Lastly, we interviewed each participant twice and conducted the thematic analysis to compare before and after improvement.

Quantitative Study

A quantitative study consisting of 3 attributes including completeness, timeliness, and data quality was conducted and compared before and after improvement of the COVID-19 surveillance system.

Completeness

We calculated the percentage of non-missing data of selected variables from the COVID-19 investigation form including national card ID, sex, age, phone number, nationality, occupation, address, symptom, date of onset, risk factor, screening hospital, and screening province. Additionally, we calculated the proportion of non-missing data for completeness score (maximum of 100). For inferential analysis, completeness during pre- and post-enhancing information system were compared using the Chi square test and its *p*-value.

Data quality

The percentage of valid data of selected variables (the same as completeness) according to validity rules (Table 1) were calculated and compared between before and after improvement with the paired T-test and its *p*-value.

In addition, the percentage of duplicated data of selected variables including exact duplicated first name, last name, and exact duplicated of unique COVID-19 case identifier, the situation awareness team (SAT) code, which was the unique number of each PUI who was verified by SAT, were calculated.

Timeliness

The lag time between the screening date and reported date was calculated with its mean and standard deviation. For inferential analysis, the date of screening was divided into two periods and compared using paired T-test with *p*-values and Kaplan-Meier survival analysis with sub-distribution of hazard approach (Log-rank test with its *p*-values).

Also, the lag time was categorized into the following scores including 0 days (10 scores), 1 day (9 scores), 2 days (8 scores), 3 days (7 scores), 3-7 days (5 scores), 1-2 weeks (4 scores), 2-3 weeks (3 scores), 3-4 weeks (2 scores) and 1-2 month (1 score). The score of pre- and post-enhancing timeliness were calculated according to the given score.

Lastly, the score (maximum of 100) of each attribute including simplicity, stability, flexibility, usefulness, accessibility, completeness, and timeliness for both pre and post enhancing periods were summarized, compared using Chi-square with its *p*-values, and visualized with a radar chart.

Results

There were 74,565 PUIs reported to the COVID-19 surveillance system during January to April. Approximately half or 38,383 cases were reported after the improvements were made. Since the improvement, approximately 700 health care facilities participate in the surveillance system. After the improvement was made in April.

Table 2. Quotation and tone from stakeholders interviewing by qualitative attributes and types of stakeholder before the improvement (February and March 2020)

Stakeholders	Simplicity	Flexibility	Acceptability	Stability	Usefulness
Strategy response team	"Messy data"	"Can adapt"	"Accept it"	"Depend on few people"	"Identify risk population, convince policy"
SAT at DDC/ODPC	"Complicated flow"	"Need to follow PUI criteria and SAT ID pattern"	"We accept it"	"No, if 20% of us got sick"	"Monitor situation"
OP at DDC/ODPC	"Work likes machine"	"Can adapt"	"It's our job"	"Manpower"	"Yes, for news reporting"
PHO	"Multiple steps"	"Always need to update new criteria"	"Work likes messenger"	"Rely on number of staffs"	"Need to collect data from hospital again"
Hospital	"Extremely hard"	"Can adapt with all criteria"	"Not much"	"Depend on number of PUIs/cases"	"No, cannot get data back"
Laboratory	"Need to send result to multiple sector"	"Can adapt if type of specimen change"	"Double work"	"No, if number of tests is increasing"	"Not sure"

Note: Red fonts illustrated a negative tone; Green fonts illustrated a positive tone; Black fonts illustrated a neutral or inconclusive tone.

2020, the number of PUIs were increased almost tripled, from 19,583 in March 2020 to 51,410 cases in April 2020. Figure 1 shows proportions of manual reporting and automatic verification system after the improvement.

Qualitative Study

We interviewed 16 staffs from various parts and roles of the surveillance system. During the pre-improvement period, most of the stakeholders (10/16) reported that the system lacked simplicity and stability. For simplicity, they reported that workflow was complicated, and they needed to do multiple steps for reporting any PUI which took a long time. Additionally, data was not systematically collected with a non-standardized data structure. For stability, most of them (10/16) reported that the system relied on manpower which was only a few stakeholders involved in each process. If the number of PUI were rising, the system might not be able to drive with limited human resources. For acceptability, most of the stakeholders (9/11) in DDC and ODPC accepted it since the pre-enhancing period as it was their primary responsibility. However, most of the stakeholders (4/5) in PHO, hospital, and laboratory center did not accept the system as it was their additional work. For flexibility, some stakeholders (3/16) reported that the system might not be able to adapt with major change such as screening in state quarantine. Additionally, they reported that it was useful to monitor the local situation, identify risked population, and adopted policies. However, various stakeholders (7/16) reported that the data was not fully disseminated. They still needed to collect data from their lower levels repeatedly.

After improving the information system, the reporting system was simpler and required less than 5 minutes. The data was more systematic which could be managed and analyzed easily. For stability, the system was more stable after replacing with information technologies. It required fewer stakeholders to drive in each process. For acceptability, most of stakeholder (4/5) in PHO, hospital and laboratory center accepted the system because it could provide rich information to them. For flexibility, most of the stakeholders (14/16) reported that the system was adaptable to any situation after the improvement (Table 2). Overall, most of stakeholders (15/16) reported that the system was improved significantly.

Quantitative Study

Completeness

Completeness of pre- and post-enhanced information system of selected variables including ID card (pre:

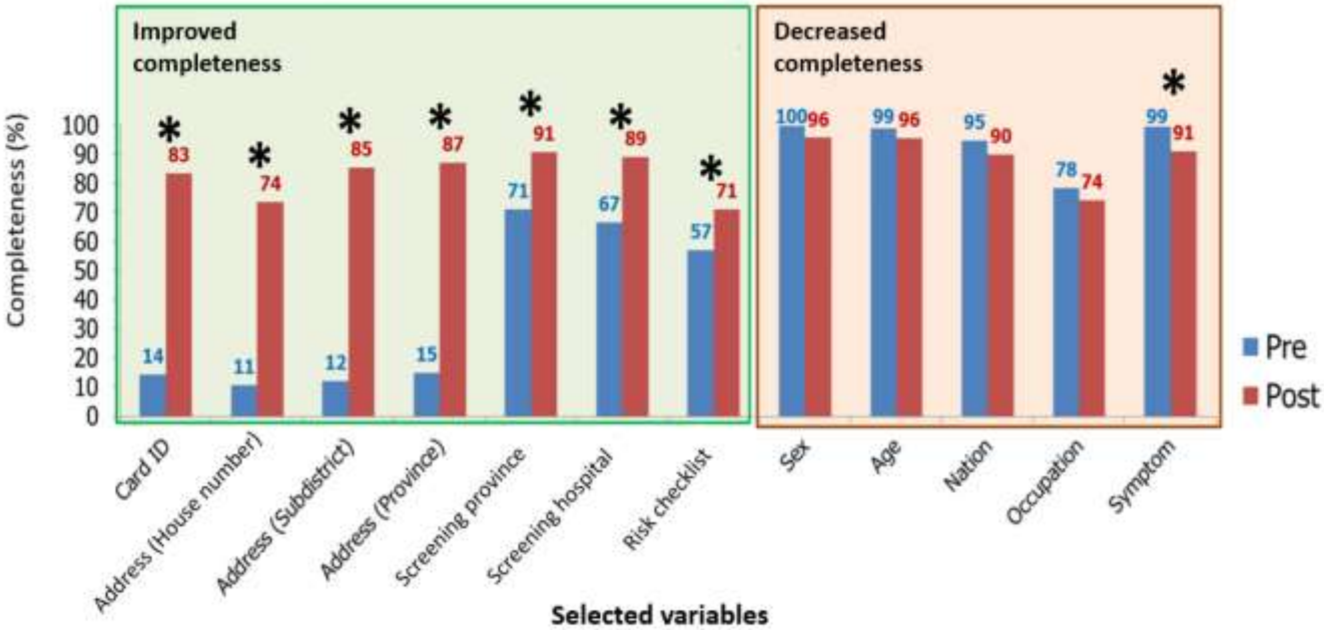

Figure 2. Completeness of selected variables from screening form of COVID-19 surveillance system, comparing pre implementation and post implemented information system period

14%, post: 83%), house number sick address (pre: 11%, post: 74%), sub-district sick address (pre: 11%, post: 74%) and province sick address (pre: 15%, post: 87%), screening hospital (pre: 71%, post: 91%), screening province (pre: 67%, post: 89%), and risk factors (pre: 57%, post: 71%) were improved with statistically significance (*p*-value<0.01). However, variables selected for evaluation of completeness included sex (pre: 99%, post: 96%, *p*-value=0.17), age (pre: 99%, post: 96%, *p*-value=0.17), nationality (pre: 95%, post: 90%, *p*-value=0.18), occupation (pre: 78%, post: 74%, *p*-value=0.50) and symptom (pre: 99%, post: 91%, *p*-value=0.03) were decreased but mostly not statistically significance (Figure 2). The pre and post implementation period score of timeliness were 55 and 66, respectively.

