Research Article

THJPH

Development of Web Application to Support Dengue Investigation Team of Communicable Disease Control Operations Unit in Phang Nga Province

Suwadee Kongpan[1], Pichitpong Soontornpipit[2], Jutatip Sillabutra[2], Prasong Kitidamrongsuk[2], Pratana Satitvipawee[2] , Vanvisa Sresumatchai[3]

[1]Master of Science Program in Health Informatics (International Program) Faculty of Public Health, and Faculty of Graduate Studies, Mahidol University, Thailand

[2]Department of Biostatistics Faculty of Public Health, Mahidol University, Thailand

[3]Department of Family Health, Faculty of Public Health, Mahidol University, Thailand

Correspondence: Suwadee Kongpan, Department of Biostatistics, Faculty of Public Health, Mahidol University,420/1 Ratchawithi RD., Ratchathewi District, Bangkok 10400. Thailand, E-mail: Suwadee.kog@student.mahidol.ac.th

Received: June 4 2024; Revised: December 4 2024; Accepted: February 27 2025

Abstract

Phang Nga Province in Thailand continues to face persistent challenges related to Dengue Hemorrhagic Fever (DHF) and associated fatalities. In response to the limitations of existing paper-based systems in managing dengue fever data effectively, this study aims to develop a web application to support the Dengue Investigation Team within the Communicable Disease Control Operations Unit in Phang Nga Province. The research engaged 22 stakeholders, including public health officers, data managers, and field investigators, who participated in a stakeholder analysis process to identify user requirements that would inform the design and development phases.

Utilizing Agile Software Development Lifecycle (SDLC) methodologies, the web application was developed using MySQL for database management and PHP for web service programming. The resulting web application includes functionalities for data collection and a stakeholder dashboard for statistical analysis. Testing and evaluation were conducted using satisfaction scales, which yielded high satisfaction scores (mean ± SD) across functionality, usability, and accessibility. Stakeholder feedback indicated the need for additional features to enhance data collection, analysis, and integration of information across healthcare facilities.

The evaluation results highlight the application's potential to address public health challenges and support the Dengue Investigation Team in combatting dengue fever in the region. Currently, the application is in the pilot testing phase, and further refinement is necessary to improve data integration and security measures. This research contributes to advancing disease surveillance and control measures, emphasizing the importance of continuous refinement to meet evolving user needs and ensure a lasting impact on public health.

Keywords: Dengue, Investigation, Web application, Disease surveillance, Phang nga

What was Known

- Dengue investigation challenges in Phang Nga Province.
- Flaws in the existing paper-based dengue investigation system, including delayed and incomplete data transmission.

What's New and Next

- Development of a web application to support the Dengue Investigation Team and improve real-time data access
- Future direction: Enhanced cross-agency data linkage and improved system security for broader implementation.

Introduction

Dengue fever poses a significant challenge to global health, particularly in tropical and subtropical regions, where its rapid proliferation over the past fifty years has marked it as the fastest-spreading mosquito-borne viral disease. With an estimated annual incidence ranging from 50 to 100 million cases worldwide, dengue affects nearly half of the world's population residing in endemic areas, predominantly in the Asia-Pacific region.[1, 2] Recent outbreaks underscore the impact of rising temperatures, partly attributed to climate change, which exacerbates dengue transmission in already endemic areas. Epidemics often peak during or after rainy seasons, with arid climates providing fertile breeding grounds for mosquitoes during dry spells. Various factors, including mosquito density, circulating virus serotypes, temperature, precipitation, and humidity, influence dengue transmission dynamics. However, insufficient proactive measures and personnel have hindered the effectiveness of control interventions.[3]

Epidemiological surveillance is crucial in disease prevention and control by facilitating systematic data collection, analysis, and dissemination. Dengue surveillance focuses on

detecting and forecasting epidemic activity by comprehensively monitoring human cases, laboratory data, vector populations, and environmental factors. In the digital age, digital epidemiology offers promising avenues for enhancing global health security, with digital systems enabling syndromic surveillance and early pandemic detection in countries such as Brazil, Latin America, and the United States.[4, 6]

