UTILIZING INFORMATION TECHNOLOGY TO ENHANCE THE CAPACITY AND EFFICIENCY OF CONTROL SYSTEM FOR TRANSMISSIBLE DISEASES IN HO CHI MINH CITY

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Abstract – *A research and development study was conducted from September 2020 to April 2023 involving 9 hospitals, 24 district health centers and 319 commune health stations. The study was to establish, refine, and update a system for controlling directly transmitted diseases in Ho Chi Minh City, as well as assess its practical implementation. Before the system update, the study identified limitations in disease surveillance, particularly in monitoring cases that were not examined or treated at hospitals. The existing reporting mechanisms also resulted in incomplete disease data, with subpar data quality due to delays and inadequate processing of reported cases. Considering the prevailing circumstances, management requirements and usage needs, the system underwent enhancements and integrated GIS capabilities. This allowed healthcare personnel to swiftly and accurately identify disease cases, determine contacts, establish epidemiological zones, trace transmission chains, and monitor the implementation of control measures. The improved control system has been successfully implemented, ensuring effective management of community-based hand, foot, and mouth disease. Additionally, the system demonstrates the potential for broader applicability in managing other directly transmitted diseases.*

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I. INTRODUCTION

The utilization of information technology in disease surveillance plays a vital role in enhancing the capacity and effectiveness of disease control efforts, making it one of the key priorities at present [1, 2]. The current infectious disease control system in Ho Chi Minh City encompasses various healthcare facilities, including hospitals, Ho Chi Minh City Center for Disease Control (HCDC), 24 district health centers and 319 commune health stations. The direct management of disease transmission cases adheres to the guidelines provided by the Ministry of Health. Since 2017, the reporting and monitoring of infectious disease cases in Ho Chi Minh City have been carried out in accordance with Circular 54/2015/TT–BYT issued by the Ministry of Health on December 28, 2015. This circular outlines the 'Guidelines for Information Reporting and Declaration of Infectious Diseases and Epidemics' [3]. As per these guidelines, both public and private hospitals within the city are mandated to report individual cases of the 35 specified infectious diseases into an online software system known as the Infectious Disease Management and Surveillance System (IDMSS) [3]. The features of the IDMSS software only facilitate one-way transmission of disease information from hospitals to the 24 district health centers, without supporting the exchange of information during the investigation, handling, and evaluation of the disease situation within the region.

Over the years, the infectious disease control system in the city has achieved certain accomplishments, effectively controlling Group A infectious diseases. However, the current operation mainly relies on manual processes and lacks efficient information sharing among relevant units within the disease control system. This results in the wastage of time for disease control officers in collecting and sharing information, delays in coordinating and implementing control measures, and an inability to accurately assess the actual progression of the outbreak. Particularly in Ho Chi Minh City, where there is a high level of population movement and dynamics, contact tracing in direct transmission disease control remains a challenge for the healthcare system. The existing system also fails to meet the requirements of monitoring the formation and progression of disease transmission chains from a specific index case, thereby accurately assessing the disease situation at a given time and ensuring effective disease control measures that are tailored to different components and areas within the system. Recognizing the complex nature of the pandemic and the management needs, HCDC has collaborated with various agencies and units to research, develop, and implement a system for controlling directly transmitted diseases. This research is based on the practical conditions of the city, the existing human resources, and the challenges in epidemic prevention and control. The aim is to establish management procedures and essential features of the system that optimize the utilization of available resources for disease control.

II. LITERATURE REVIEW

The research project titled 'Application of GIS Technology for Monitoring Dangerous Diseases in Ho Chi Minh City' conducted by Le Truong Giang in 2006 – 2007 laid the foundation for a supportive database for epidemic prevention and control efforts for 11 types of dangerous diseases. The project also developed a set of software tools to facilitate data updating, searching and statistical analysis related to epidemic prevention and control. Furthermore, spatial analysis tools were applied to assist in disease mapping, delineating disease outbreak areas, identifying high-risk regions and establishing disease distribution maps [4]. The research was conducted in a context where hardware and software technologies for online data collection, as well as the regulations and personnel supporting the operation of GIS systems, still faced numerous difficulties and limitations.

