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COVID-19 Impact on Event-based Public Health Surveillance, Thailand, 2019 – 2021

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Abstract

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Introduction

Thailand established event-based (EBS) public health surveillance (PHS) to support indicator-based PHS as the foundation of a national effort, with the goal of contributing to the early detection and response to acute public health events. As a result of the COVID-19 epidemic, other infectious disease PHS was disrupted. This study examined EBS from Thailand's Department of Disease Control (DDC) to evaluate the effect of the COVID-19 pandemic.

Methods

The EBS database of the Thai DDC from Jan 1, 2019 to Dec 31, 2021 was analyzed. I manually reviewed each event to identify specific diseases and arrange them in the appropriate disease category. Then, I determined the percentage change of each pairwise comparison (2019 vs 2020, 2019 vs 2021, and 2020 vs 2021) as well as selected several diseases that would most likely be affected by COVID-19 to determine the reported change during 2019 – 2021.

Results

During the pandemic, there were 44% fewer events reported in 2020 and 34% fewer events reported in 2021 to the EBS of the Thai DDC than before the pandemic (2019). Most disease categories experienced a decline in notification in 2020, except for injury, which increased due to a flood. Comparing 2019 to 2021, there was a 36% increase in vaccine-preventable diseases and 28% increase in others. Specifically, adverse effects following immunization and cardiovascular diseases were reported in greater numbers linked to the COVID-19 vaccination campaign, which began in 2021.

Discussion

The COVID-19 pandemic had an impact on other diseases reported to EBS of Thailand. The EBS platform should be modified to reduce redundant work and enhance its capacity to reflect the real disease occurrence. Further studies should explore the association between each region health authority and the number of event reports. This may aid in determining the most affected area from the pandemic that may require support.

Keywords

Public health surveillance, Event-based public health surveillance, Thailand, COVID-19

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Acronyms

COVID-19	Coronavirus disease 2019
DDC	Department of Disease Control
DOE	Division of Epidemiology
EBS	Evidence-based public health surveillance
EOC	Emergency Operation Center
HDC	Health data center
IBS	Indicator-based public health surveillance
IS	Injury public health surveillance
MoPH	Ministry of Public Health
NCDs	Non-communicable diseases
NNDSS	Nationally Notifiable Disease Surveillance System
PHS	Public health surveillance
R506	National communicable public health surveillance of Thailand
SRRT	Surveillance and Rapid Response Team
UA	Under-ascertainment
UE	Underestimate
UR	Underreporting

Chapter 1: introduction

A. Background

Public health surveillance (PHS) is defined as the *ongoing, systematic collection, analysis, and interpretation of health-related data essential to planning, implementation, and evaluation of public health practice.* [1] PHS data from diseases and geographic areas are critical to determining the relevance of a health occurrence. [2]

PHS has objectives depending on what health-related outcome is monitored. The principle is that different public health objectives and actions require different information systems. The type of PHS should be determined by the type of action that can be taken, when or how frequently that action needs to be taken, what information is required to complete or monitor the action, and when or how often the information is required.

For example, if the purpose is to avoid the transmission of acute infectious diseases (e.g., SARS) professionals must act quickly to stop spread. They require a PHS infrastructure that guarantees early detection data from health centers and laboratories. Chronic diseases or other health-related behaviors, on the other hand, develop over time. Professionals typically evaluate the effectiveness of programs to modify risky behaviors (e.g., tobacco smoking or chronic diseases) once-a-year or less frequently. The core concept of PHS is that it must be designed and managed in a manner that provides valid (true) information to decision-makers in a timely and cost-effective manner. [3]

Establishing and maintaining PHS systems requires political commitment as well as human and financial resources. Every public health system must motivate and develop the capability of public health employees to offer effective public health services. There are six steps to putting the system in place: 1) Set goals; 2) Create case definitions; 3) Hire the right people; 4) Get the right tools and clearances for data collection, analysis, and distribution; 5) Put the PHS system in place; 6) Evaluate the PHS activities. Because the system must adjust to demographic change as well as the physical and social environment on a continuous basis, these phases are intertwined. [3]

Thailand established event-based PHS (EBS) in 2011 to detect and respond to clusters of unexpected threats. [4] The goals of EBS are to: 1) detect new or rare events that are not covered by indicator-based PHS (IBS); 2) detect diseases or syndromes within the context of IBS that occur in populations not normally accessible to basic health care; 3) improve the efficacy of IBS. [5,6] EBS is proceeded by Surveillance and Rapid Response Team (SRRT) which is also responsible for outbreak containment in each area [4] as a frontline public health workforce.
COVID-19 (coronavirus disease 2019) is caused by the SARS-CoV-2 virus discovered in Wuhan, China Dec 2019. It is highly contagious and rapidly spread throughout the world. [7]
Thailand was the first rank destination of international air travel from Wuhan. [8] Thailand set up the Emergency Operation Center (EOC) to respond to COVID-19 beginning Jan 4, 2020. [9] During public health emergencies, regular public health services may be disrupted. [10–12] Epidemiologists and other public health practitioners respond to public health threats through PHS (e.g., testing), investigation (e.g., contact tracing), and prevention (e.g., vaccination programs) among other responsibilities. [13] In terms of PHS, other infectious disease reporting had been disrupted as a result of the COVID-19 epidemic. [14]
The COVID-19 outbreak had a negative impact on global healthcare systems, with repercussions throughout every aspect of human life, including social and economic costs. Social distancing, self-isolation, and travel restrictions resulted in a reduced workforce across all sectors of the economy, resulting in the loss of many jobs. [15] In contrast with the health sectors, despite the growing need for robust public health infrastructure, chronic insufficient funding, workforce shortages, and aging infrastructure limit the sector's ability to address existing population health needs as well as its flexibility in responding to emergency situations. [16] The pandemic has exacerbated a burnout crisis among frontline medical staff as well as it has been disastrous for the mental health of public health workers – the data analysts and policy advisers whose recommendations are supposed to shape the nation's pandemic response. [17]
Pandemics have a short-term economic effect as well as a long-term economic impact on countries all over the world. Quarantine is being imposed, health facilities are being prepared, infectious cases are being isolated, and contacts are being traced, all of which require public health resources, human resources, and

operational costs. It also includes health-system expenditures for providing health-care services to infectious cases, as well as the procurement of essential items such as antibiotics, medical supplies, and personal protective equipment. [18]

I will explore the EBS from the Department of Disease Control (DDC) of Thailand to compare the impacts of the COVID-19 pandemic. Monitoring public health trends and disease outbreaks require effective and reliable PHS and notification systems. [19] Underestimation (UE) refers to the various ways in which PHS fail or are unable to capture all events in a given population. UE is the number of events estimated to have occurred in a community but not captured by PHS for each reported case over a given period. The UE of PHS is divided into two distinct levels: under-ascertainment (UA) occurring at the community and underreporting (UR) occurring at the healthcare levels. UA occurs in people who do not seek medical treatment, while UR can be calculated as the number of patients attending healthcare services whose health event is not reported to the appropriate public health body by their health care provider. [20] The presence of UE obscures the true magnitude of disease incidence and decreases the efficiency of the notification system and PHS ability. [21]

B. Problem Statement

EBS is one of two basic types of PHS used to monitor and locate infectious diseases and other public health events. EBS examines reports, stories, rumors, and other information regarding health incidents that may pose a major threat to public health. EBS supports IBS, the backbone of national PHS and aims to contribute to the rapid detection of acute public health events. [22]

Thailand's EBS was established and operated by a moderate system that relied heavily on public health workers known as SRRT to notify and report on events in the region. Furthermore, these public health workers are the frontline workers responding to outbreak investigations. [4]

Since the beginning of 2020, public health authorities and healthcare providers have had to prioritize their work toward COVID-19 management in response to the pandemic. [23] The COVID-19 pandemic has also caused significant changes in population behavior in the United States; for example, potentially altering patterns of exposure to other infectious illnesses. [24] Furthermore, healthcare seeking behavior has shifted dramatically which is likely to be complex, and could be linked to a reluctance to visit health-care institutions due to fears of contracting COVID-19. [25]

Despite COVID-19 PHS prominence, other disease outbreaks must not be disregarded. As a result, we must identify the effects of the COVID-19 pandemic on EBS in Thailand. This impact should be identified to determine the effectiveness of EBS during the pandemic, whether it reflects the actual situation or whether it underreports during the epidemic due to overburdened healthcare and public health professionals.