Dengue fever remains a pressing public health issue in Thailand, where a robust surveillance system consistently records a high number of cases annually.[7] Among the provinces in southern Thailand, Phang Nga Province is particularly vulnerable due to its geographical and climatic conditions, which make it one of the worst-hit provinces by dengue fever each year. Despite ongoing efforts to combat the disease, both morbidity and incidence rates have shown a worrisome upward trend over the past five years, particularly in the Muang Phang Nga District. This highlights the urgent necessity for improved surveillance and control measures to alleviate the impact of dengue fever in the region. Additionally, the province grapples with endemic dengue transmission despite existing surveillance systems. Local surveillance teams, such as the Communicable Disease Control Operations Unit (CDCU), conduct community epidemiological investigations. However, the reliance on paper-based reporting systems results in delayed and incomplete data transmission, hindering effective disease control efforts. Consequently, there is an imperative need for enhanced electronic surveillance systems to enable comprehensive data analysis and informed decision-making.[8]

This study aims to bridge this gap by developing a web application to enhance dengue investigation efforts in the Phang Nga province. The application serves as a robust recording and reporting system for CDCU teams, enabling the collection of case-specific information and environmental data. Equipped with a user-friendly dashboard, the application provides real-time statistical insights, empowering authorities to monitor and manage disease investigations effectively. By streamlining the reporting process, the web application enhances the strategic planning and implementation of dengue prevention measures by providing health officials with timely and accurate information.

Materials and Methods

Agile Software Development Lifecycle (SDLC)[9, 13] were employed to ensure iterative development, flexibility, and adaptability in the design and implementation of the web application for dengue investigation in Phang Nga Province. These methodologies streamlined processes and minimized inefficiencies, enabling continuous refinement of the system. The existing dengue

investigation process was thoroughly reviewed to identify key inefficiencies. Workflow analysis, data diagram evaluations, and functionality assessments of the current system were performed. Special focus was placed on identifying bottlenecks in data recording, transmission, and analysis.

Stakeholder and SWOT Analysis

Stakeholder analysis was conducted to gather user requirements and align the system with practical needs.[14, 15] This included consultations with the Communicable Disease Control Operations Unit (CDCU) team[16] in Phang Nga Province, comprising 22 members, Communicable Disease Control Officers and Medical and Public Health Officers responsible for disease surveillance and prevention who are directly involved in dengue investigation. Structured interviews and brainstorming sessions were utilized to capture detailed feedback. A SWOT analysis was conducted to evaluate the strengths, weaknesses, opportunities, and threats of the project, providing valuable insights to guide the development process and mitigate potential risks.[17, 18]

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Database and System Redesign

The research undertook the task of redesigning the existing paper-based database into an efficient and accessible electronic[19] system to better meet the requirements of stakeholders. Users were required to register and create accounts to access the system, with different roles and permissions assigned accordingly. The role-based permissions included users who could record and update dengue case data, admins who managed data and system settings, and super admins who had control over system configurations and user accounts. The web application was designed with five key sections aimed at optimizing functionality, including a New Case Entry for recording new dengue case information, an Edit Data feature for updating or correcting case details, an Analysis section for generating statistical insights and identifying patterns, a Reports section for creating comprehensive investigation summaries, and a Dashboard for real-time visualization of case data and trends.

System Development

The system development phase, MySQL was used to build the database, and PHP was utilized for the programming of the web-based system.[20, 21] The development process involved constructing the database using SQL to ensure efficient storage and retrieval of data, designing a user-friendly web interface with essential features, integrating security measures such as role-based access control and data encryption, and testing the system with sample data to ensure its reliability and functionality before deployment.

Testing and Evaluation

System testing was approved by the Phang Nga Provincial Public Health Office, and the prototype was evaluated by users based on criteria such as ease of use, functionality, and overall satisfaction. Descriptive statistics were employed to analyze user demographics, such as gender, age, education, and work experience, while also evaluating their levels of satisfaction.[22] Feedback was gathered to identify areas for further improvement, ensuring that the web application would effectively support dengue investigation efforts in the region.