In addition, the research on the application of remote sensing and GIS for monitoring the risk of malaria outbreak to serve community healthcare, conducted by author Pham Viet Hong from the Institute of Geology and Marine Physical Research in the years 2013 – 2014, established a model for integrating technology in the management and early warning of malaria. The study also developed hierarchical maps indicating potential and actual outbreaks of dengue fever in Gia Lai Province [5]. The research is notable for its strategic approach, wide geographical coverage, and early prediction capabilities, achieved through the application of highly detailed maps at a scale of 1:100,000.

In another study conducted in 2016, Le Thi Ngoc Anh and Dau Hoang published research on the application of GIS in predicting epidemics. This study was conducted in Hanoi City, examining the impacts of climate change, water bodies, and spatial distribution of population on the number of disease cases over time. The advantage of the research lies in the integration of data and the use of new machine learning methods to develop a model [6]. However, the study used maps with a low scale (1/50,000) and specialized data from the period of 2001–2010, which means that the accuracy is not the strength of the system.

III. RESEARCH METHOD

A. Research location and time

The research was conducted from September 2020 to April 2023 in Ho Chi Minh City, consisting of three phases:

- Phase 01: From September 2020 to March 2021, a cross-sectional survey was conducted involving 9 hospitals, 24 district health centers, 319 commune health stations, and 383 cases of hand, foot, and mouth disease to provide an overview of the operation of the system for

controlling directly transmitted diseases through the surveillance of hand, foot, and mouth disease.

- Phase 02: From April 2021 to February 2023, the construction of management procedures, integration of advanced features, and improvement of the control system were carried out at HCDC.

- Phase 03: From March 2023 to April 2023, three training sessions were conducted and implemented for selected units with 71 personnel responsible for 202 cases of the disease and 1058 contacts to evaluate the operation of the system after the improvements.

B. Data collecting and processing

The study evaluated 9 hospitals, 24 district health centers, and 319 commune health stations in Ho Chi Minh City.

Sampling method:

- Hospital selection: convenience (integrated with other surveillance activities).

- Health center and health station selection: entire sample selection.

- Hand, foot, and mouth disease cases selection: First, a framework of sample cases of hospital admissions/visits in December 2020 (1943 cases) was established. Then, a simple random sampling method was used to select 383 cases from the initial 1943 cases ($p = 0.47$, $d = 0.05$).

Research tools and techniques of data collection:

- Structured interviews and interviews using pre-prepared questionnaires.

- Reviewing survey forms and instructional documents.

IV. RESULTS AND DISCUSSION

A. An overview of the operation of the system for controlling directly transmitted diseases before improvement

Since 2017, reporting of cases, outbreaks, and hand, foot, and mouth disease prevention and control activities in Ho Chi Minh City has been carried out in accordance with Circular No. 54/2015/TT–BYT issued by the Ministry of Health on December 28, 2015, providing 'Guidelines on the reporting and declaration system for infectious diseases' [3]. The participating units in the surveillance system include the Ministry of Health, regional institutes such as the Pasteur Institute, the Institute of Malaria, Parasitic Diseases and Entomology, Department of Health of Ho Chi Minh City, Ho Chi Minh City Center for Disease Control, district health departments (24 health departments), district health centers (24 centers), ward/commune health stations (319 stations), and public and private hospitals (68 hospitals). Ho Chi Minh City Center for Disease Control, assigned by the Department of Health of Ho Chi Minh City, acts as the organizing and monitoring focal point for hand, foot, and mouth disease surveillance throughout the city.

The surveillance of hand, foot, and mouth disease in Ho Chi Minh City is conducted through a comprehensive approach involving both public and private hospitals. Data collected from these hospitals are directly transmitted to various management entities such as the Department of Preventive Medicine – Ministry of Health (Vietnam), the Department of Health of Ho Chi Minh City, district health offices and district-level medical centers in Ho Chi Minh City. Hospitals have the option to report individual cases or input the data into an online software system, which facilitates the transmission of information to the preventive medical units. However, it should be noted that the integration of general clinics in the area into the infectious disease reporting system has not been implemented. As a result, cases treated at these clinics are identified through active case finding activities carried out by health stations. However, the number of cases identified through this method is relatively small. Furthermore, it is important to highlight that health stations currently do not have direct access to the data and are not provided with online accounts. Instead, they receive a list of infectious diseases via Email/Zalo from the district health center. This list serves as a means for managing community cases within their respective areas of responsibility.