C. Purpose Statement

The goal is to describe the occurrence of disease reported to EBS in the DDC, Thailand, before and during the COVID-19 pandemic. I will explore every event reported in the EBS, but the focus will be on the reported events of interest that would most likely be affected by COVID-19 such as respiratory diseases (e.g., influenza), contact diseases (e.g., hand-foot-mouth disease), food-borne diseases (e.g., acute diarrhea/ food poisoning), vaccine-preventable diseases (e.g., pertussis, measles), etc. in the EBS during Jan 2019 – Dec 2019 (before the pandemic) comparing to Jan 2020 – Dec 2021 (during the pandemic) at the national level.

D. Research Question and Hypothesis

Research question: Is there a difference of occurrence of diseases reported to EBS of DDC, Thailand, before and during the COVID-19 pandemic?

Null hypothesis: There is no difference of occurrence of diseases reported to EBS of DDC, Thailand, before and during the COVID-19 pandemic.

E. Significance

It is crucial to have an exact count of the number of health threats in any country to assess the national and global burden as well as to determine resources required for each country to combat the epidemic now and in the future. [26] Thailand established EBS to support IBS, the foundation of national PHS and to attempt early detection of acute public health crises. [22] Even during normal times in a developed province in China, almost a quarter of tuberculosis cases reported in internal hospital records were not put into the national tuberculosis reporting systems, resulting in an underrepresentation of national tuberculosis burden. Unqualified and overworked health staff, inadequate oversight and accountability at the local and national levels, and a sophisticated incoherent health information management system were all factors related with underreporting. [26] As a result, during the COVID-19 epidemic, it is apparent that health personnel are overwhelmed to respond to the pandemic. This issue may have occurred with the EBS database, which must be identified and ensured that the EBS is still functioning to offer information to decision-makers for public health initiatives on a consistent basis. Other diseases continue to occur on a regular basis during the pandemic.

Chapter 2: Literature Review

Public Health Surveillance in Thailand

In 2013, Thailand's DDC revised its operating structure, identifying 12 key duties of the national health authority, one of which is national PHS. PHS consists of four main aspects: diseases and health threats, health promotion, food, drugs and health products, and health services. DDC is in charge of the diseases and health threats that is composed of five major health issues: 1) communicable diseases, 2) HIV/AIDS and tuberculosis, 3) non-communicable diseases (NCDs), 4) injury, and 5) environmental and occupational diseases. Each must have at least five dimensions of PHS: determinants; behavioral risk; program response; infection/morbidity/mortality/disability; and abnormal event and outbreaks. [27] The abnormal event and outbreak also known as the EBS which I will go deeper to this dimension later.

Regarding the five major health issues and five dimensions of PHS, The Thai DDC operated six major PHS systems in Thailand as following:

1) Communicable PHS (R506) [28] is the main communicable disease PHS in Thailand, established in 1968 starting from 14 diseases to 71 diseases in the system at this moment. It acts as a national IBS of Thailand. The data sources come from district and provincial hospitals as well as subdistrict primary care units across Thailand. The Bureau of Epidemiology, at central level, provided a free access for aggregated information of this PHS data through its website (http://doe.moph.go.th/surdata/index.php).

2) HIV/AIDS and tuberculosis PHS [29,30] integrated the data in the hospital information system into health data center (HDC). The DDC collaborated with Information and Communications Technology Center of Ministry of Public Health (MoPH) developed the AIDS Epidemic Intelligence Information System to storage the data reporting from HDC which related to HIV/AIDS and tuberculosis in order to analyze and report the current situation of HIV infection and its consequence.

3) NCDs PHS is very complex because of multi-factors: physiology, socio-economic of each level - individuals, community and society – including the different of specific disease PHS. [27] For example, the morbidity and mortality PHS system, which relies on data from the national health information system, an electronic database that collects patient data from all government hospitals in order to track public healthcare

outcomes, determine mortality and morbidity, and epidemiological characteristics of NCDs patients. [31] The Behavioral factors surveillance system [32] was the huge survey among Thai population aged 15-75 years conducing every three years in sentinel provinces. The data of this survey is crucial to reflect the behavioral risks that cause NCDs.

4) Injury PHS (IS) [33] began in 1993 as the Provincial Injury PHS System and was developed in five main hospitals across Thailand in 1995, one in Bangkok and four in other important cities. Currently, there are around 33 hospitals in Thailand that are part of a sentinel hospital-based PHS system. IS is a critical PHS system for road traffic and other injuries that captures risky behaviors that lead to injury and death. [34] Many injuries data were collected into the IS: accidents (transportation and non-transportation), self-harm, assault, unintended injuries, and legal intervention/war. EBS was one of the database of IS. [27]

5) Environmental and occupational disease PHS [27] defined three health problems under PHS as: diseases related to agricultural activities, diseases related to industrial activities, and diseases related to pollutions. The data sources consist of health data and environmental data. The health data can be acquired using a variety of methods, including national electronic health record, R506/2, injury PHS, EBS, routine employee's health check-up, etc. The environmental data can be obtained by looking at different types of working places and chemicals use such as pesticides.

6) EBS [4] had been established in 2011 to collect abnormal events, including communicable diseases, injury, environmental and occupational threats such as chemical leakage, floods, as well as any abnormal events and disease outbreak in animals. It has the potential to improve timeliness of the response and complement the existing surveillance system.

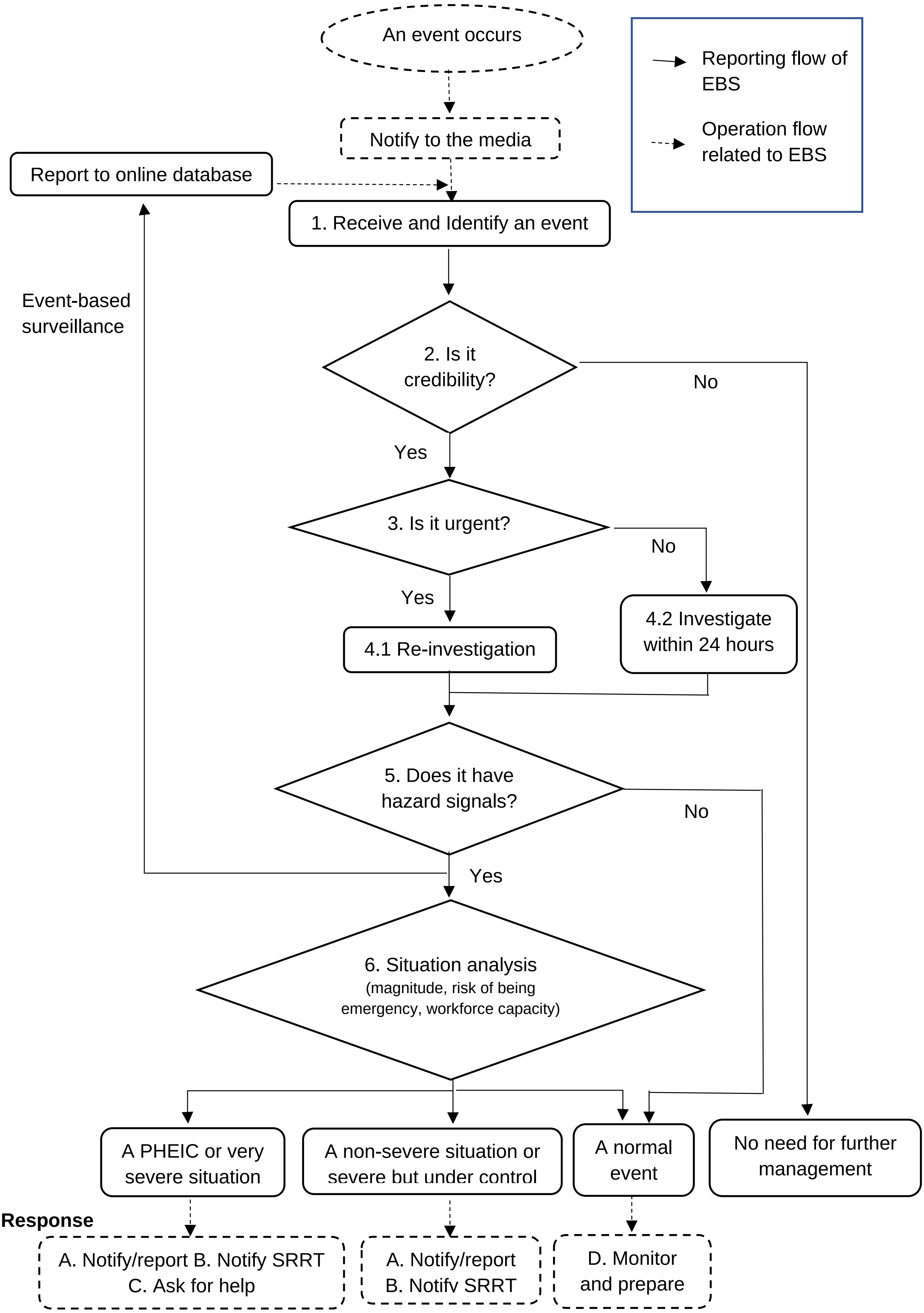
Establishing Event-based PHS reporting system in Thailand