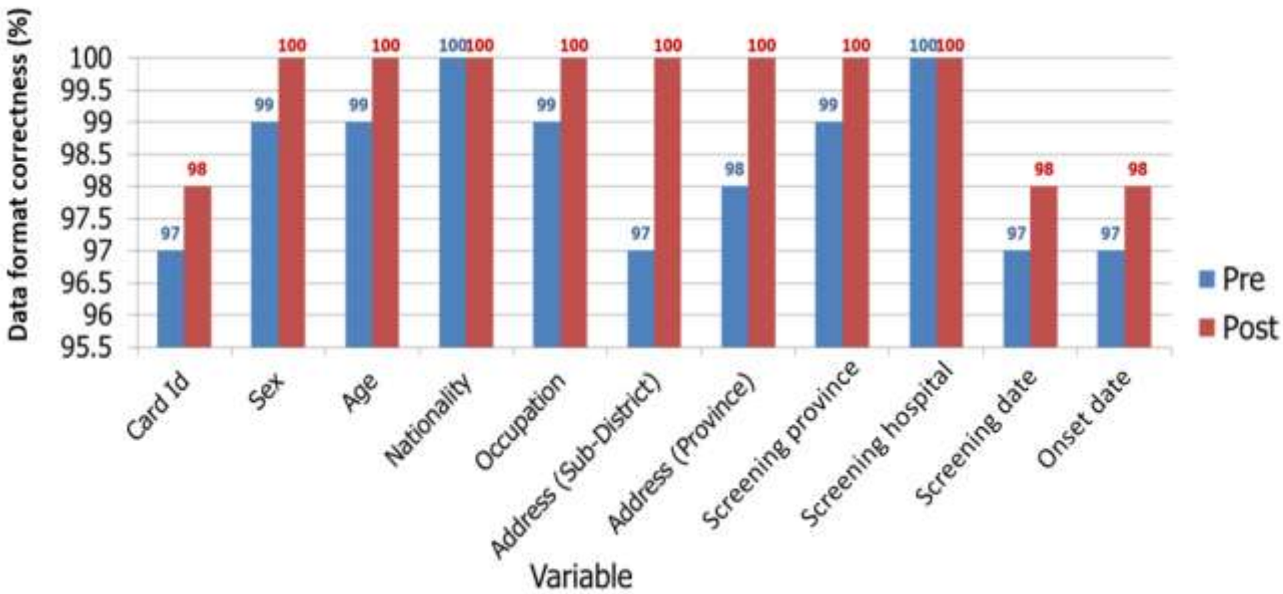

Figure 3. Data format correctness of selected variables from the screening form of COVID-19 surveillance system comparing before and after the improvement

Data quality

Data format correctness of all selected variables were improved without statistical significance at *p*-value>0.05 (Figure 3). In addition, duplication of records, which were checked by both name and surname, and ID card declined from 9.86% to 1.66% and 0.90% to 0.07%, respectively.

Figure 4. Proportion of timeliness of variables in COVID-19 surveillance system comparing pre- and post-enhancing period with its mean and standard deviation

Timeliness

Proportion of 0-day, 1-day, 2-day, the 3-day lag time between screening date and reported date were 31%, 24%, 13%, and 9% before improvement and 88%, 7%, 2% and 1% after improvement, respectively (Figure 4). The mean and standard deviation of lag time between screening date and reported date was 3.99 days and 9.45 days for pre-enhancing, and 0.29 and 1.27 days for the after improvement, respectively. For inferential statistics, the timeliness of the COVID-19 surveillance system was significantly improved. Additionally, from Kaplan-Meier survival analysis, the probability of early reporting to the COVID-19 surveillance system was increased month by month with significant differences according to the log-rank test with *p*-value<0.01 (Figure 5). The timeliness score was 75 and 96 for before and after improvement, respectively.

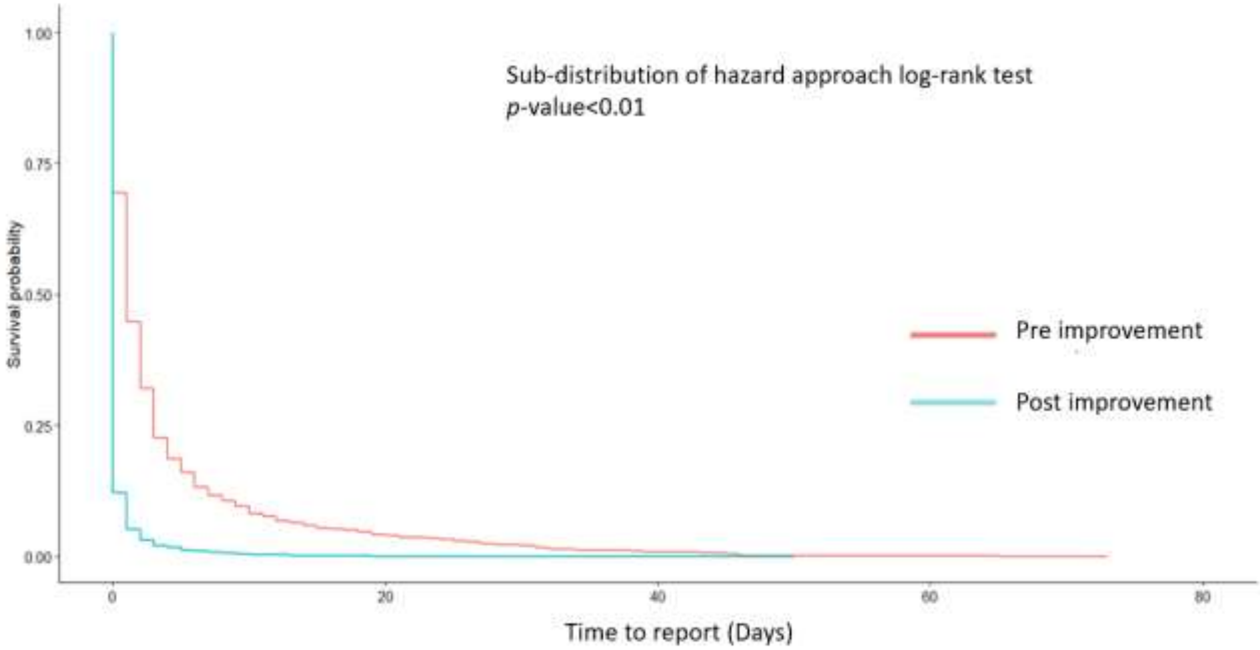

Figure 5. Kaplan-Meier survival analysis for the duration of screening date to reporting date to the surveillance system, comparing pre and post improvement with the log-rank test

In summary, the overall scores of both qualitative and quantitative attributes were improved. For quantitative attributes, completeness and timeliness were improved from 55 to 66 and 75 to 96%, respectively. For qualitative attributes: acceptability, simplicity, stability, flexibility, and usefulness scores were improved from 57 to 73, from 43 to 77, from 47 to 80, from 57 to 73, and 50 to 80 scores, respectively.

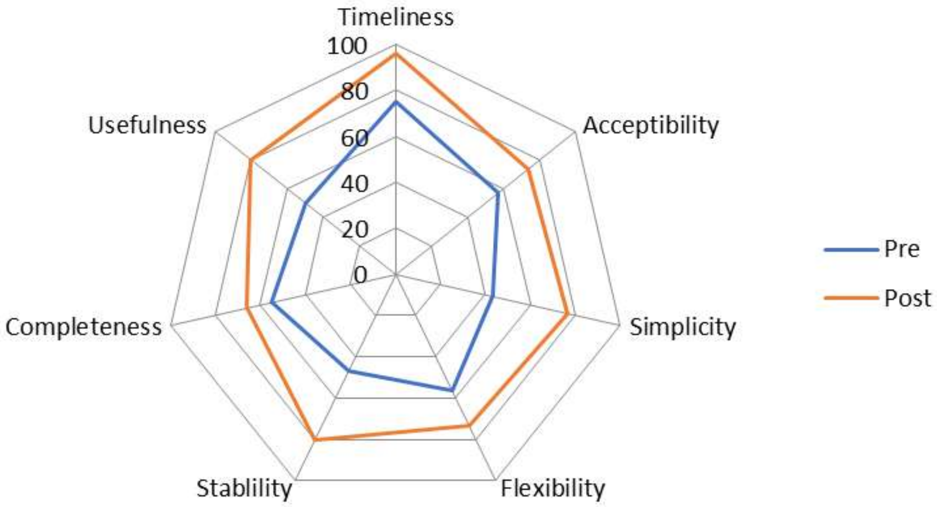

Figure 6. Radar chart illustrates the qualitative and quantitative attributes of COVID-19 surveillance system comparing pre- and post-improvement information system

All those qualitative and quantitative attributes were improved significantly (*p*-value<0.01) as shown in Figure 6.

Discussion

After the system was improved, the performances in both qualitative and quantitative attributes of the system were also improved significantly. This is because of the better understanding of stakeholder roles and workflows to improve the surveillance system.[8-12] According to the result, approximately 700 health care facilities participated in the surveillance system resulting in a large increase in the reported PUI number.