Table 1: Description of data sources, time, and reporting methods for hand, foot, and mouth disease

Object	Data format	Data source	Time	Reporting method
Cases	Detailed information of each case	Hospitals, health stations, schools, and communities	Daily	
	Demographic characteristics, diagnosis, disease classification, and testing	Hospitals, health stations. Collecting data from schools and communities (insignificant cases)	Daily	IDMSS software
	Clinical and epidemiological information of cases	Health stations supplement after case investigation–verification in section B	Daily	Email
Outbreaks	Detailed information of each outbreak	Health stations and district health centers	When detected Daily	Email
Epidemic prevention and control activities	Statistics of the quantity and content of activities	Health stations District health centers Ho Chi Minh City Center for Disease Control	Weekly	IDMSS software

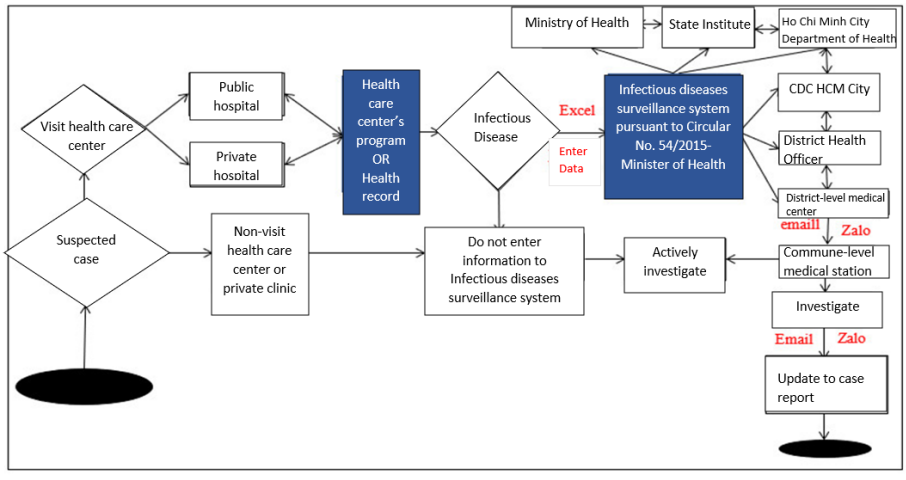

Fig. 1: Describing the process of daily case information collection and reporting

In terms of infectious disease cases, they will be verified and managed at the community health stations after receiving information via Email/Zalo. The verification information includes the place of residence and epidemiological information that needs to be reported back to the higher level (Figure 1).

Based on Figure 2, it can be observed that the verified case information is reported back via email, while the information obtained after the investigation is only communicated to the district health centers. However, for outbreak clusters, the community health stations provide feedback to the district health center and the Ho Chi Minh City Center for Disease Control, and then receive feedback from the district health center. The feedback on outbreak cluster information is conducted via email.

In relation to the anti-epidemic measures, a weekly reporting system has been established using a software platform that is also utilized by hospitals for reporting case-related information. This system allows for the regular monitoring and reporting of the number of anti-epidemic activities conducted. Additionally, on a monthly basis, comprehensive reports are compiled to document

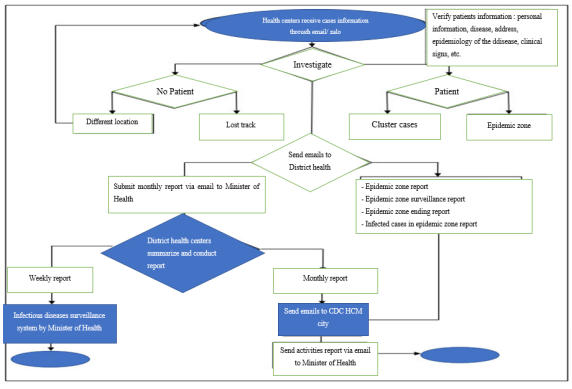

Fig. 2: Describing the process of case investigation and feedback on the case information and outbreak prevention activities for hand, foot, and mouth disease

the anti-epidemic activities carried out at health stations and district health centers. These reports are then transmitted via email for submission and review.

B. Quality of data and timeliness of data in the hand, foot, and mouth disease surveillance system before improvement

Accurate and comprehensive data entry is crucial in the reporting software used for monitoring and surveillance of infectious diseases, as it enables timely assessment of patient information and disease trends by the preventive units. Out of the 383 cases surveyed, certain essential information such as residential addresses, date of disease onset, and phone numbers were relatively well-updated, with high completion rates of 92.7% for residential addresses, 98.4% for disease onset dates, and 100% for phone numbers. These three data fields are mandatory in the software, which explains the high rate of complete reporting for them.