Since 2001, the Division of Epidemiology (DOE) has developed a central investigation team that verifies news and information. At the time, the urgency disease reporting system had detected 114 outbreak events, 40 news from the provincial health office, 28 news from newspapers/televisions, 15 news from other MoPH departments, and 19 news from people who had connections with the officers of the DOE. [35]

The Surveillance and Rapid Response Team (SRRT) was established in 2009 to act as a public health workforce that is responsible for EBS as part of their disease PHS capabilities. In late 2010, an event reporting course and instructor capacity building were constructed in order to train the SRRT at the sub-district level. The majority of SRRT members are village health volunteers, and they are a useful source of information in the community. Finally, the EBS system was officially set in 2011 under the supervision of the Thai DDC [4]. Currently, the SRRT has since grown into a national network of epidemiologists, public health officers, and nurses. The teams are in charge of monitoring, investigating outbreaks, and containing infectious diseases such as dengue, acute flaccid paralysis, measles, the Zika virus, and food poisoning. [36]

The EBS reporting system [4] in Thailand might start with any anyone who encounters an unusual incident and reports it to the media. When the agent receives the alerts and identifies the event, they will determine if it is a rumor or an actual occurrence. The urgency of the event would then be determined, and it would be re-examined if it is an urgent event. Following that, the hazard signals would be analyzed, and the event would be reported into an online database of EBS, as well as the situation evaluation (magnitude, risk of being an emergency, workforce capacity) would begin. Finally, the event would be categorized into 3 levels: 1) a Public Health Emergency of International Concern (PHEIC) or the most severe condition, 2) a non-severe or severe but under control crisis, and 3) a normal event. The response varied depending on its degree, range from only preparing and monitoring, to notifying SRRT, and risk communication/reporting. **(Figure 1)**

Figure 1. Event-based Public Health Surveillance Reporting System, Thailand, 2014 – 2021



A successful PHS system should not only gather data at the central level but should also use PHS data at the local level. Furthermore, the vast majority of the data (90 percent) came from the municipal level. As a result, every local unit should be able to collect, analyze, report, and use PHS data in order to prevent and control diseases and health concerns in the community. One of the most critical factors in ensuring that the PHS system achieves its objectives is the workforce. [27]

COVID-19 emerging in Thailand and its impacts on public health

Since COVID-19 was discovered in Wuhan, China in Dec 2019, Thailand has begun screening travelers from Wuhan, China upon arrival at the Suvarnabhumi, Don Mueang, Phuket, and Chiang Mai international airports beginning Jan 3, 2020. [9] As the disease spread, the Thai MoPH expanded its PHS procedures on Jan 22, 2020, by implementing the highest level of precautionary measures and expanding the EOC in response to the influx of inbound Chinese tourists expected to arrive during the Chinese New Year Festival celebration. [37]

The advent of COVID-19 has emerged as the most threatening global health issue, necessitating the prompt response of medical and public health professionals. The Thai government deployed healthcare workers, mostly nurses and public health officers, to help collect nasal swabs from all Thai and non-Thai visitors at points of entry (air, land, and sea ports) for laboratory analysis, as well as take histories for the test-and-trace system. Workers were also positioned to manage, supervise, and provide services to case contacts at the 14-day quarantine sites. These services included daily clinical monitoring, specimen collection for laboratory testing (on days 3 – 5 and 11 – 13), and hospitalization of all positive cases in accordance with the national protocol. [36] These duties increase the routine work of health workforce and burden their lives. As well as the public health workforce, the SRRTs have been the primary contributors to public health function; by 2020, Thailand would have around 1000 such teams distributed across the public health ministry, provincial health offices, and all district hospitals [38] Although the Thai government has numerous strategies in place to reduce COVID-19 mortality in a timely manner, combining the function and quality of the Thai public health system should also be studied and implemented to avoid the health system being overburdened. [36]

Related studies

PHS systems for communicable diseases rely on fast and accurate case reporting. Cases that match the criteria for state or national case definitions are identified and reported by the systems. [39] At numerous situations, the ongoing COVID-19 pandemic had the potential to affect communicable diseases reporting. Changes in exposure, diagnostic testing, reporting to public health organizations, and public health investigations would all be addressed. Individuals who limit their activities may be less likely to be exposed to communicable diseases. Closing schools and public places could lessen the danger of respiratory infections like influenza and pertussis spreading. Restaurant closures may help to prevent large outbreaks of foodborne illness. Reduced local and foreign travel could result in a reduction in a variety of risks.

There were fewer in-person visits to healthcare facilities because of the pandemic, even for non-respiratory symptoms. Each report details the efforts of the local health authority. In Washington, for example, approximately 200,000 verified COVID-19 cases were reported in 2020, a 40-fold increase in workload. Local health jurisdictions that are primarily focused on COVID-19 may not have the resources to investigate other types of cases. Another effect was the temporary suspension of Public Health Laboratories' strain typing capacity, which made it difficult to detect outbreaks. [39]

I reviewed the literature on COVID-19 and its impact on PHS. Even though most studies claimed that COVID-19 reduced the number of other diseases reported and attributed this to control measures and limitations on people's mobility, some studies revealed that some diseases had increased. These literatures included any type of PHS system, such as IBS, which is typically a national PHS in each country, with no geographical or disease restrictions.

Crane *et* al. examined data on 42 Nationally Notifiable Disease Surveillance System (NNDSS) reported human diseases from 2015 to 2021 which were operated by the Centers for Disease Control and Prevention. According to their findings, reporting of infectious diseases apart from COVID-19 has decreased significantly throughout the COVID-19 pandemic. This decrease varies by transmission route, reporting state, and COVID-19 incidence at the time of reporting. The respiratory diseases had the biggest percentage decrease in reporting compared to 2019 levels (50.7 %), followed by injection drug use–associated diseases (47.2 %), vector-borne diseases (43.6 %), foodborne/waterborne diseases (39.7 %), and sexually transmitted diseases (9.7 %).

These findings highlight the importance of robust PHS in the aftermath of the COVID-19 pandemic in order to respond to potentially unknown patterns of disease transmission. Furthermore, emphasizing the importance of ongoing investment in routine PHS efforts despite pandemic conditions. [14]

Bright *et* al. extracted data from NNDSS of Australia during 2015 – 2020. They selected several diseases that would most likely be affected on NNDSS notification by COVID-19 related public health measures and categorized them as: social diseases (influenza, chlamydia, infectious syphilis, rotavirus), imported diseases (measles, dengue), and foodborne disease (salmonellosis). There were 50% fewer notifications reported to the NNDSS in the first six months of 2020 (1 Jan to 30 Jun) than in the same period in 2019, and 20% fewer notifications than the 5-year (2015 – 2019) average. The majority of notifiable illnesses and disorders showed decreases. A small number of notifiable diseases, including Barmah Forest virus infection, Ross River virus infection, and legionellosis, saw an increase in notifications.