Several factors including the change in PUI criteria, and the mandate by law that the COVID19 is a dangerous communicable disease since 29 Feb 2020, enforce personnel to report the case to public health authorities within three hours after the suspected case was identified.[13] This might contribute to the improvement. We believe that the better and less complex system also contribute to a better reporting due to an automatic verification feature on the electronic-based platform. Simplification of the system also improves the timeliness by simplifying the reporting process.[14] A similar finding was also reported from Cambodia.[15]

Form our result, we found that both qualitative and quantitative attributes of the surveillance system were improved significantly. To improve the efficiency of the disease surveillance system, many electronic and automated innovations have been tried.[16,17] Additionally, the implementation of electronic-based platforms could be able to improve the simplicity, stability, flexibility, and acceptability of the system by replacing human-required tasks such as SAT code generation. Improving simplicity, stability, and acceptability of the surveillance system could contribute to the observed good quality and completeness of data.[18]

Additionally, data export function and visualization could play an important role to improve the usefulness of the system by providing users the ability to access to the epidemiological data allowing more timely analysis and response.[19-21] This could improve acceptability and cooperation through returning benefits to stakeholders similar to the previous study of influenza surveillance.[16] Additionally, this could improve the data quality as stakeholders were able to validate their data.[22]

Completeness and validity were significantly improved. This was because of the new automated system. It was observed that automated system of disease monitoring and reporting could improve the completeness of variables from several data input validation including the use of the mandatory field, repeatable fields, design logical order of variable and predefined variables. All these could improve the completeness of the system.[23-25]

There were limitations in this study. Firstly, face to face interviewing with local stakeholders was limited. Before the system improvement, our opportunity to gather the system gaps was limited. However, the teleconference was set-up instead and was utilized in the study after the improvement. Secondly, the study did not assess the system reliability (sensitivity and positive predictive value) and representativeness of the surveillance system, which were important attributes of surveillance evaluation.

Public Health Recommendations

Enhancing information system with careful understanding of existing workflow and stakeholders supported by information technologies could improve surveillance system performances in both qualitative and quantitative attributes. This could contribute to better reporting and stakeholders' workload. Additionally, surveillance evaluation process can be used to assess the improvement, gather feedback, and identify the gaps. More attributes of quantitative should be studied, for instance; sensitivity, positive predictive value, and representativeness to better understand the performance of the surveillance system.

Conclusion

With information technology, a traditional coronavirus disease (COVID-19) surveillance system was enhanced. The surveillance evaluation was conducted to compare pre- and post-improvement performance. After implementing enhanced information systems, all selected qualitative and quantitative attributes were improved significantly. Enhancing information system with careful understanding of existing workflow and stakeholders could be used to improve surveillance system performance. Surveillance evaluation process could be used to assess the improvement, gather feedback, and identify the gaps.

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An Outbreak of Coronavirus Disease (COVID-19) among Healthcare Personnel in a Private Hospital Related to Delayed Detection of SARS-CoV-2 Infection Foci

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Abstract

Healthcare personnel are front-line workers for disease prevention and control. On 6 Apr 2020, the Department of Disease Control received a notification on a cluster of healthcare personnel in a private hospital infected with coronavirus disease (COVID-19). The event was investigated and a cross-sectional study was conducted to describe the epidemiological characteristics of the cluster, including risk factors for SARS-CoV-2 infection. A confirmed COVID-19 case was a person with SARS-CoV-2 virus tested by reverse transcription polymerase chain reaction in one reference laboratory; and a probable COVID-19 case was a person who died of pneumonia in the hospital, did not tested for COVID-19, and had an epidemiological linkage to a confirmed case. Among total 2,287 healthcare personnel working at the hospital, 25 were confirmed cases (attack rate 1.1%). Although the attack rate was relatively low, the specific attack rate in the inpatient ward was high (32.4%) due to delayed outbreak detection. Analytic results suggested that attending infection prevention and control (IPC) training was a protective factor for COVID-19 (Odds ratio 0.04, 95% CI 0.00-0.64). In addition, a survey on personal protective equipment (PPE) showed that 66.7% of those conducting sputum suction/drug nebulization and 83.9% of those performing cardiopulmonary resuscitation used inappropriate PPE. Therefore, IPC training, including appropriate use of PPE, should be provided to all healthcare personnel. In addition, healthcare personnel should be alert for COVID-19 infection, and protect themselves according to the standard protocols. Routine screening of healthcare personnel should be performed during the COVID-19 epidemic.

Keywords: healthcare personnel, coronavirus disease, COVID-19, SARS-CoV-2, outbreak investigation, hospital

Introduction

Coronavirus disease (COVID-19), an emerging disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus, has become a new global health threat.[1] As of 11 May 2020, over four million people were infected with SARS-CoV-2, with about 300,000 deaths reported globally.[2]

In Thailand, SARS-CoV-2 was first detected among international travelers from China, and the first case of local transmission was detected on 31 Jan 2020.[3] As of 28 Apr 2020, 2,938 people were diagnosed with COVID-19, with 54 deaths.[4]

Since COVID-19 cases have been increasingly reported, healthcare personnel become more at risk. In the United States, the Centers for Disease Control and Prevention reported that of those who had COVID-19 infection, 19% were healthcare personnel which included frontline staffs fighting against COVID-19.[5] The reported risk of COVID-19 infection among these group is related to PPE.[6,7]

On 6 Apr 2020, the situation awareness team of the Department of Disease Control (DDC), Ministry of Public Health, Thailand, notified the operation teams about a cluster of COVID-19 cases at a private hospital (Hospital R) in Bangkok. The operation teams from the Urban Institute for Disease Prevention and Control, Bamrasnaradura Infectious Diseases Institute and DDC jointly investigated the event during 7 to 10 Apr 2020. The objectives of the investigation were to describe epidemiological characteristics, identify a possible source of transmission and factors related to SARS-CoV-2 infection, assess the practice of personal protective equipment (PPE) usage among healthcare personnel attending to COVID-19 patients, and provide recommendations for prevention and control measures.

Methods

A cross-sectional study was conducted among healthcare personnel and patients in Hospital R during 10 Mar to 13 Apr 2020. A probable COVID-19 case was a person died of pneumonia in Hospital R during 10 Mar to 13 Apr 2020, had an epidemiologic link with a confirmed COVID-19 case, and was not tested for COVID-19. A confirmed COVID-19 case was defined as a person with SARS-CoV-2 virus in a nasopharyngeal specimen tested by reverse transcription polymerase chain reaction (rt-PCR) in a standard reference laboratory, as per the national guideline for COVID-19 investigation in Thailand dated 23 Mar 2020.[8]

Data Collection

For healthcare personnel infected with COVID-19, their demographic information and activities in hospitals and communities were collected by reviewing COVID-19 epidemiologic investigation forms, interviewing via phone and conducting an online survey with a structured questionnaire. For COVID-19 patients admitted in the hospital, their medical records were reviewed and close relatives were interviewed.

The potential factors associated with COVID-19 infection, including job position, work section, PPE usage and infection prevention and control (IPC) training, were collected by interviewing via phone and performing a survey among healthcare personnel in ward A and intensive care unit A where the probable case were admitted.

For the PPE survey, an online structured questionnaire was used for data collection among all healthcare personal in Hospital R. The collected data included PPE practice in each working process.

Data Analysis

For the descriptive study, continuous variables such as age were described by median with interquartile range, whereas categorical data were described in frequency and percentage. For bivariate and multivariate analysis, we included healthcare personnel in ward A and intensive care unit A. Potential factors associated with confirmed cases were analyzed as well. The factors included PPE usage, attending IPC training and job position at the hospital. In terms of PPE survey, the national standard guideline was used for categorization.[9]

Odds ratio (OR) with 95% confidence interval (CI) were calculated. Variables with p-value less than 0.1 in bivariate analysis were included in logistic regression analysis. Adjusted OR with 95% CI were presented as outputs of the multivariate analysis. Stata software version 14 was used for data analysis.

Results

Hospital R is a private tertiary care hospital located in Bangkok, Thailand. There are three buildings, 500 beds and 2,287 healthcare personnel. During 10 Mar to 13 Apr 2020, total 25 confirmed cases of COVID-19 were identified among healthcare personnel, and there were one probable case and three confirmed cases among patients admitted in the hospital.

Healthcare Personnel Infected with COVID-19

Of 25 confirmed cases among healthcare personnel, corresponding to an attack rate of 1.1% (25/2,287), male to female ratio was 7.3:1and median age was 26 years (Q1 = 22 and Q3 = 30 years). The highest attack rates were found among physiotherapists (5.3%) and practical nurses (4.1%). (Table 1)

The ward A was resulted with the highest attack rate (32.4%), followed by intensive care unit A (12.5%), and chest and cardiovascular outpatient department (OPD) clinic (12.5%). (Table 2)

The most common signs and symptoms were fever or body temperature higher than 37.5 degree Celsius (60%), sore throat (56%) and runny nose (40%). (Figure 1)

The outbreak began on 17 March 2020 and reached its peak during 23 to 30 March 2020, starting in ward A and spreading to intensive care unit A. The epidemic curve suggested that there was a transmission within the hospital. The index healthcare personnel cases were three females: one registered nurse, one nursing assistant and one practical nurse in the ward A. The index cases were tested one day after their symptoms developed. The first case among healthcare personnel was likely to be a male physician, Physician P, who worked at the chest and cardiovascular clinic, ward A and intensive care unit A. He had low risk of infection from the community as he lived alone or had not been to the crowed areas. He developed respiratory symptoms on 17 Mar 2020 and as his symptoms got worse on 28 Mar 2020, he was tested for SARS-CoV-2 on the same day. (Figure 2B)

About 76% of the infected healthcare personnel worked less than 70 hours per week. About 20% of the cases worked more than one unit in Hospital R, which included areas at high risk of COVID-19 infection (i.e. acute respiratory infection clinic, and chest and cardiovascular clinic). Only one healthcare worker (4.0%) attended IPC training. (Table 3)

Probable and Confirmed COVID-19 Patients in Hospital R

Among patients admitted in Hospital R, one probable case and three (patients X, Y and Z) confirmed cases of COVID-19 were identified. The probable case was admitted to ward A on 21 Feb 2020, transferred to intensive care unit A due to pneumonia on 22 Mar 2020 and had a nebulization procedure during hospitalization. The patient died on 27 Mar 2020. The probable case's two cousin shad history of contact with the probable case before and during hospitalization and were confirmed to have SARS-CoV-2 later on.