Results

Stakeholders and SWOT analysis

The research aimed to enhance the management of dengue outbreaks through the development of a comprehensive system, with key stakeholders playing a crucial role in shaping its success. Stakeholders were categorized into distinct groups, each contributing in different ways to the program's execution. Group 1 stakeholders, including hospitals, prioritized real-time tracking of dengue cases, while Disease Control Officers, positioned centrally in the implementation process, ensured effective execution. Group 4 stakeholders, on the other hand, were focused on providing strategic insights through detailed reporting and analysis, which was essential for the ongoing evaluation and improvement of the program. All are shown in summary as Table 1

Table 1 The result of the stakeholder analysis

Role	Interest				
	Communicable disease control officer (5)	Medical and Public Health Officers			
		Group 1 (5)	Group 2 (4)	Group 3 (4)	Group 4 (4)
Collection Data	+	+	+	+	+
- General data	+	+	+	+	+
- Symptom	+	+	+	-	+
- Lab	+	+	+	+	+
- Treatment	+	+	+	+	+
- Risk factor	+	+	+	+	+
- Source of disease	+	+	+	+	+
- Active case finding	+	+	+	-	+
- Activity to control	+	+	+	+	+
Analysis statistic					
- Incidence rate	+	+	+	+	+
- Incidence rate/month	+	+	+	+	+
- Mortality rate	+	+	-	+	+
- Proportion of types of dengue fever	-	+	-	+	-
Dashboard					
- Number of cases/areas	+	+	+	+	+
- Number of cases/months	+	+	+	+	+
Report					
- Summary Report	+	+	+	+	+
- Full Report	-	-	+	-	+
Linking information between hospitals and Sub-district Health Promotion Hospital	+	+	+	+	+
Notification System	+	-	+	+	+
Geospatial Analysis	+	+	+	+	+
Collaboration with Public Health Organizations	+	+	+	+	+

** (+) Stakeholder supports the project and aligns with its objectives.

(-) Indicates stakeholders who do not support or have reservations about the project.

A SWOT analysis of the system highlighted several key aspects. The strengths of the system were its accessibility, regular updates, and the ability to provide robust data analysis, which supports strategic planning efforts. However, weaknesses were identified, particularly the lack of a notification system and the system's dependency on internet access, which could hinder its functionality in low-connectivity areas. Opportunities for further improvement were also evident, such as potential system enhancements and the broadening of its practical applications across various health sectors. The analysis also uncovered threats, notably the system's limited integration with the Department of Disease Control, which could affect data sharing and coordination efforts at a national level.

Stakeholder feedback underscored the importance of incorporating functions that support the CDCU team's work, such as comprehensive data collection, statistical analysis tools, dashboard visualizations, and streamlined reporting processes. Additionally, enhancing the linkage of information between hospitals and sub-district health promotion hospitals was recognized as a critical need to improve coordination and response times.

The database design for the system was restructured to accommodate key data elements, ensuring more efficient data management and accessibility. It included general patient information, such as demographics and case-specific details; symptoms and laboratory findings, which provided insights into clinical presentations and diagnostic results; risk factors, focusing on both environmental and personal elements that contribute to dengue transmission; and active case finding, which captured ongoing investigations and interventions. This structured framework aimed to streamline the data flow and facilitate better decision-making processes at various levels of the health system. The required functions include:

Data Collection:

- General data
- Symptoms
- Laboratory findings
- Treatment details
- Risk factors
- Source of disease
- Active case finding
- Control activities

Statistical Analysis:

- Incidence rate
- Monthly incidence rate
- Mortality rate
- Proportion of dengue fever types

Dashboard:

- Number of cases per area
- Number of cases per month

Report:

- Summary Report

Furthermore, there is a pressing need to establish information linkage between hospitals and Subdistrict Health Promotion Hospitals. These enhancements are crucial for optimizing the dengue investigation system's effectiveness and facilitating seamless coordination among healthcare facilities.

Database Design

Based on the data requirements outlined it became apparent that the database should accommodate dengue investigation data, including general information, symptoms, laboratory results, treatment details, risk factors, and active case findings. A sample data table design is presented in Figure 1