According to this study, COVID-19 public health measures such as physical separation, an emphasis on sanitation, and travel limitations are likely to have influenced the number of notifications sent to the NNDSS. However, other factors, such as changes in laboratory testing priorities, redirection of resources to the COVID-19 response, changes in health-seeking behaviors, increased use of telehealth practices, and financial impacts such as lack of income and ability to afford healthcare, will have also influenced notification quantities. [40]

Adegbija *et* al. described a report on communicable disease PHS in Central Queensland (CQ) for six months (1 Apr to 30 Sep 2020) following the implementation of physical distance and broader lockdown measures in Queensland, Australia. The numbers of all notifiable communicable diseases were retrieved from the Queensland Notifiable Conditions System, an online epidemiological database, from 1 Jan 2015 to 30 Sep 2020. Blood-borne viruses, gastrointestinal disorders, sexually transmissible infections, vaccine-preventable diseases, vector-borne diseases, zoonotic diseases, and other diseases were among the diseases studied. The count for each disease for the six months following the implementation of COVID-19 public health measures (1 Apr to 30 Sep 2020) was compared to the average for the same six-month period from 2015 to 2019. From 1 Apr to 30 Sep 2020, following the implementation of Queensland's COVID-19 countermeasures, there was a reduction in several diseases' notifications reported to the CQPHU, predominantly vaccine-preventable diseases, when compared to the same months in 2015 to 2019 and the 5-year average (2015 – 2019) for those months. However, rises in notifications were recorded in a bigger number of other notifiable illness groups during the period Apr – Sep 2020. Long-term research of disease notification patterns may provide more information on the impact of countermeasures on notifiable diseases in CQ. [41]

Chen *et* al. described the prevalence characteristics of notifiable infectious diseases from the People's Republic of China's official website in 2020 and compared them to historical data in 2019. Other notifiable infectious diseases in 2020 decreased to varying degrees when compared to the same period in 2019, with a year-on-year decrease of 41.4 percent in total. Dengue fever, rubella, and whooping cough had the greatest decreases in incidence. Influenza, hand-foot-mouth disease, and other infectious diarrhea diseases saw the greatest decrease in reported cases. In comparison to 2019, the monthly incidence among many common blood-borne and sexually transmitted diseases in China in 2020 remained on a downward trend for the most part, with a relatively obvious slowdown in Feb 2020 and then a fluctuating recovery. In conclusion, changes in the incidence of notifiable infectious diseases in China generally demonstrated a lower trend under the COVID-19 preventive and control strategies, with respiratory infectious diseases showing the most noticeable drop. However, multiple factors influence the spread of infectious disease; data on the interaction of vaccination and population immunity, seasonal and climate change, travel and human mobility, and virus variation is difficult to access. Hence, it is impossible to draw a direct causal link between COVID-19 prevention and control efforts at various stages and a reduction in the incidence of related diseases. Improvement of PHS and examine the long-term impact of COVID-19 preventative and control measures on additional notifiable infectious illnesses would be considered in the next step. [42]

Omid *et* al. performed a systematic review to investigate the effect of COVID-19 preventative methods on other prevalent respiratory infectious illnesses. Adherence to the COVID-19 preventive measures and procedures was found to be protective and minimize the occurrence of various respiratory infectious illnesses such as influenza, pneumonia, tuberculosis, rhinovirus, enterovirus, adenovirus, etc. Control measures included social distance, community education, lockdown, mandatory mask wearing in public, and school closures. They also discovered that the decrease in influenza detection during the 2019 – 2020 seasons might have been attributable to reduced testing for influenza, which could have occurred if doctors had begun testing for SARS-CoV-2 preferentially during this time frame. However, some findings are questionable, such as the fact that the number of documented influenza and pneumonia fatalities in the United States was higher in 2020 than in 2019. In conclusion, while the overall findings indicate that COVID-19 preventive measures have a positive effect on controlling seasonal endemics of other respiratory diseases, there will still be controversies, and more research is needed to determine the exact impact of COVD-19 on other respiratory infections. [43]

Ullrich *et* al. analyzed data from the German reporting system for the PHS of notifiable infectious illnesses with a date of notification between 1 Jan 2016 (week 01–2016) and 9 Aug 2020 (week 32–2020). During week 2020–10 to 2020–32, the greatest reduction in cases were reported for respiratory diseases (from -86 percent for measles to -12 percent for tuberculosis), gastro-intestinal disorders (from -83 percent for rotavirus gastroenteritis to -7 percent for yersiniosis) and imported vector-borne infections (-75 percent dengue fever, -73 percent malaria). Healthcare-associated pathogens (from -43 percent infection/colonization with carbapenem-resistant Acinetobacter to -28 percent for Methicillin-resistant Staphylococcus aureus invasive infection) and sexually transmitted and blood-borne disorders were the least affected infections (from -28 percent for hepatitis B, to -12 percent for syphilis). Taking seasonality and long-term trends into account, researchers found a considerable decrease in notifications for practically all notifiable diseases during the COVID-19 pandemic compared to previous years. The reasons for this shifting dynamic are multifaceted, including decreased healthcare utilization, decreased transmission due to non-pharmaceutical interventions (e.g., school closures, physical distancing, and enhanced hand-hygiene), and alterations in mobility. The actual number of infections, healthcare seeking behavior, diagnosis, and subsequent reporting all influence notification data. In Germany, the key public health interventions for COVID-19, including physical distancing, hand and cough hygiene, face masks, and ventilation, aim to reduce human-to-human transmission of infectious diseases, particularly respiratory infections via droplets. These efforts may

have resulted in a reduction in overall transmission of some other infectious diseases as a side effect. However, vigilance is advised because a decrease in notifications does not always imply a decrease in transmission. [25]
Chen *et* al. studied 39 notifiable diseases reported in the Infectious Disease Surveillance System in Changsha, Hunan Province's capital city in China, from Jan 2017 to Dec 2020 to explore the effect of universal implementation of COVID-19 countermeasures on the incidence of other common infectious diseases. Except for AIDS, cases of most infectious diseases decreased dramatically from Feb to Apr 2020 when compared to the average levels from Feb to Apr 2017 – 2019. Cases of hand-foot-mouth disease decreased the greatest (97 %), influenza (86.7 %), mumps (82.3 %), acute hemorrhagic conjunctivitis (81.7 %), and scarlet fever (80.5 %). Syphilis prevalence climbed over time to the same level as in 2017 – 2019, but rates of hand-foot-mouth disease, tuberculosis, bacillary dysentery, gonorrhea, Hepatitis B, Hepatitis C, and other infectious diarrheal diseases were indeed higher in 2020. Taking the transmission route into consideration, the number of respiratory and intestinal infections from Feb to Jun 2020 declined considerably when compared to the same period's average levels from 2017 to 2019. However, from Jul to Dec 2020, the number of gastrointestinal infections grew by 100.57 % when compared to the same period from 2017 to 2019. Sexually transmitted and bloodborne disease cases fell marginally from Feb to Apr 2020, then rose 2.8 % from May to Dec 2020, compared to the three-year average. Because parasite and vector-borne diseases account for only 0.2 percent of all notifiable diseases, determining the impact of COVID-19 on these diseases remains difficult. During the period Jan 2018 to Dec 2020, they discovered that passenger volume was substantially connected with sexually transmitted and bloodborne diseases (correlation coefficient $r = 0.782$, $p = 0.001$), as well as digestive diseases ($r = 0.418$, $p = 0.011$). Protective measures had a positive impact on limiting the spread of gastrointestinal infections, but their impact waned in the second half of 2020 due to increasing social interaction following the release of epidemic restrictions. Sexually transmitted and bloodborne infections were shown to be more directly linked to population mobility. The decrease in the number of notifiable infectious diseases cannot be attributed only to the implementation of control measures, as patients were less likely to seek medical attention during the epidemic. This might be because they couldn't get an appointment (during the pandemic, hospitals cancelled or limited nonurgent outpatient visits) or because they