However, non-mandatory information such as clinical classification and workplace addresses of patients were frequently not updated by the majority of hospitals. For example, 90.6% had been missing clinical classification information, and 100% had been missing workplace addresses. Clinical classification and workplace addresses play a crucial role in assessing the disease situation and implementing appropriate measures. The low completion rates for these data fields may pose challenges in future disease assessments.

Based on interviews with reporting personnel from certain hospitals, it was found that these hospitals extracted lists from their own software and inputted them into the reporting software specified in Circular 54. However, their software did not include information related to the patient's occupation. Similarly, for clinical classification information, only four major hospitals in Ho Chi Minh City (Children's Hospital 2, City Children's Hospital, Children's Hospital 1, and Hospital for Tropical Diseases) entered 92.8% of the clinical classification data totaling 322 cases. The reason for the lack of clinical classification information was that all four hospitals imported the cases into the Circular 54 software using a Microsoft Excel file exported from their own software, and the provided sample Excel file did not include a field for clinical classification information. Furthermore, due to the high volume of cases in city hospitals, updating the clinical classification for each case proved to be challenging, resulting in incomplete data.

Following the data entry process in the software by hospitals, daily Excel files containing case information are exported by district health centers and transmitted to commune health stations via email, Zalo, or phone. The purpose of this step is to verify addresses, investigate contact history, and classify cases at the local level to determine appropriate management measures. However, based on the survey findings, the completeness of case investigation activities at the health stations was suboptimal. Only slightly over 50% of cases (201 cases) had recorded addresses and were managed locally in accordance with regulations. On the other hand, 25.6% of cases (98 cases) were not documented in the health station's records. Approximately 21% of cases (82 cases) did not have local addresses, and only half of these cases (39 out of 82) had additional address information collected by the health stations to transfer them to other localities for appropriate management. The remaining half of these cases (43 out of 82) were inaccessible due to incorrect addresses and contact information. Consequently, approximately one-third of the cases may not be

effectively managed, potentially resulting in an inaccurate representation of the disease situation due to lost investigation records and unreliable case information in the software.

According to the regulations specified in Circular No. 54/2015/TT–BYT issued by the Ministry of Health, healthcare units are required to input hand, foot, and mouth disease cases into the software within 24 hours of diagnosis [3]. However, in this survey, the retrieval of case information from medical records at hospitals was not performed. Therefore, the evaluation of timeliness in updating cases in the software was based on the admission date rather than the actual diagnosis of hand, foot, and mouth disease. Out of the 383 cases included in the survey, only 68.4% (262 cases) were updated in the software by hospitals in a timely manner within 24 hours of admission. Hospital staff responsible for reporting cited reasons such as the absence of reporting personnel on weekends and the entry of cases upon discharge as contributing factors for the delayed updates. Once the cases were entered into the software, 55.9% of them were promptly transmitted by the district health center to the commune health stations within 24 hours. As per the Ministry of Health's regulations, the health stations should investigate and manage the cases within 48 hours of receiving the information. The proportion of cases that were promptly investigated by the health stations within this time frame was 66.1

C. The enhanced system for monitoring directly transmitted diseases

The system for monitoring directly transmitted diseases plays a crucial role in managing the activities of detection, notification, contact tracing, investigation, intervention, and handling of cases, contacts, and outbreak clusters throughout the entire healthcare network. Simultaneously, it supports real-time disease surveillance [2]. The system comprises three main components that communicate with each other through a shared database, HTTP, and EventBus (a mechanism that facilitates inter-component communication, enabling disparate components to interact with one another without requiring explicit knowledge of each other's existence).

Regarding the disease management and control software, this component includes processes, data entry forms, assessment criteria, object chaining, data extraction, and statistical reporting. It is designed with dynamic permissions that can be tailored to the administrator, and it encompasses systems that comprehensively manage various processes, including the overall process, notified case identification process, notified case investigation process, handling and intervention process for confirmed cases, contact tracing and monitoring process, and disease control and outbreak management process. The software digitizes data entry forms for each process, enabling users to directly input data without the need for paper forms. It facilitates the chaining of various objects, such as cases, locations, epidemiological milestones, contacts, and outbreak clusters, providing a coherent view of the entire progression of each transmission chain and the interconnected relationships between objects. Data management is implemented across three data regions (three nodes), with similar data being stored and synchronized.