Regarding to three confirmed cases among patients, patient X was admitted to the intensive care unit A on 21 Mar 2020, the same period when the probable case was admitted. Then, patient X was transferred to ward B on 28 Mar 2020. Patient X had intubation procedures and died later on. Two other confirmed patients (Patients Y and Z) received treatment at emergency room and Ear, Nose and Throat Out-Patient Department (ENT OPD). They were confirmed to have COVID-19 before admission (Figure 2A).

Transmission Between Healthcare Personnel and Patients in Hospital R

Two sub-clusters were found in this outbreak: a sub-cluster linked with the probable case, Physician P and Patient X, and a sub-cluster associated with Patient Y.

For the first sub-cluster, the outbreak started in ward A. The probable case's cousins or healthcare personnel were likely to be the source of infection. Since the probable case were admitted for several months, the chance of COVID-19 infection from community was low. The probable case might transmit the infection to other healthcare personnel in ward A. Although the probable case was later transferred to intensive care unit A where Patient X was in admission at the same time, possibility of direct transmission between the probable case and Patient X was low since they stayed in different rooms and both were bedridden. Therefore, healthcare personnel might transmit the virus to Patient X.

For the second sub-cluster, Patient Y was detected early due to high risk of COVID-19 infection. Only one nurse was exposed in emergency room when collecting blood specimens from Patient Y before confirmation of COVID-19 infection. The nurse was later confirmed to have COVID-19 infection.

Regarding to Patient Z, since he informed the risk of COVID-19 infection early, healthcare personnel protected themselves appropriately and no subsequent infected healthcare staff related to Patient Z was detected.

Two other healthcare personnel infected with COVID-19 were not epidemiologically linked with COVID-19 confirmed cases. However, they worked at a medical screening point in the hospitaland might have exposed to unidentified COVID-19 patients.

Factors Associated with COVID-19 Infection

Bivariate analysis found that being a practical nurse was a significant risk factor for COVID-19 infection (OR 3.9, 95% CI 1.4-10.9) compared to other job positions. Multiple logistic regression showed that attending IPC training significantly reduced the odds of COVID-19 infection (Adjusted OR 0.04, 95% CI 0.00-0.64) (Table 4).

PPE Survey

Of 1,687 healthcare personnel participated in the survey, 337 (20.0%) reported contact with COVID-19 confirmed cases or patients at risk of COVID-19 infection. According to the national standard guideline on PPE in hospitals, appropriate PPE usage for medical screening include face shield and surgical mask while appropriate PPE for blood specimen collection and drug injection included hair net, goggle or face shield, surgical mask, gloves and protective gown. For aerosol generating procedures, hair net, goggle, face shield, N95 mask, gloves, and protective gown are required. For cardiopulmonary resuscitation, hair net, goggles or face shield, N95 mask, gloves, protective gown and leg cover are recommended.[14] About 66.7% (52/78) of those conducting sputum suction/drug nebulization and 83.9% (47/56) of those performing cardiopulmonary resuscitation used inappropriate PPE. (Table 5)

Table 1. Job positions of healthcare personnel with COVID-19 in Hospital R between 10 and 29 Mar 2020 (n=25)

Job position	Number of cases	Total population[a]	Attack rate (%)
Physician	2	301	0.7
Registered nurse	9	386	2.3
Practical nurse	3	74	4.1
Nursing assistant	7	261	2.7
Medical assistant	2	326	0.6
Physiotherapist	1	19	5.3
Maid	1	N/A[b]	N/A[b]
Total	25	2,287	1.1

Note: [a] The total number of people employed in each occupation. It was not the number of being tested.

[b]Total number of hospital maids were unknown, therefore the attack rate among hospital maids could not be calculated.

Table 2. Designated work stations of healthcare personnel with COVID-19 in Hospital R between 10 and 29 Mar 2020 (n=23)*

Hospital section	Number of cases	Total number of staff working at the section[a]	Attack rate (%)
Ward A	11	34	32.4
Ward B[b]	1	40	2.5
Intensive care unit A	5	40	12.5
Emergency room	1	44	2.3
Physical therapy department	2	39	5.1
OPD- chest and cardiovascular clinic	1	8	12.5
OPD- gastrointestinal clinic	1	22	4.6
OPD- diabetes clinic	1	16	6.3
Total	23	243	9.5

*Note: * Two physicians were excluded as. they worked more than one location.*

[a] The total number of healthcare personnel worked in each section; It was not the number of being tested.

[b] Denominator included hospital maids working in the ward.

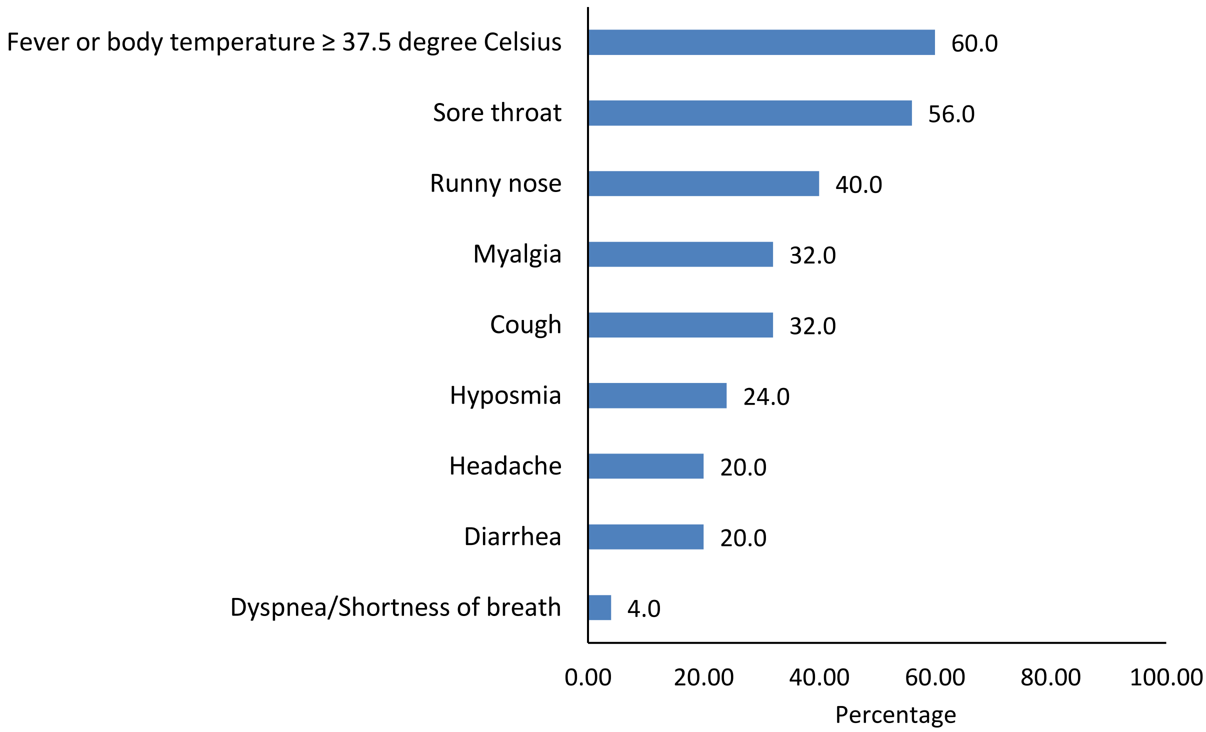

Figure 1. Clinical signs and symptoms of healthcare personnel with COVID-19 in Hospital R between 10 and 29 Mar 2020 (n=25)