were afraid of becoming infected with the SARS-CoV-2 virus. Their investigation revealed that the number of outpatient visits significantly decreased 26.17 percent lower from Feb to Jun compared to the same time in 2017 – 2019. Outpatient visits began to rise at the end of Feb, and by mid-May 2020, they had returned to pre-recession levels. However, there were the possibility of infectious disease underreporting. According to these findings, the epidemic had a particularly large impact on respiratory and intestinal infectious infections. Sexually transmitted and bloodborne diseases were more vulnerable to population mobility's effects. [44]
The Communicable Disease Unit, Division of Epidemiology reviewed dengue, influenza, acute diarrhea, and hand-foot-mouth disease reported in Thailand R506 and discovered that during 2020 – 2021, when the COVID-19 pandemic was emerging, all of the above-mentioned diseases were reported less frequently. Dengue, on the other hand, may be normally reduced by its pattern of Dengue outbreaks, which were epidemic every other year or every two to three years (the latest epidemic of dengue occurred in 2013, 2015, and 2019). These findings of decreased reported in R506 could be attributable to COVID-19 control strategies affecting human health behaviors such as being aware of infections and restricting movement to hospitals where COVID-19 was threatening. To track the actual number of patients, the coverage and completeness of disease reporting at the hospital level should be examined. [45]
The factors that influence notifiable condition reporting are complicated, but a combination of reduced exposures, reduced detection, and reduced reporting and investigation may have an impact on the majority of PHS data such as in Washington for 2020. It may be necessary to mark by adding an explanatory footnote to the results of notifiable conditions PHS. [39] Since the EBS would capture abnormal events and respond in timely manner to complement the existing PHS such as the IBS. During the pandemic, many studies revealed that there were significant reductions in reporting on other diseases. As a result, I will explore the EBS in Thailand how COVID-19 impacts on its number of reporting on other events by comparing the number of event reporting before (2019) and during the pandemic (2020 – 2021). This study gathered reported incidence data for all notifiable infectious diseases and all notifiable events in Thailand prior to and after the COVID-19 epidemic, as well as discussed the incidence trends of other diseases under epidemic prevention and control measures, to provide a reference base for

future disease PHS, prevention, and control work. This will help us to get the evidence-based information to alert and emphasize the importance of running the existing PHS even we faced an emergency crisis.

Chapter 3: Manuscript

Introduction

PHS data from diseases and geographic areas are critical for determining the significance of a health occurrence. [2] The central idea behind PHS is that it should be designed and managed in such a way that it provides valid (true) information to decision-makers in a timely and cost-effective manner. [3]

In 2011, Thailand established EBS to detect and respond to clusters of unexpected threats. [4] EBS is one of the two basic types of PHS being used monitor and locate infectious diseases and other public health events. EBS investigates reports, stories, rumors, and other information about health incidents that may pose a significant risk to public health. EBS promotes IBS, which serves as the foundation of national PHS, and aims to contribute to the early detection of acute public health events. [22] The goals of EBS are to: 1) detect new or exceptional events that are not captured by IBS; 2) detect diseases or syndromes that occur in populations not commonly accessible to basic health care within the context of IBS; and 3) improve the efficacy of IBS. [5,6]

Since the COVID-19 outbreak first appeared and quickly spread around the world. [7] It impacted negatively on global healthcare systems, with ramifications in every aspect of human life, including social and economic costs. [15] Thailand established the EOC on Jan 4, 2020, to respond to COVID-19. [9] Regular public health services may be disrupted during a public health emergency. [10–12] As a result of the COVID-19 epidemic, other infectious disease reporting had been disrupted in PHS. [14] The COVID-19 pandemic has also influenced population behavior, potentially altering patterns of exposure to other infectious diseases. [24]

I examined the event-based PHS from Thailand's DDC to compare the effects of the COVID-19 pandemic. This impact should be identified in order to determine the effectiveness of EBS during the pandemic, whether it accurately reflects the situation or underreports during the epidemic. Despite the prominence of the COVID-19, other disease outbreaks must not be ignored. To ensure that the EBS continues to function in order to provide information to decision-makers for public health initiatives on a consistent basis.

Methods

Data collection

The EBS database of DDC from Jan 1, 2019 to Dec 31, 2021 were extracted. Diseases reported to EBS had been categorized into 10 categories following the Thai DDC criteria: 1) contact; 2) respiratory diseases; 3) neurology diseases; 4) vaccine-preventable diseases; 5) zoonotic diseases; 6) environmental and occupational diseases; 7) food-borne diseases; 8) injury; 9) vector-borne diseases; and 10) others. The following were example diseases of each category: 1) contact i.e., hand foot mouth diseases/herpangina/enterovirus infection, jellyfish related-injury, scabies; 2) respiratory diseases i.e., acute respiratory infection(unspecified), avian influenza, COVID-19, influenza, leprosy, MERS, pneumonia, RSV infection, Tuberculosis; 3) neurology diseases i.e., encephalitis, meningococcal meningitis, meningitis (unspecified); 4) vaccine-preventable diseases i.e., acute flaccid paralysis, adverse effect following immunization (AEFI), chickenpox, diphtheria, JE encephalitis, measles, mumps, pertussis, polio, rubella; 5) zoonosis diseases i.e., anthrax, brucellosis, leptospirosis, melioidosis, streptococcus suis infection; 6) environmental and occupational related diseases i.e., asphyxia, chemical explosion/leakage/poisoning, disaster, gas (vapor) poisoning, pollution; 7) food-borne diseases i.e., botulism, cholera, diarrhea/food poisoning, hepatitis A/E 8) injury i.e., drowning, traffic injury; 9) vector-borne diseases i.e., chikungunya, dengue, filariasis, leishmaniasis, malaria, scrub typhus, zika; 10) other diseases (i.e., cardiovascular diseases (including heart diseases and stroke), febrile convulsion, hyperthyroidism, microcephaly, travel-associated infectious diseases (including legionnaire, Lassa fever, etc.), unknown death, unspecified. This database covers events occurred across Thailand which mostly reported by regional and central health authorities while some were notified by social media or news directly to the Thai DDC.

Ethical issue

There are no ethical issues involved in this study since I have worked at the DOE, DDC, Thailand. Therefore, I have been given permission to access the database. This project is a secondary data analysis which does not require IRB review because it does not include "human subjects" as defined in the federal regulations.

Data analyses

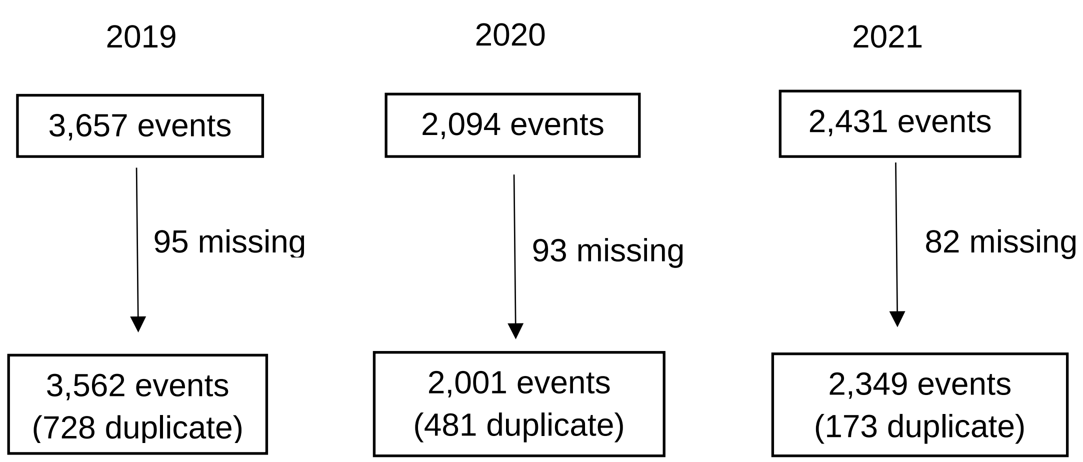
I used Microsoft Excel 365[46] for data management and analysis, Microsoft PowerPoint 365[46] was used for graph/chart drawing, and Stata14[47] was also used for data analysis. I manually reviewed each event to identify specific diseases and arrange them in the appropriate disease category. Then, the number of events reported of each disease categorize was compared during 2019 – 2021 as 2019 vs 2020, 2019 vs 2021, and 2020 vs 2021. I determined the percentage change of each pairwise comparison as well as selected several diseases that would most likely be affected by COVID-19 to determine the number of events reported change during 2019 – 2021.