Regarding the GIS application, it utilizes geographic information layers to visually represent data on digital maps. It has been developed with multiple layers of geographic information and integrated with the disease management and control software. It visually represents disease data on digital maps, facilitating field personnel in investigation and contact tracing activities and providing managers with an overview of the disease's progression.

And regarding the Blockchain 2.0 application, this component ensures data integrity and maintains a traceable record of each user's activities within the system [7]. The Blockchain application has been developed and implemented in the management of the three data regions created by the disease management and control software, ensuring data integrity, preserving a traceable record of user actions, and ensuring accountability and legal compliance [7].

In March 2023, the HCDC organized four training sessions for the direct transmission disease monitoring system. Following the training, the system was deployed in three districts and municipalities to input data on disease cases and

contacts, allowing for an experiential trial of the system and further adjustments based on user feedback. A total of 202 cases of hand, foot, and mouth disease and 1,058 associated contacts were inputted into the system. Specifically, the data entry quantities for the three districts/municipalities were as follows:

- District 3 Health Center: 49 cases, 293 contacts.
- Tan Phu Health Center: 77 cases, 462 contacts.
- Tan Binh Health Center: 76 cases, 303 contacts.

Table 2: Survey results of staff regarding display and storage functions (n = 52)

Function related to display and storage	Frequency	Percentage (%)
1. Is the data on cases and contacts stored accurately and completely compared to the input data?		
Completely accurate and complete	30	57.7
Complete, with occasional discrepancies	19	36.5
Incomplete and inaccurate	3	5.8
2. Is it necessary to restrict editing/deleting of verified or transferred information to other facilities? Does it cause difficulties for you?		
Necessary, even if it causes difficulties	21	40.4
Necessary and does not cause difficulties	19	36.5
Not necessary, only causes difficulties	12	23.1
3. Is the generated transmission chain accurate with verified information?		
Completely accurate	31	59.6
Accurate, with occasional slight discrepancies	20	38.5
Inaccurate	1	1.9
4. Is the search and data extraction function easy to use?		
Easy	44	84.6
Difficult	6	11.5
Very difficult	2	3.8
5. Is the display of the list of cases, contacts, and outbreak clusters on the interface convenient for your operation?		
Not very convenient	8	15.4
Convenient	44	84.6

A survey of 52 medical staff members responsible for disease control was conducted to evaluate the current system functions. The respondents directly used the system for case investigation, disease verification, case management, outbreak control, and cluster management in their respective localities. Overall, the results indicate that the current functions are easy to use and convenient, with the ability to store, extract, and search for data accurately.

Table 3: Survey results of staff regarding display and storage functions (n = 52)

Function Related to Maps and Geolocation	Frequency	Percentage (%)
1. Are the maps fully covered and accurate for your locality (district/ward)?		
Not covered	5	9.6
Partially missing (roads/districts)	5	9.6
Fully covered	35	67.3
Unclear	7	13.5
2. Is the automatic geolocation of cases, contacts, epidemiological milestones, and outbreaks accurate when entering addresses?		
Completely accurate	23	44.2
Mostly accurate, occasional slight deviations	26	50.0
Inaccurate	3	5.8
3. Is the process of repositioning cases, contacts, epidemiological milestones, and outbreaks simple and easy?		
Easy	46	88.5
Difficult	5	9.6
Very difficult	1	1.9
4. Is it easy to change/update the location of cases, contacts, epidemiological milestones, and outbreaks on the map?		
Easy	44	84.6
Difficult	7	13.5
Very difficult	1	1.9
5. Are the clusters and outbreaks accurately displayed on the map?		
Occasionally accurate	3	5.8
Mostly accurate, occasional deviations	20	38.5
Completely accurate	28	53.8
Completely inaccurate	1	1.9

Regarding the survey results on the functionalities related to maps and geolocation, the system has provided sufficient and accurate coverage for each specific locality, although there are still a few inaccuracies due to delayed updates and synchronization. However, the impact of these inaccuracies is negligible. The precise geolocation feature for tracking cases and contacts has greatly optimized contact tracing and monitoring efforts.

V. CONCLUSION

The improved infectious disease surveillance system has incorporated modern information technology techniques, contributing to the effective control and prevention of infectious diseases. In addition to system upgrades, task procedures

and workflows have been standardized, facilitating unified, comprehensive, and detailed reporting. The research output has met the demand for disease control in the current context, while the system's features continue to be developed and enhanced for future iterations.

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