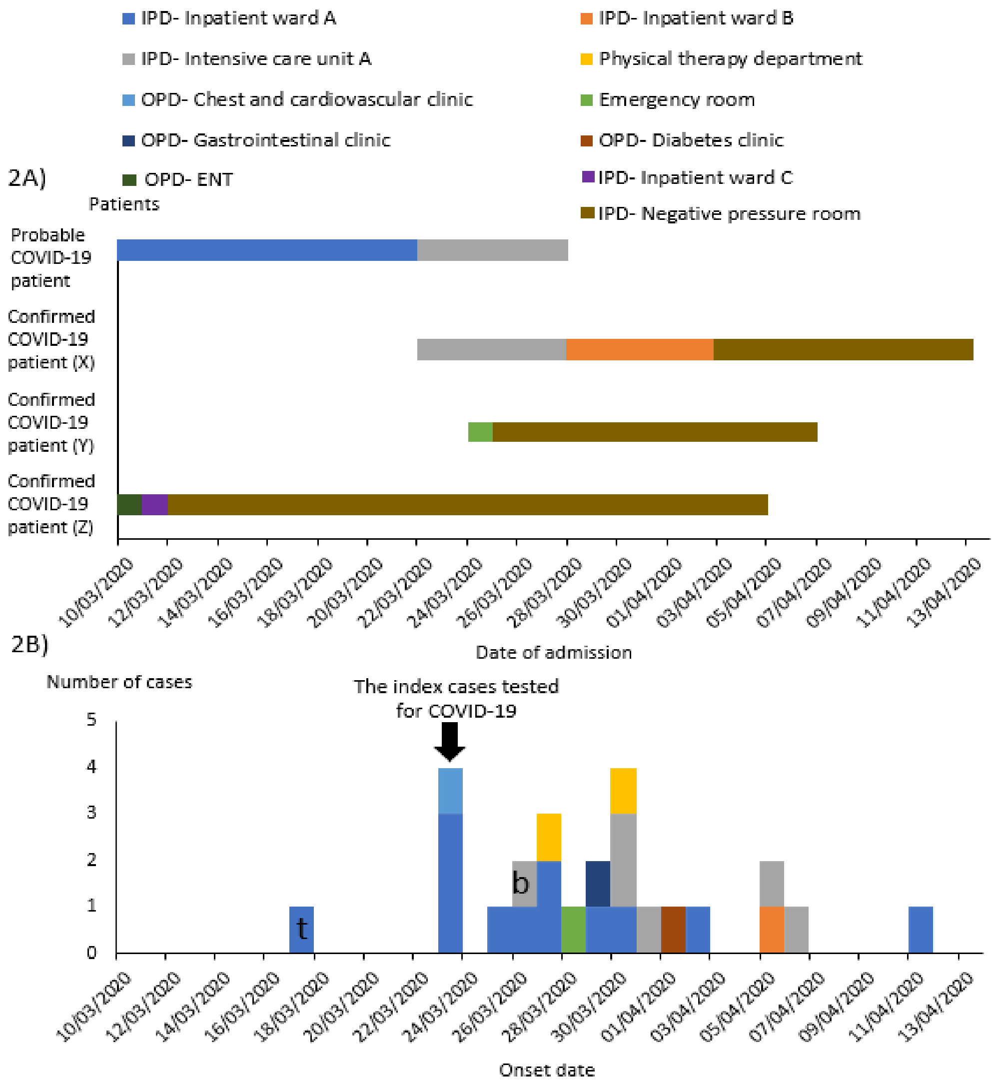

Figure 2A. Duration of probable and confirmed COVID-19 patients admitted to Hospital R classified by hospital subunits between 10 March 2020 - 6 April 2020 (n=4), Figure 2B. Epidemic curve of healthcare personnel with COVID-19 classified by locations, between 10 and 29 March 2020 (n=25)

Note: [t] The Physician P worked at inpatient ward A, intensive care unit A, and OPD-chest and cardiovascular clinic.
[b] The Physician Q worked at intensive care unit A and OPD-chest and cardiovascular clinic.

Discussion

This event was a confirmed COVID-19 outbreak among healthcare personnel in a private hospital, Bangkok, Thailand. The overall attack rate among healthcare personnel was considerably low; however, the specific attack rates in ward A and intensive care unit A were relatively high compared with the previous outbreaks among healthcare personnel in other countries. In China, the attack rate among healthcare staff ranged 2.1-29.0%.[10-12] This might be due to delay in outbreak detection since the first case among healthcare personnel (Physician P) developed the symptoms about one week before the outbreak was detected. In addition, he was still working in several wards during symptomatic period.

In addition, the probable case and Patient X were admitted for several months in the wards which were not designated for COVID-19 patients. The risk of infection was increased by inappropriate or inadequate use of PPE for COVID-19 protection; none of healthcare personnel in wards A and B and intensive care unit A used full PPE, especially N95 mask, face shield, gloves and gown during the outbreak period. Additionally, the likelihood of COVID-19 transmission in healthcare personnel increased with procedures of intubation and nebulizing. Full PPE or at a minimum of N95 mask with face shield are needed for these procedures while surgical facemask is adequate to prevent COVID-19 transmission for routine clinical practices.[9,13,14]

Table 3. Characteristic of work among healthcare personnel with COVID-19 in Hospital R between 10 March 2020 - 29 March 2020 (n=25)

Epidemiological characteristics	Number of cases	(%)
Work time per week		
Less than 40 hours	2	(8.0)
41 to 50 hours	7	(28.0)
51 to 60 hours	4	(16.0)
61 to 70 hours	6	(24.0)
71 to 80 hours	3	(12.0)
More than 80 hours	2	(8.0)
No information	1	(4.0)
Work sections		
Work only at one ward	20	(80.0)
Work more than one ward	5	(20.0)
- Inpatient ward A, IPD- intensive care unit A and OPD- chest and cardiovascular clinic	2	(40.0)
- Inpatient ward A and acute respiratory infection clinic	1	(20.0)
- Inpatient ward A and OPD- medical clinic	1	(20.0)
- Inpatient ward A and othernon-specific wards, depending on assignment	1	(20.0)
Infection prevention and control (IPC) training		
Yes	1	(4.0)
No/Not sure	8	(32.0)
No information	16	(64.0)
Attending COVID-19 conference		
Yes	0	(0.0)
No/Not sure	9	(36.0)
No information	16	(64.0)
Level of PPE		
Cloth mask with gloves	2	(8.0)
Surgical face mask without gloves	4	(16.0)
Surgical face mask with gloves	9	(36.0)
No available information	10	(40.0)

Table 4. Factors associated with COVID-19 among healthcare personnel worked at inpatient ward A and intensive care unit A

Factors	Number of cases (%)[a]	Crude OR	95% CI	Adjusted OR[t]	95% CI
Occupation (n=69)					
Practical nurse	3 (60.0)	8.3	1.1, 60.3*	0.2	0.0, 7.2
Nursing assistant	6 (24.0)	1.7	0.5, 6.2	0.2	0.0, 2.9
Registered nurse	6 (15.4)	Reference		Reference	
Number of wards (n=69)					
Work more than one ward	8 (27.6)	1.8	0.6, 5.7		
Work only at one ward	7 (17.5)	Reference			
Infection prevention and control (IPC) training (n=25)					
Yes	1 (9.1)	0.08	0.0, 0.8 *	0.04	0.0, 0.6*
No/Not sure	8 (57.1)	Reference		Reference	
Level of PPE (n=32)					
Surgical face mask /Clothes mask with glove	6 (60.0)	2.2	0.47, 9.9		
Surgical face mask with gloves	9 (40.9)	Reference			

Note: [a] *Number of cases among exposed participants, * P-value was less than 0.1,* [t] *Twenty-five participants were included in the multiple logistic regression analysis.*

Table 5. PPE use among healthcare personnel working with COVID-19 patients or patients at risk of COVID-19 infection (n=337)

Type of work	PPE level	Number of healthcare personnel (%)
Screening	Appropriate PPE[£] or higher level than recommended PPE	83 (56.8)
Blood specimen collection/ drug injection	Appropriate PPE[¥] or higher level than recommended PPE	66 (71.0)
Sputum suction/drug nebulization	Appropriate PPE[€] or higher level than recommended PPE	26 (33.3)
Cardiopulmonary resuscitation	Appropriate PPE[π] or higher level than recommended PPE	9 (16.1)

Note: [£] *Appropriate PPE for screening included face shield and surgical mask.*

[¥] *Appropriate PPE for blood specimen collection/ drug injection included hairnet, goggles or face shield, surgical mask, gloves, and protective gown.*

[€] *Appropriate PPE for sputum suction/drug nebulization included hairnet, goggles, face shield, at least N-95, gloves, and protective gown.*

[π] *Appropriate PPE for cardiopulmonary resuscitation included hairnet, goggles, face shield, at least N-95, gloves, protective gown, and leg cover.*

IPC training could be useful for protection of infection. IPC training was found to be a significant and independent factor associated with reduced risk of COVID-19 infection in Hospital R. IPC training not only provide knowledge of PPE use, but also includes other activities for healthcare personnel to prevent transmission, including cleaning, hand washing and information on risky medical procedures.[15,16] Our findings were similar to a previous study which suggested that receiving appropriate PPE training reduced risk of COVID-19 infection.[17,18] In addition, our PPE survey suggested that PPE usage in the hospital was mostly inappropriate. Therefore, IPC training, including PPE, should be conducted among healthcare personnel, especially among those dealing with COVID-19 confirmed cases and patients at risk of COVID-19 infection.

There were several limitations. Information bias, including memory recall, might occur in this investigation due to social desirability and long recall period. The routine activities of healthcare personnel during the outbreak period could not be observed; therefore, some risk behaviors might not be captured. As the sample size was small, the power to detect significant risk factors was limited. All contacts were not tested for SARS-CoV-2; therefore, information bias might occur, and magnitude of healthcare personnel infected with COVID-19 might be underestimated. In addition, since whole genome sequencing was not performed, the transmission routes of COVID-19 cases could not be identified.

Recommendations

To control and prevent COVID-19 outbreaks in hospitals, IPC training should be performed among all healthcare personnel, especially physiotherapists, registered nurses, practical nurses and nursing assistants. In addition, all healthcare personnel should monitor their symptoms, have access to PPE, be vigilant to consider COVID-19 infection in patients and protect themselves appropriately, according to the national guidelines by the Ministry of Public Health.