Results

Overview of the event reporting of the Thai DDC EBS during 2019 – 2021

There were totally 3,657 events reported, 2,094 events reported, and 2,431 events reported during 2019, 2020, and 2021, respectively. I excluded missing events which were the events recorded which did not have any details of the events, accounting for 95 records, 93 records, and 82 records of year 2019, 2020, and 2021, respectively. Finally, I have 3,562 events recorded in 2019; 2,001 events recorded in 2020; and 2,349 events recorded in 2021 those I used for our analysis even among those had duplicate events: 728 duplicate events in 2019, 481 duplicate events in 2020, and 173 duplicate events in 2021. **(Figure2)**

Figure 2. Overall Number of Events Reported of Event-based Public Health Surveillance, Thailand, 2019 – 2021



The duplicate events mostly were the Division of Epidemiology creating the events. This is one form of communication via the reporting system that the events had been noticed by the national level.

When I explored the database following each disease categorization which had been reported and reviewed the event description, I found some events were misclassification from its true disease categorization. For example, influenza diseases were reported into vaccine categorization. Thus, I re-classified the data into its true disease group as it should be categorized during the data management process and calculated the percentage error of each disease group each year. Finally, I got the number of actual events reported and percentage of error of each disease group each year **(Table1)**.

Table 1. Percentage Error of Disease Reporting By Disease Category of Event-based Public Health Surveillance, Thailand, 2019 – 2021

Disease category	2019			2020			2021		
	No. of reported events	No. of actual events	% error	No. of reported events	No. of actual events	% error	No. of reported events	No. of actual events	% error
Contact	70	83	-15.7	33	35	-5.7	19	17	11.8
Respiratory	777	664	17	173	170	1.8	106	435	-75.6
Neurology	67	59	13.6	38	28	35.7	34	14	142.9
Vaccine-preventable	711	767	-7.3	275	279	-1.4	1523	1040	46.4
Zoonosis	248	257	-3.5	159	167	-4.8	94	133	-29.3
Environment and Occupational	74	96	-22.9	70	94	-25.5	61	74	-17.6
Food-borne	361	320	12.8	265	236	12.3	138	102	35.3
Injury	179	282	-36.5	135	349	-61.3	68	170	-60
Vector-borne	899	827	8.7	613	579	5.9	101	99	2
Others	271	207	30.9	333	64	420.3	287	265	8.3
Total	3657	3562	-	2094	2001	-	2431	2349	-

During 2019, there were both underreported and overreported event categorized by disease group. Underreported disease groups included injury, environmental and occupational diseases, contact diseases, vaccine-preventable diseases, and zoonosis diseases. For example, approximately 37% error of the number of injury events were underreported. The number of actual injury event should be 282 events, but the injury events were reported only 179 events. While overreported diseases group were others, respiratory diseases, neurology diseases, food-borne diseases, and vector-borne diseases.

There were 271 other diseases were reported whereas there were only 207 other diseases occurred, accounting for 31% error. In 2020 which was the pandemic period, there were still both underreported and overreported. Underreported disease groups were injury, environmental and occupational diseases, contact diseases, zoonosis diseases, and vaccine-preventable diseases. Injury events were reported 135 events whereas the actual injury events should be reported at 349 events, accounting for 61%.

When I explore deeper, I found that 211 events of injury diseases were reported into others group. On the contrary, overreported disease groups included others, neurology diseases, food-borne diseases, vector-borne diseases, and respiratory diseases. Others group were 420% error of overreporting: there were 333 reported events while there were only 64 actual events should be reported into others group. In 2021, there were underreported diseases group less than overreported diseases group surprisingly.

Underreported diseases were respiratory diseases, injury, zoonosis diseases, and environmental and occupational diseases. Respiratory and injury diseases were underreported accounting for 76% and 60% respectively. There were 435 actual events of respiratory diseases, but it was reported only 106 events. I also found that 330 events of respiratory diseases were reported into vaccine category and the specific diseases were mostly COVID-19. Injury diseases were underreported as well: there were 170 injury events should be reported but it was reported only 68 events into injury diseases. more than half of the misclassification events were reported into other diseases group even they were obviously related to injury such as drowning and traffic injury. On the other hand, overreported diseases group were neurology diseases, vaccine-preventable diseases, food-borne diseases, contact diseases, others, and vector-borne diseases. Neurology diseases had 142% error of overreporting: it had only 14 actual events, but it was reported 34 events. Most of misclassification which caused an overreported were AEFI that should be reported into the vaccine-preventable diseases. AEFI events mostly related to the COVID-19 vaccine with patients presented with neurology symptoms such as stroke and seizure. In addition, the vaccine-preventable diseases were overreported approximately 46%: it was reported 1,523 events instead of 1,040 events that was the actual events of vaccine-preventable diseases. Many of the events were related to COVID-19 vaccine and patients then presented with some illness, which were categorized in others disease group, whether it occurred nearly a month ago from immunization.

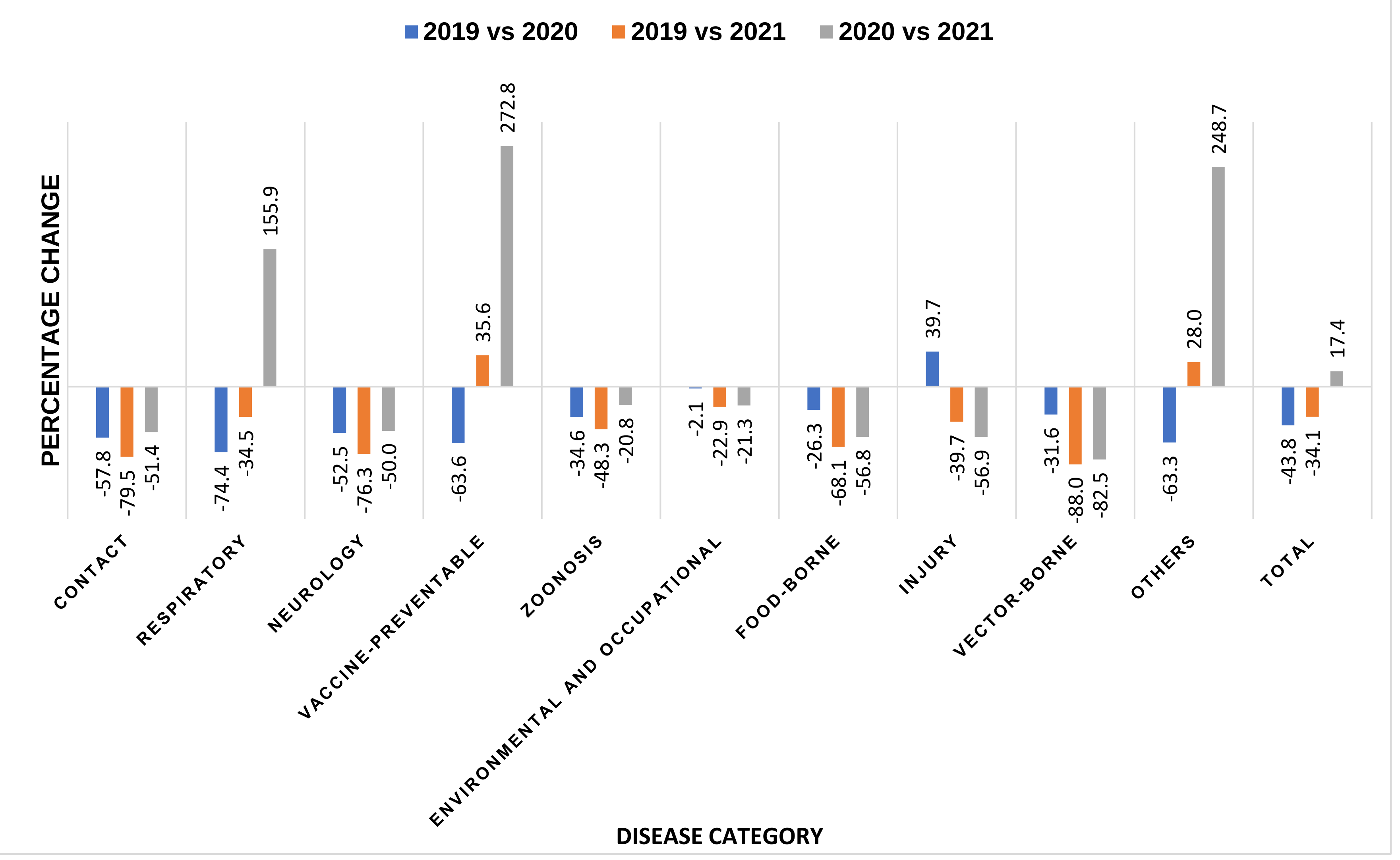
Changes in event reporting by disease categorization

Totally, during the pandemic, there were 44% fewer event reported in 2020 and 34% fewer event reported in 2021 to the EBS of the Thai DDC, compared to before the pandemic (2019). COVID-19 beginning reported to the EBS in 2021 which I found 345 events reported into respiratory, vaccine-preventable diseases, and others category. Additionally, there were 311 events of COVID-19 were reported into vaccine-preventable diseases group under AEFI event.