Conclusion

A COVID-19 outbreak was confirmed among healthcare personnel in one hospital. There are important steps that can be taken to protect healthcare personnel from acquisition and transmission of COVID-19 infection including early outbreak detection and access to, and appropriate use of PPE in the health care setting. The most likely source case was patients' cousins or healthcare personnel who worked at risk area. Limiting areas of hospital work by hospital employees and daily screening for respiratory symptoms among healthcare personnel may limit spread within the hospital during outbreaks and detect the outbreak early. IPC training on appropriate PPE use should be provided to all hospital employees, especially those working in COVID-19 risk sections.

Suggested Citation

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Case Screening Criteria for Early Detection of COVID-19 Cases in the First Wave of the Pandemic, Thailand

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Abstract

In response to the emerging threat of a global pandemic, on 4 Jan 2020, Thailand became one of the first countries to activate a national emergency operations center for what was later to be known as the COVID-19 response. On 8 Jan 2020, just four days later, the first COVID-19 case outside of China was detected at an international airport in Thailand. As prompt detection of cases is critical to mitigate transmission, identifying the optimum case screening criteria for RT-PCR testing for SARS-CoV-2 was a priority for the Thai government, but also a challenge given the non-specific symptoms associated with COVID-19. Eight case screening criteria (CSC) were applied over four months. This study describes Thailand's COVID-19 CSC, the validity of individual criteria, and provides acceptable sensitivity for future waves by analyzing retrospective surveillance and laboratory data reported through Thailand's national surveillance system. Between 4 Jan and 26 Apr 2020, 1,209 hospitals reported 53,068 individuals who were laboratory tested for COVID-19. Of these, 20,061 (37.8%) met at least one of the criteria and the number of confirmed cases was 2,922. Each criteria was sensitive to detect confirmed cases (overall sensitivity=83.3%). There were no significant differences between individual criteria ($p>0.05$), and a low positive predictive value (12.1%) indicated that the criteria were broad. The criteria were regularly revised to improve COVID-19 detection and response. The acceptable sensitivity of these criteria should be monitored regularly and should be more than 80% for disease detection and subsequently trigger the immediate response.

Keywords: coronavirus disease, SARS-CoV-2, COVID-19, detection

Introduction

Thailand was among the first countries that detected a coronavirus disease (COVID-19) case outside China after the report of an unusual outbreak of viral pneumonia in Wuhan, China, in December 2019. The Department of Disease Control (DDC), Ministry of Public Health (MOPH) activated the Emergency Operations Center (EOC) for COVID-19 on 4 Jan 2020. In response, the Thai government established an active surveillance system for COVID-19 at 1) ports of entry, including international airports, seaports, and border crossings, 2) government and private hospitals, and 3) in the community.[1] The government also implemented disease screening in government quarantine facilities for Thai people returning from high-risk areas.[1,2]

The initial reports of COVID-19 cases in Thailand were mainly travelers returning from Wuhan, China. Subsequently, local transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) among Thai citizens became the most prominent form of transmission.[1-3] Thus, initially the early detection of imported COVID-19 cases was a priority for Thailand's surveillance and response strategies but later the detection of cases through rapid screening at hospitals and communities became more important to prevent and control widespread community outbreaks. Hence, the case screening criteria (CSC) used to define eligibility for suspect cases to be tested for SARS-CoV-

2 by reverse transcription polymerase chain reaction (RT-PCR) must be routinely reviewed and adjusted to fit the changing epidemiology and context. An optimal CSC can be used to identify COVID-19 cases earlier and more accurately to subsequently reduce the workload of medical staff and save costs, to ensure accuracy of epidemiologic classification, and to hasten control of the outbreak.

In Thailand, the eight criteria of suspect cases were applied during 4 Jan to 26 Apr 2020.[4] The objective of this study was to describe the COVID-19 case screening system, assess the validity of each criteria, and provide acceptable sensitivity in another wave of the pandemic eventuates.

Methods

We retrospectively reviewed various documents, for example, the COVID-19 operation guideline for health personnel and public health officers, daily COVID-19 situation reports, and the Declaration of an Emergency Situation according to the Emergency Decree on Public Administration in Emergency Situation B.E. 2548 (2005), to review case screening procedures, changes in the criteria for suspect cases, and different contexts that affected surveillance for COVID-19. The case screening criteria are summarized in Table 1. We extracted de-identified data of all persons recruited for RT-PCR testing for all suspect and confirmed COVID-19 cases in the DDC COVID-19 National Surveillance Database during 4 Jan to 26 Apr 2020. A person was defined as a suspect COVID-19 case if they met any criteria during the epidemic periods. A confirmed COVID-19 case was defined as any person who tested positive for SARS-CoV-2 from his or her clinical specimen at a national reference laboratory.

The validity and usefulness of the case screening criteria during each epidemic period was assessed by the sensitivity and the positive predictive value. The specificity and the negative predictive value could not be evaluated because there were limitations in the DDC COVID-19 National Surveillance Database.

In the analytic part, we used proportions to present the results of the quantitative study and the Chi-square test was used to assess differences in sensitivity by time.

Results

The Department of Disease Control (DDC), Ministry of Public Health (MOPH) performed a COVID-19 risk assessment and found that Thailand was the top destination for travelers from Wuhan, China.[5-7] Therefore, the DDC activated the Emergency Operations Center (EOC) specifically for COVID-19 on 4 Jan 2020. The COVID-19 surveillance system involved screening 1) at ports of entry, airports, seaports and ground crossings, 2) at government and private hospitals, and 3) in the community.[1] Furthermore, screening was conducted in government quarantine facilities for Thai people returning from high-risk areas. Table 1 summarizes the eight screening criteria used during the study period.[4]

Of the 1,422 hospitals in Thailand, 1,209 (85.0%) reported that 53,068 individuals had been tested for SARS-CoV-2 infection by RT-PCR to the DDC COVID-19 national surveillance system. Of these, 20,061 individuals (37.8%) met criteria of the CSC. There were 2,922 confirmed COVID-19 cases during the study period (Figure 1), resulting in an overall positivity rate of 5.5%. Of the confirmed cases, 59.8% were detected in hospitals, 34.8% in the community (34.3% by contact tracing and 0.5% by active case finding), 4% in government quarantine centers, and 1.4% in international airports. The median age was 36 years (range: 1 month - 91 years) and the ratio of males to females was 1.2:1 (Figure 2). Most were Thai (86.3%), followed by Burmese (1.7%), Chinese (1.1%), French (0.8%), and British (0.8%) nationals. There were 51 deaths resulting in a case fatality rate of 1.7%. All died from respiratory failure, with other contributing causes reported as sepsis (7.8%) and acute renal failure (5.8%).

Case screening criteria (CSC)

CSC 1: 3 to 27 Jan 2020

Individuals suspected of having COVID-19 were recruited for SARS-CoV-2 testing if they met both of the following clinical and epidemiological risk criteria:

1. Clinical criteria: Fever (temperature>38°C), plus at least one acute respiratory tract infection (ARI) symptom such as cough, rhinorrhea, sore throat, or difficult breathing,

2. Epidemiological criteria: Travel from Wuhan within 14 days prior to onset of symptoms.

The COVID-19 screening process at all international airports in Thailand used these criteria for case detection. DDC officers performed the clinical and thermal screening process among all air passengers arriving directly from Wuhan.

The first imported COVID-19 case was detected at Suvarnabhumi international airport on 8 Jan 2020. The case was a 61-year-old Chinese female who lived in Wuhan and developed fever, cough, sore throat and a runny nose on 5 Jan 2020. The total number of cases investigated during this period was 136, of which 8 were confirmed cases (positive rate = 5.9%). The sensitivity of the first case definition was 87.5% and the PPV was 6.5%.

CSC 2 and 3: 28 Jan to 17 Feb 2020

These two screening criteria used the same clinical and epidemiological criteria, so were combined. The evidence of clinical manifestation from the first phase showed that some of the COVID-19 cases in Thailand had mild symptoms. Therefore, the significant changes of the criteria were as follows:

1. Clinical criteria:

1.1 Fever (temperature>37.5°C), or a history of fever, plus at least one ARI symptom as mentioned in CSC 1 and,

1.2 Pneumonia: diagnosed with pneumonia which did not improve after treatment or had an unknown cause or was severe or caused death.

2. Epidemiological criteria:

2.1 Travel from mainland China within 14 days prior to onset of symptoms,

Table 1. Thailand's eight case screening criteria for early detection of COVID-19 (from 4 Jan-26 Apr 2020)

<table>
<tr><th rowspan="2">Case screening criteria</th><th rowspan="2">Completed the criterion when</th><th colspan="2">1. Fever</th><th rowspan="2">2. ARI symptom (at least 1)</th><th colspan="4">3. Pneumonia</th><th rowspan="2">4. Risk area</th><th colspan="2">5. Closed contact</th><th colspan="2">6. Occupations with high COVID-19 risk</th><th colspan="2">7. Cluster of ARI that tested negative for flu</th><th rowspan="2">8. Physician suspected</th></tr>
<tr><th>(1.1) Temp (°C)</th><th>(1.2) History of fever</th><th>(3.1) Not improve after treatment</th><th>(3.2) Unknown cause</th><th>(3.3) Severe case</th><th>(3.4) Unknown cause with dead</th><th>(5.1) Suspect case</th><th>(5.2) Confirmed case</th><th>(6.1) HCW</th><th>(6.2) Others</th><th>(7.1) HCW setting</th><th>(7.2) Other setting</th></tr>
<tr><td>1</td><td>1 and 2 and 4</td><td>≥38</td><td></td><td rowspan="20">Yes</td><td></td><td></td><td></td><td></td><td>Wuhan</td><td></td><td></td><td rowspan="5"></td><td></td><td rowspan="8"></td><td rowspan="8"></td><td rowspan="17"></td></tr>
<tr><td>2</td><td>1 and (2 or 3) and (4 or 5 or 6)</td><td rowspan="13">≥37.5</td><td rowspan="19">Yes</td><td rowspan="19">Yes</td><td rowspan="19">Yes</td><td rowspan="19">Yes</td><td rowspan="19">Yes</td><td rowspan="4">China</td><td rowspan="19">Yes</td><td rowspan="19">Yes</td><td rowspan="13">contact with traveler who came from the risk area</td></tr>
<tr><td rowspan="3">3</td><td>1 and (2 or 3) and (4 or 5 or 6)</td></tr>
<tr><td>3 and 6</td></tr>
<tr><td>3.4</td></tr>
<tr><td rowspan="3">4</td><td>1 and (2 or 3) and (4 or 5 or 6)</td><td rowspan="3">Country with local transmission</td><td rowspan="15">Yes</td></tr>
<tr><td>3 and (5 or 6.1)</td></tr>
<tr><td>3.2 or 3.4</td></tr>
<tr><td rowspan="3">5</td><td>1 and (2 or 3) and (4 or 5 or 6)</td><td rowspan="6">Epidemic area</td><td rowspan="12">≥ 3 cases in the same ward in a week</td><td rowspan="12">≥ 5 cases in the same area in a week</td></tr>
<tr><td>3 and (5 or 6.1)</td></tr>
<tr><td>3.2 or 3.3 or 3.4 or 7</td></tr>
<tr><td rowspan="3">6</td><td>1 and 2 and (4 or 5 or 6)</td></tr>
<tr><td>3 and 6.1</td></tr>
<tr><td>3.1 or 3.2 or 3.3 or 3.4 or 7</td></tr>
<tr><td rowspan="3">7</td><td>1 and (2 or 3) and (4 or 5 or 6)</td><td rowspan="6">≥37.5 (≥ 37.3 for PoE)</td><td rowspan="6">Epidemic area (all international flight)</td><td rowspan="6">contact with traveller / crowded area</td></tr>
<tr><td>6 with any symptom</td></tr>
<tr><td>3.1 or 3.2 or 3.3 or 3.4 or 7</td></tr>
<tr><td rowspan="3">8</td><td>1 and (2 or 3) and (4 or 5 or 6)</td><td rowspan="3">Yes</td></tr>
<tr><td>6 and (5 or 8)</td></tr>
<tr><td>3.1 or 3.2 or 3.3 or 3.4 or 7</td></tr>
</table>

Note: ARI: Acute respiratory infection, HCW: Health care worker, POE: Person of interest, Temp: Temperature

2.2 Close contact with a suspect/confirmed COVID-19 case within 14 days prior to onset of symptoms.

A total of 566 individuals were tested for COVID-19 using RT-PCR, 27 of whom were confirmed cases (positive rate=4.8%). The sensitivity of the CSC during this period was 85.1% and the PPV was 4.1%.

CSC 4: 18 Feb to 1 Mar 2020

On 30 Jan 2020, the World Health Organization (WHO) declared the COVID-19 pandemic a public health emergency of international concern to accelerate preparedness and response in all countries.[1,3] At this stage, the disease was spreading in many countries in East and South-East Asia and caused the CDC to change their CSC. The high-risk areas during this period were those countries with evidence of local transmission such as China (including Hong Kong, Macao, and Taiwan), Japan, and Singapore. Healthcare workers were also classified as a high-risk population. The number of people who were tested with RT-PCR during this period was 2,380, of which seven were confirmed cases (positive rate=0.3%). The sensitivity was 85.7% and the PPV was 0.3%.

On 1 Mar 2020, the Thai government announced that COVID-19 was a dangerous communicable disease under the Communicable Diseases ACT 2015 (B.E. 2558).[1,2]

CSC 5: 2 to 19 Mar 2020

After local transmission was observed in Thailand.[1,3] the EOC modified the screening criteria by including in the list of people to be screened, those who were living or had lived in the same residential area with travelers from a high-risk area or in an area with a cluster of ARI (not influenza outbreak). During this period, territories outside Thailand were defined as Disease Infected Zones of COVID-19, dated 5 Mar 2020, and included North Korea, China (including Macau and Hong Kong), Italy, and Iran. The list also included countries in which there was evidence of local transmission. Consequently, 5,477 people were tested for COVID-19, of which 230 were confirmed cases (positive rate= 4.2%). The sensitivity of the fifth CSC was 83.9% and the PPV was 4.2%.

CSC 6: 20 Mar to 2 Apr 2020

In mid-March, two large clusters of COVID-19 were detected one at a boxing stadium, which contained 274 confirmed cases, and the other at a nightspot, which contained 224 confirmed cases. Those who were later identified as high-risk contacts had already traveled back to their hometown provinces, thus spreading the virus throughout the country, and the number of confirmed cases rose rapidly. The Office of the Prime Minister announced the Decree on Public Administration in Emergency Situation B.E. 2548 (2005) on 25 Mar 2020.[2] There were 13,724 people who were investigated, of which 1,603 were confirmed cases (positive rate=11.7%). The sensitivity of this criteria was 87.5% and the PPV was 17.8%.

CSC 7 and 8:3 to 26 Apr 2020

After the infection had begun spreading more rapidly, the government decided to impose a lock-down order on the entire country on 3 Apr 2020. Traveling was restricted to those whose entry into the kingdom was deemed necessary. The essential travel documents required for entering Thailand were 1) The Fit to Fly Health Certificate that had been certified or issued no more than 72 hours before traveling, and 2) a letter from the Royal Thai Embassy at the country of origin. The law allowed non-Thai nationals who met some specific conditions to enter the country, for example, persons on diplomatic or consular missions, those under international organizations or representatives of the government performing their duties in Thailand, other persons or international agencies, including their families, that the Ministry of Foreign Affairs deemed necessary, and people who had work permits or had been granted permission from government agencies to work in Thailand. Upon entry into the country, people were told to strictly comply with disease prevention and control measures prescribed by the government such as quarantine for 14 days at a government-designated place.[1,2]

Therefore, the new screening criteria during this period included all inbound travelers. The seventh case screening criteria was in effect for only a few days before the eighth criteria was added, and as the change was minor, we combined them. After the country had been locked down and the MOPH had activated the active case finding activity nationwide to prevent the COVID-19 spreading as much as possible, 30,785 people were screened, of which 1,047 were confirmed cases (positive rate=3.4%). The sensitivity of this criteria was 76.6% and the PPV was 15.2%.

Overall, the sensitivity and PPV of these eight case screening criteria was 83.3% and 12.1%, respectively.

There were no significant differences between sensitivities and PPV of individual criteria (p>0.05).

Discussion

Eight case screening criteria which had been used in each epidemic phase were relatively sensitive to detect COVID-19 cases at a good level. Although, the CSC were expanded in order to detect more cases but the sensitivity over time period was not increasing. This point was important to be aware that there might be a large number of asymptomatic COVID-19 cases in the community. The positive predictive value of these eight CSC was small indicated that the criteria for disease investigation were broad and might reflect the low incidence of COVID-19. Moreover, many people had been tested for SAR-CoV-2, even they did not meet the CSC. Therefore, we are quite confident that the overall incidence of COVID-19 from January to April 2020 was relatively low in Thailand. However, in order to know the incidence close to reality as possible, the seroprevalence survey or special surveillance may be conducted, e.g. sentinel surveillance among high risk population.

Figure 1. Epidemic curve of confirmed cases during the COVID-19 pandemic in Thailand (4 Jan to 26 Apr 2020)