Comparing 2019 vs 2020, only injury was 40% increase event reported while the rest diseases group had a decrease in event reporting, range from 2-74%. The highest decrease of event reporting was respiratory diseases, accounting for 74%. Following by vaccine-preventable diseases (64%), others (63%), contact (58%), neurology diseases (53%), zoonosis (35%), vector-borne (32%), food-borne (26%), and environment and occupational diseases (2%). While comparing 2019 vs 2021, most of the disease categories had a decrease in event reporting as well.

There were only vaccine-preventable diseases and others category had an increase in event reporting, accounting for 36% and 28% increase respectively. Vector-borne diseases was the highest decrease in event reporting at 88%, followed by contact (80%), neurology diseases (76%), food-borne (68%), injury (57%), zoonosis (48%), respiratory diseases (34%), and environmental and occupational diseases (23%). I also compare the percentage change of event reporting even during the pandemic which was 2020 vs 2021. The overall, there was an increase in event reporting during the pandemic, accounting for 17%. There were 3 disease groups had a dramatically increase in event reporting: others (249%), vaccine-preventable diseases (273%), and respiratory diseases (156%). Whereas most of disease groups were still had a decrease in event reporting. The highest decrease in event reporting was vector-borne diseases (83%), followed by injury (57%), food-borne diseases (57%), contact diseases (51%), neurology diseases (50%), environmental and occupational diseases (21%) and zoonosis (21%). **(Figure3)**

Figure 3. Percentage Change of Event reported of Event-based Public Health Surveillance, Pair-wise Comparison, Thailand, 2019 – 2021



Changes in event reporting by specific diseases

I also analyzed through specific diseases of each event in order to explore deeply why some disease categories had an increase or a decrease in event reporting. It might be affected by some specific diseases. As I selected several diseases that would most likely be affected by COVID-19 to determine the number of events reported change during 2019-2021. I observed a decrease across the majority of selected diseases, but some specific diseases also had an increase in event reporting.

Diseases with decreased notifications

Comparing between before (2019) and during (2020 – 2021) the pandemic, notifications decreased for contact diseases such as hand-foot-mouth/ herpangina/ enterovirus infection (-53% of 2019 vs 2020 and -77% of 2019 vs 2021); respiratory diseases such as acute respiratory infection (-95% of 2019 vs 2020 and -98% of 2019 vs 2021), influenza (-82% of 2019 vs 2020 and -99% of 2019 vs 2021), pneumonia (-44% of 2019 vs 2020 and -56% of 2019 vs 2021), tuberculosis (-61% of 2019 vs 2020 and -34% of 2019 vs 2021); Neurology diseases such as meningococcal meningitis (-63% of 2019 vs 2020 and -78% of 2019 vs 2021); vaccine-preventable diseases such as diphtheria (-48% of 2019 vs 2020 and -94% of 2019 vs 2021), measles (-89% of 2019 vs 2020 and -99% of 2019 vs 2021), pertussis (-36% of 2019 vs 2020 and -92% of 2019 vs 2021); zoonosis diseases such as leptospirosis (-37% of 2019 vs 2020 and -77% of 2019 vs 2021); environmental and occupational diseases such as pollution (-75% of 2019 vs 2020 and -100% of 2019 vs 2021), food-borne diseases such as diarrhea/ food poisoning (-23% of 2019 vs 2020 and -66% of 2019 vs 2021); injury such as traffic injury (-30% of 2019 vs 2020 and -64% of 2019 vs 2021); vector-borne diseases such as dengue (-59% of 2019 vs 2020 and -95% of 2019 vs 2021); other diseases such as travel-associated infection diseases (i.e., legionnaire, Lassa fever) (-97% of 2019 vs 2020 and -97% of 2019 vs 2021).

Diseases with increased notifications

Observed notifications during the pandemic (2020-2021) were more than before the pandemic (2019) for injury such as drowning (131% of 2019 vs 2020 and 11% of 2019 vs 2021); other diseases such as cardiovascular diseases (i.e., heart disease and stroke) (300% of 2019 vs 2020 and 13300% of 2019 vs 2021).

There were observed an increased notifications event during the pandemic (2020 vs 2021) for respiratory diseases such as COVID-19 (1 vs 345, increase = 34,400%); vaccine-preventable diseases such as adverse effect following immunization (AEFI) (36 vs 994, increase = 2,661%); other diseases such as cardiovascular diseases (i.e., heart diseases and stroke) (4 vs 134, increase = 3,250%). **(Table 2)**

Table 2. Percentage Change of Event Reporting By Diseases of Event-based Public Health Surveillance, Thailand, 2019 – 2021

Diseases	Number of reported events			Percentage change		
	2019	2020	2021	2019 vs 2020	2019 vs 2021	2020 vs 2021
Contact						
HFM/ herpangina/ enterovirus infection	57	27	13	-52.6	-77.2	-51.9
Jellyfish related-injury	5	6	2	20	-60	-66.7
Scabies	7	0	0	-100	-100	0
Respiratory						
Acute respiratory infection (unspecified)	42	2	1	-95.2	-97.6	-50
Avian influenza	9	2	0	-77.8	-100	-100
COVID-19	0	1	345	-	-	34400
Influenza	395	70	5	-82.3	-98.7	-92.9
Leprosy	12	5	3	-58.3	-75	-40
MERS	52	4	0	-92.3	-100	-100
Pneumonia	39	22	17	-43.6	-56.4	-22.7
RSV infection	4	10	0	150	-100	-100
Tuberculosis	94	37	62	-60.6	-34	67.6

Diseases	Number of reported events			Percentage change		
	2019	2020	2021	2019 vs 2020	2019 vs 2021	2020 vs 2021
Neurology						
encephalitis (unspecified)	6	9	4	50	-33.3	-55.6
meningococcal meningitis	40	15	9	-62.5	-77.5	-40
meningitis (unspecified)	3	4	1	33.3	-66.7	-75
Vaccine-preventable						
Acute flaccid paralysis	90	49	20	-45.6	-77.8	-59.2
Adverse effect following immunization (AEFI)	93	36	994	-61.3	968.8	2661.1
Chickenpox	17	7	1	-58.8	-94.1	-85.7
Diphtheria	158	82	10	-48.1	-93.7	-87.8
JE encephalitis	4	1	0	-75	-1000	-100
Measles	260	28	2	-89.2	-99.2	-92.9
Mumps	20	1	3	-95	-85	200
Pertussis	115	74	9	-35.7	-92.2	-87.8
Polio	2	0	1	-100	-50	-
Rubella	4	1	0	-75	-100	-100
Zoonosis						
Anthrax	1	0	0	-100	-100	0

Diseases	Number of reported events			Percentage change		
	2019	2020	2021	2019 vs 2020	2019 vs 2021	2020 vs 2021
Brucellosis	23	10	8	-56.5	-65.2	-20
Leptospirosis	75	47	17	-37.3	-77.3	-63.8
Melioidosis	11	28	23	154.6	109.1	-17.9
Streptococcus suis infection	82	51	62	-37.8	-24.4	21.6
Environmental and occupational related diseases						
asphyxia	1	16	15	1500	1400	-6.3
Chemical explosion/ leakage/ poisoning	12	17	10	41.7	-16.7	-41.2
Disaster	6	24	3	300	-50	-87.5
Gas (vapor) poisoning	11	14	2	27.3	-81.8	-85.7
Pollution	8	2	0	-75	-100	-100
Food-borne						
Botulism	0	2	0	-	-	-100
Cholera	20	9	3	-55	-85	-66.7
Diarrhea/food poisoning	292	224	98	-23.3	-66.4	-56.3
Hepatitis A/E	1	1	1	0	0	0
Injury						
Drowning	94	217	104	130.9	10.6	-52.1

Diseases	Number of reported events			Percentage change		
	2019	2020	2021	2019 vs 2020	2019 vs 2021	2020 vs 2021
traffic injury	178	124	64	-30.3	-64	-48.4
Vector-borne						
Chikungunya	261	299	10	14.6	-96.2	-96.7
Dengue	392	161	21	-58.9	-94.6	-87
Filariasis	7	5	1	-28.6	-85.7	-80
Malaria	36	31	20	-13.9	-44.4	-35.5
Scrub typhus	3	7	0	133.3	-100	-100
Zika	123	75	43	-39	-65	-42.7
Others						
Cardiovascular diseases (i.e., heart diseases and stroke)	1	4	134	300	13300	3250
Febrile convulsion	6	13	1	116.7	-83.3	-92.3
Hyperthyroidism	9	4	1	-55.6	-88.9	-75
Microcephaly	38	4	6	-89.5	-84.2	50
Travel-associated infectious diseases (i.e., legionnaire, Lassa fever, etc.)	76	2	2	-97.4	-97.4	0
Unknown death	5	0	20	-100	300	-
Unspecified	37	15	6	-59.5	-83.8	-60

Discussion

Overall, there was a decreased in the number of events reported during the pandemic (2020 – 2021) compared to before (2019). Moreover, the duplicate events also decrease year by year. Because the Division of Epidemiology was entirely repeated for the duplicate events, it is possible that during the pandemic, officers from the Division of Epidemiology were rotated to respond to the COVID-19 EOC as a priority.

Therefore, there were only a few members of the situation awareness team in charge of EBS during COVID-19, they may not have had enough time to create repeat events even it was one form of communication of the reporting system, and the majority of outbreaks were investigated by local authorities. This crisis has pushed public officials to quickly reprioritize, identify critical positions and areas, and redeploy the workforce to meet changing demand[48].

In general, there were some misclassifications in EBS event reporting, whether before or during the pandemic. Each disease classification had both underreported and overreported occurrences. In 2020, there were a skyrocket overreported in other diseases group which accounted for 420% error of overreporting.

Additionally, I found many COVID-19 events, beginning reported to EBS in 2021, which should be reported into respiratory diseases, were reported into vaccine-preventable diseases. Furthermore, the events related to the COVID-19 vaccine were misclassified into vaccine-preventable diseases as AEFI although the events might not correlate with the vaccine by time of onset or illness.

According to the mandatory reporting of events listed on the reportable events table of the Vaccine Adverse Event Reporting System, health care personnel should report all events listed in product inserts as contraindications, as well as all clinically significant adverse events, even if they are unsure that the adverse event is causally related to vaccination. [49] The previous study found that local health authorities are overburdened with the COVID-19, which has put political pressure from the national and regional governments and has now been added to routine PHS activities, resulting in a drop in disease reporting quality even though the system report has no alterations or changes. [50] Therefore, the high percentage of misclassification of EBS Thailand, which included COVID-19 that was an emerging disease in disease notification, may contain some errors.

During the pandemic, there were nearly half fewer notifications in 2020 and roughly one-third fewer events reported in 2021 than there were before the pandemic even with COVID-19 set to be reported into EBS in 2021. However, many events related to COVID-19 were misclassified of disease categorization. As COVID-19 is an emerging disease with a crisis pandemic, there may have been no definitive guidelines or criteria that detailed how to correctly report COVID-19 related events into EBS. The COVID-19 pandemic has been riddled with false dichotomies, which have been used to stifle or polarize debates while oversimplifying complex issues and obscuring the nuances. [51]

Comparing 2019 to 2020, only injury had an increase in notifications because there was a flood during 2020, leading to many events of drowning occurred in 2020 [52–54] compared to 2019. While there was a decrease in notifications for all the other diseases categorization in 2020 which was concomitant with the many previous studies. [25,39–43,45] This effect is asserted COVID-19 public health measures influenced individuals to limit their activities, which may result in fewer communicable disease exposures. Closure of schools and public areas may reduce the risk of exposure to respiratory diseases such as influenza and tuberculosis, vaccine-preventable diseases transmitted by droplet or airborne transmission such as pertussis and measles, as well as contact diseases such as hand-foot-mouth/ enterovirus infection. Restaurant closures may help to reduce large outbreaks of food-borne diseases such as food poisoning/ acute diarrhea.

Whereas comparing 2019 vs 2021, there were an approximately one-third increase in notifications for vaccine-preventable diseases and other diseases. The specific diseases under these disease categories illustrated that AEFI under vaccine-preventable diseases had 969% increase and cardiovascular disease (i.e., heart diseases and stroke) under other diseases had 13,300% increase notifications. These increases were associated with COVID-19 vaccination campaign against the COVID-19 pandemic in Thailand begun in Feb 2021. [55] There were four COVID-19 vaccine administer in Thailand which were Sinovac, AstraZeneca, Sinopharm, and Pfizer. Following mass vaccination, cases of a distinct novel focal neurological syndrome have begun to emerge across the country among those who received Sinovac [56,57] as well as some cardiovascular symptoms among those receiving AstraZeneca [58,59] although the researchers found no increase in the rate of arterial clots, such as heart attacks or stroke. [60]

These findings suggested that COVID-19 had an impact on other diseases reported to EBS, Thailand. This study made use of a national EBS database in Thailand, which was a PHS that was used to improve the functions of the PHS in terms of early detection and response to outbreaks. Despite the fact that the data was unstructured and that each event had to be manually explored to classify its specific diseases, this study demonstrated the misclassification error that I can finally explore each specific disease under each disease categorization to explain why disease groups had a decrease or an increase notification during the pandemic. However, there were some limitations due to EBS characteristics. The event reported were voluntary that can lead to biased data and might non-representative population. Some events needed to be followed-up to validate report of its definite diagnosis and to classify the event correctly into its disease group.

Chapter 4: Recommendations

The EBS platform should be modified to reduce redundancy work and enhance its capacity to reflect the real situation of disease occurrence. According to the findings of this study, the number of events reported during the pandemic (2020 – 2021) was lower than the number of events reported prior to the pandemic (2019). However, there were more duplicate events included in the number of events reported before the pandemic than there were during the pandemic.

The Division of Epidemiology created the majority of duplicate events, implying that during the pandemic, not only were local public health officers responsible for reporting events, but officers at the Division of Epidemiology at the national level were also overwhelmed by the COVID-19, which was set as the first priority over other diseases during the pandemic.

The EBS platform needs to be modified. For example, if a local health authority reports an event to the EBS, officers in the Division of Epidemiology (central level) should review, verify, follow-up on, and correct the event until it is definite diagnosed. The event does not have to be repeated by officers at the central level simply to inform them that this event was noticed by the central level.

Furthermore, it would have variables indicating that the event had been received notification by the central level, where the source of information is, and how to contact the key person of the event, as well as the status of the event such as received, investigating, completed, and so on.

Establish criteria and guidelines for diseases reporting before implementing specific diseases to be reported into the EBS to increase quality of disease reporting.

Despite the fact that COVID-19 was the first priority during the pandemic and had been requested to be reported into EBS since 2021, many events associated with COVID-19 or COVID-19 vaccine were misclassified. Therefore, disease reporting criteria and guidelines should be established, especially during the crisis of an emerging disease, when officers may have no previous data or guidelines to follow. Furthermore, officers should use the criteria and guidelines in order to correctly report disease and improve the quality of the EBS data.

Further studies should explore the association between each region health authority and the number of event reports may aid in determining the most affected area from the pandemic that may require organization. The findings of this study implied the overall impact of COVID-19 on EBS across Thailand without specifying the specific area most impacted. Although the pandemic may affect every area as a crisis, there may be some vulnerabilities that are the most affected and require assistance. If we could locate it and provide assistances, the PHS system would be strengthened, as the PHS requires collaborative work from all stakeholders. Furthermore, qualitative studies exploring and understanding what is going on and challenges during the pandemic may provide some new and interesting points to improve the EBS.

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