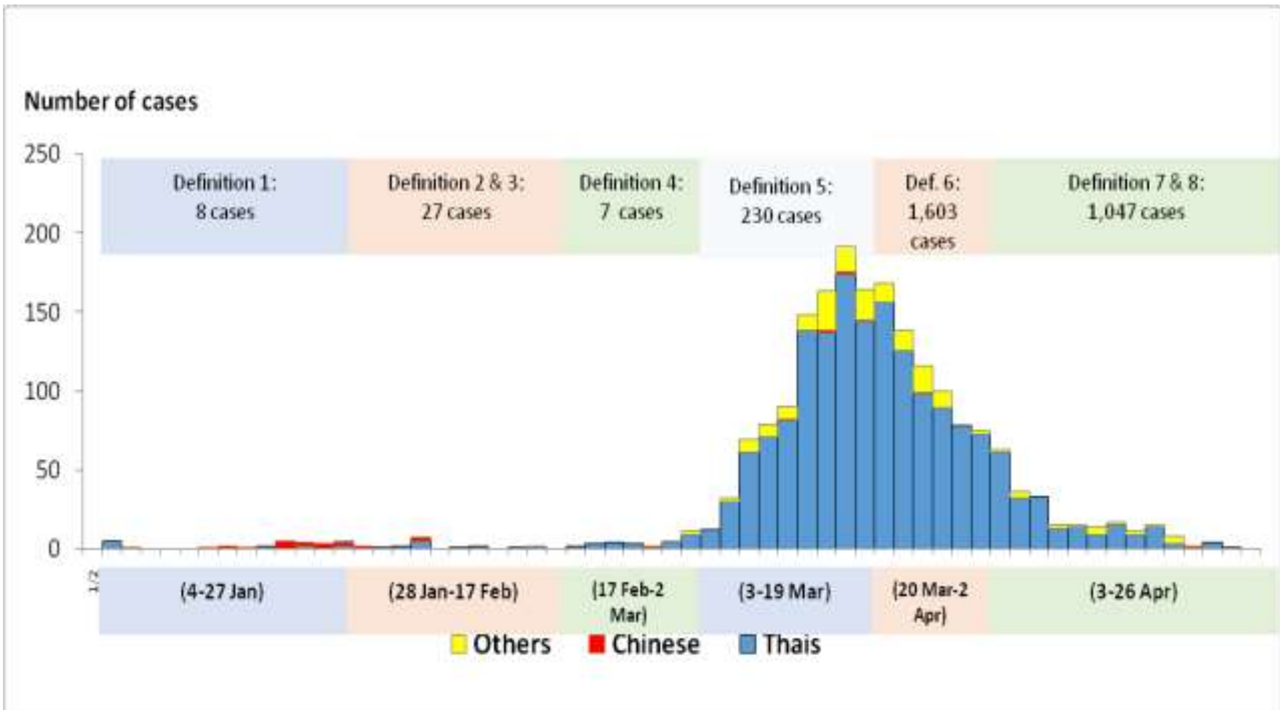
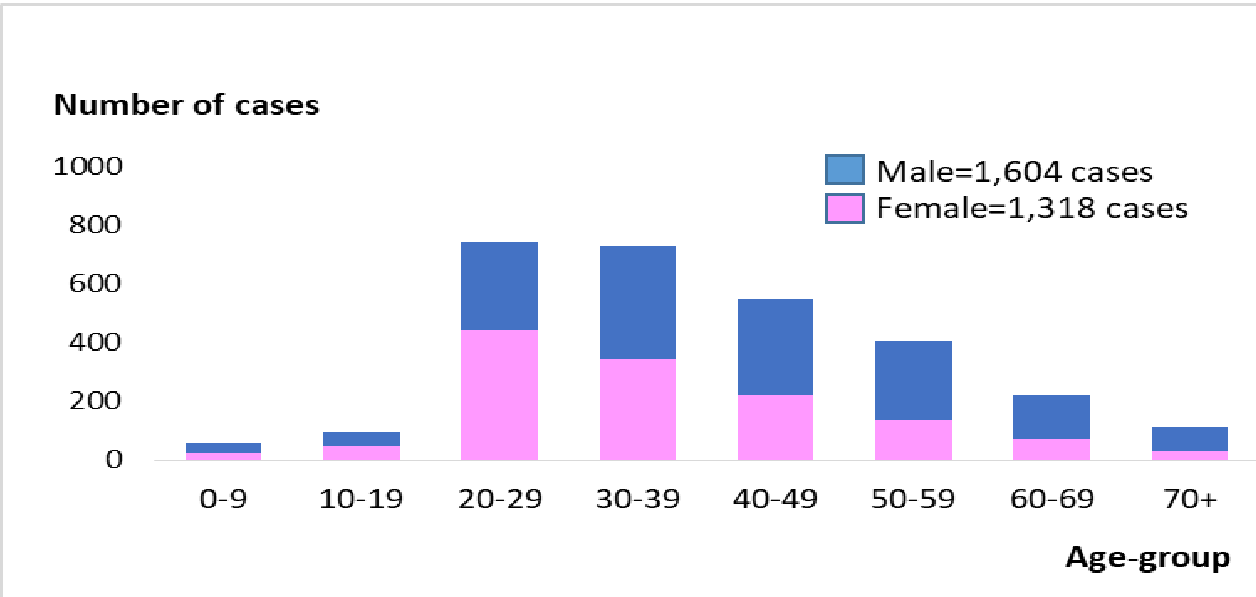


Figure 2. Number of confirmed cases by age-group and gender (4 Jan to 26 Apr 2020)



Overall, the surveillance system was able to detect COVID-19 cases, the CSC in each context of the situation was suitable for COVID-19 that required a highly sensitive tool for early detection.[8,9] because the disease can spread even the infected individuals had mild symptoms.[10,11] The data from the COVID-19 national surveillance system was brought back to improve the surveillance system all the time and was used to plan and formulate strategies for disease prevention and control as well as resource management, e.g. personal protective equipment procurement and distribution.

It was clear that the first phase of the pandemic of Thailand, most COVID-19 patients were imported from China. After the central government of China imposed a lockdown in Wuhan and other cities in Hubei, the number of cases in Thailand was declined.[1,12,13] In the later phase, most of the cases were Thais. The first wave of the COVID-19 pandemic peaked in March 2020. The number of cases was rising rapidly due to boxing stadium and nightspot outbreak which were mass gathering places, similar to many events that mass gathering activities were highly visible events with the potential for infectious disease spreading.[14] After the government expropriated a lock-down order on the entire country, the number of COVID-19 cases was declined rapidly. The intervention was designed by the guidance of surveillance information that detected a rise of COVID-19 cases rapidly and timely, by context specific CSC, and the information from surveillance system that helped to identify problems and risk factors. As a result, the government was able to launch effective prevention and control measures suitable to the situation that contribute toa successful control of epidemic. From this study the acceptable sensitivity of CSC should be more than 80%.

Limitations

There were some biases when validity of each case screening criteria was compared due to dynamic of epidemic and lock-down measure. Thus, this study assumed that all population recruited between 4 Jan to 26 Apr 2020 were from the same setting. This study would like to compare both sensitivity and specificity to demonstrate the acceptable case screening criteria in which Thailand can afford using available resources for laboratory testing. However, the DDC COVID-19 National Surveillance Database did not collect data of people who did not meet the CSC so the specificity and negative predictive value could not be evaluated. In early period of pandemic, some data were not collected therefore these missing data might lead to analysis bias. For example, data on loss of smell was not collected thus we might loss some COVID-19 case.

Conclusion

Each case screening criteria (CSC) was sensitive and broad to detect confirmed cases. Overall sensitivity was 83.3% and overall PPV was 12.1%, and no significant difference between individual criteria. The CSC were regularly revised to improve the performance of surveillance system. Although the epidemic in each period was controlled without direct correlation to the sensitivity of CSC. But the sensitivity level of CSC may be used for the surveillance's performance monitoring and to trigger the immediate response in the next wave of COVID-19 epidemic that may occur if prevention measures especially country locks down was removed as it occurred in other countries.[1,3,15] From this study the acceptable sensitivity of CSC should be more than 80%.

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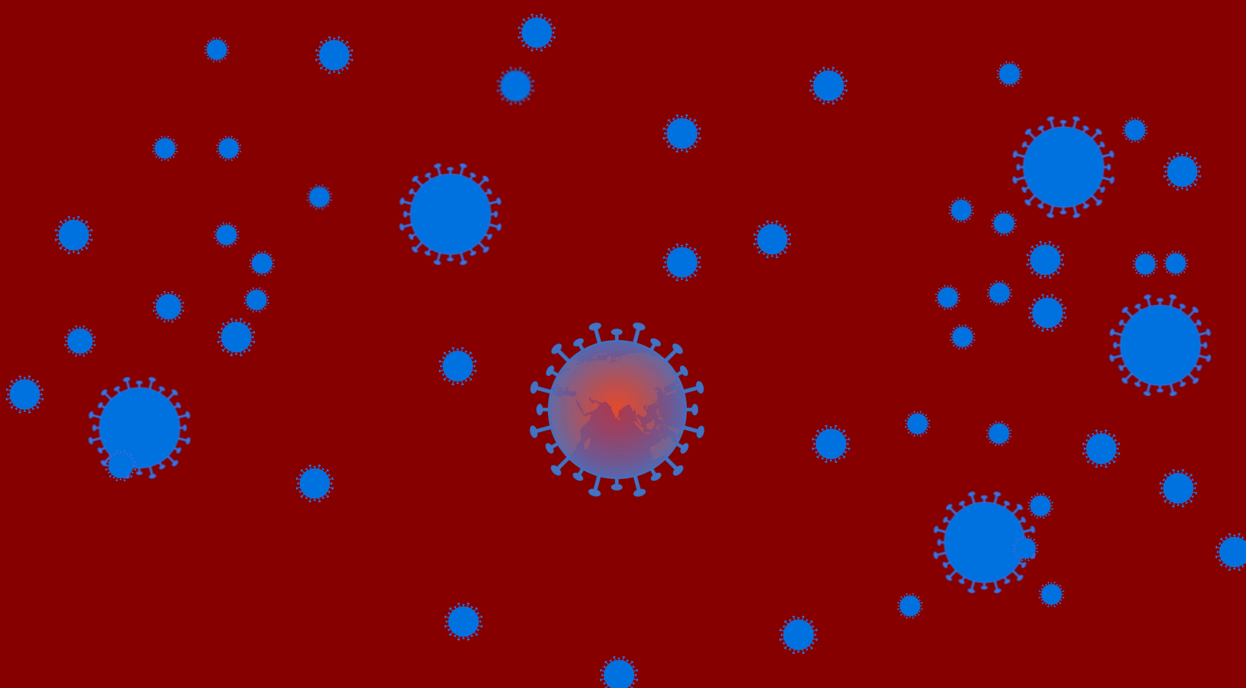

Outbreak, Surveillance,
Investigation and Response