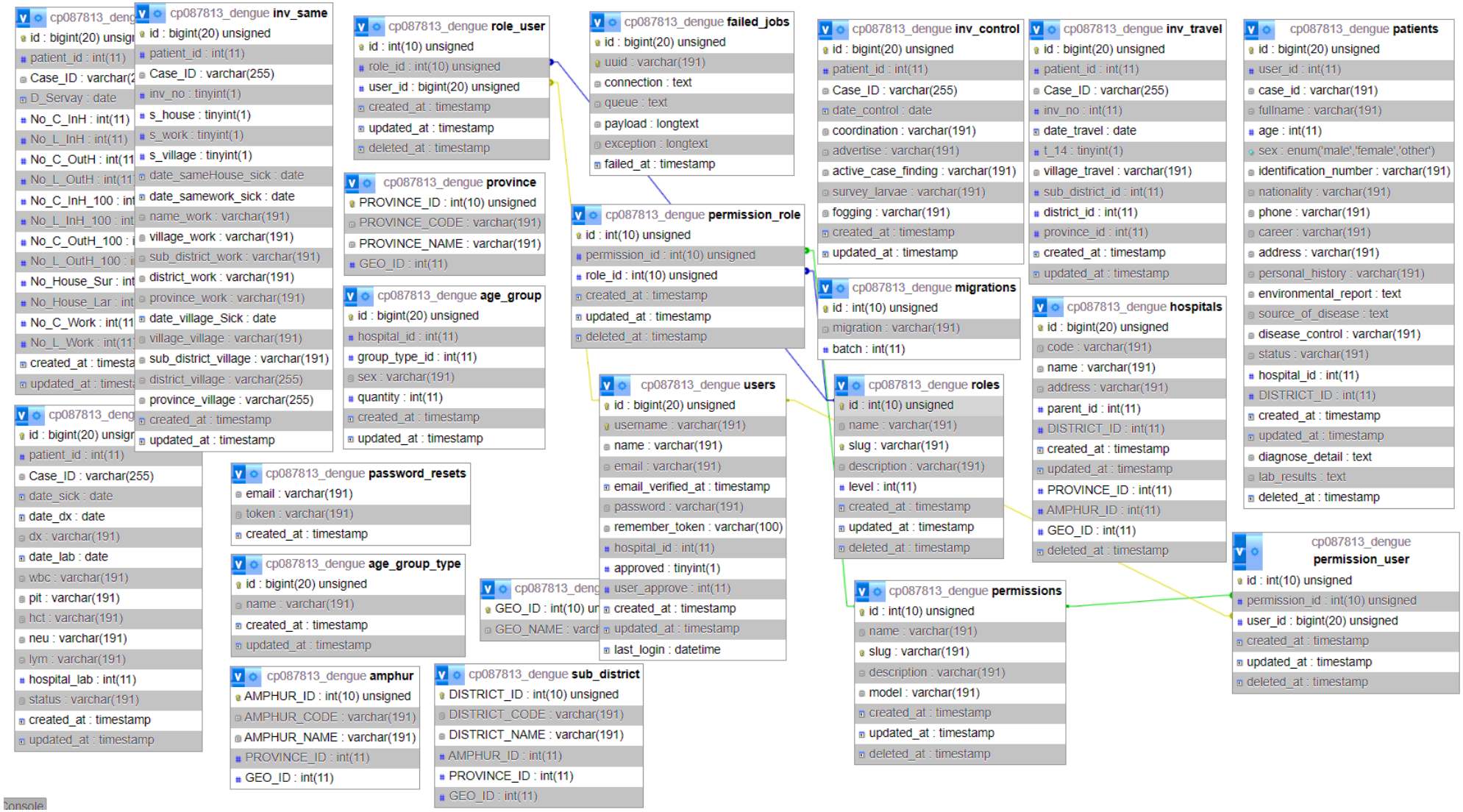

Figure 1 Database relationship of investigation of dengue data

This design provides a structured framework for storing and retrieving essential dengue investigation data, ensuring efficient data management and accessibility for stakeholders involved in disease control and prevention efforts.

Result of User Interface Design (UI)

The user interface (UI) design was tailored to ensure ease of use and functionality. The web application was divided into two main sections: the administrator section, which handles administrative tasks and system management, and the user section, which offers several key features. These features include real-time data visualization on dengue trends, tools for entering and updating patient information, and data analysis tools to generate statistical insights into case distribution and outcomes. The interface design prioritized user-friendliness to ensure efficient navigation and operation, even for those with limited technical expertise. then, the application was found to comprise two primary components:

Administrator Part: This section facilitates administrative tasks and system management. (Figure 2)

User Part: Designed for users to interact with the application, this part is subdivided into:

a. Situation about Dengue: Provides insights into the current dengue situation. (Figure 3)

b. Patient Data: Enables access to patient-related information. (Figure 4)

c. Data Analysis: Facilitates data analysis for informed decision-making and planning. (Figure 5)

This design ensures intuitive navigation and functionality for administrators and users, enhancing usability and effectiveness in managing dengue-related data and activities.

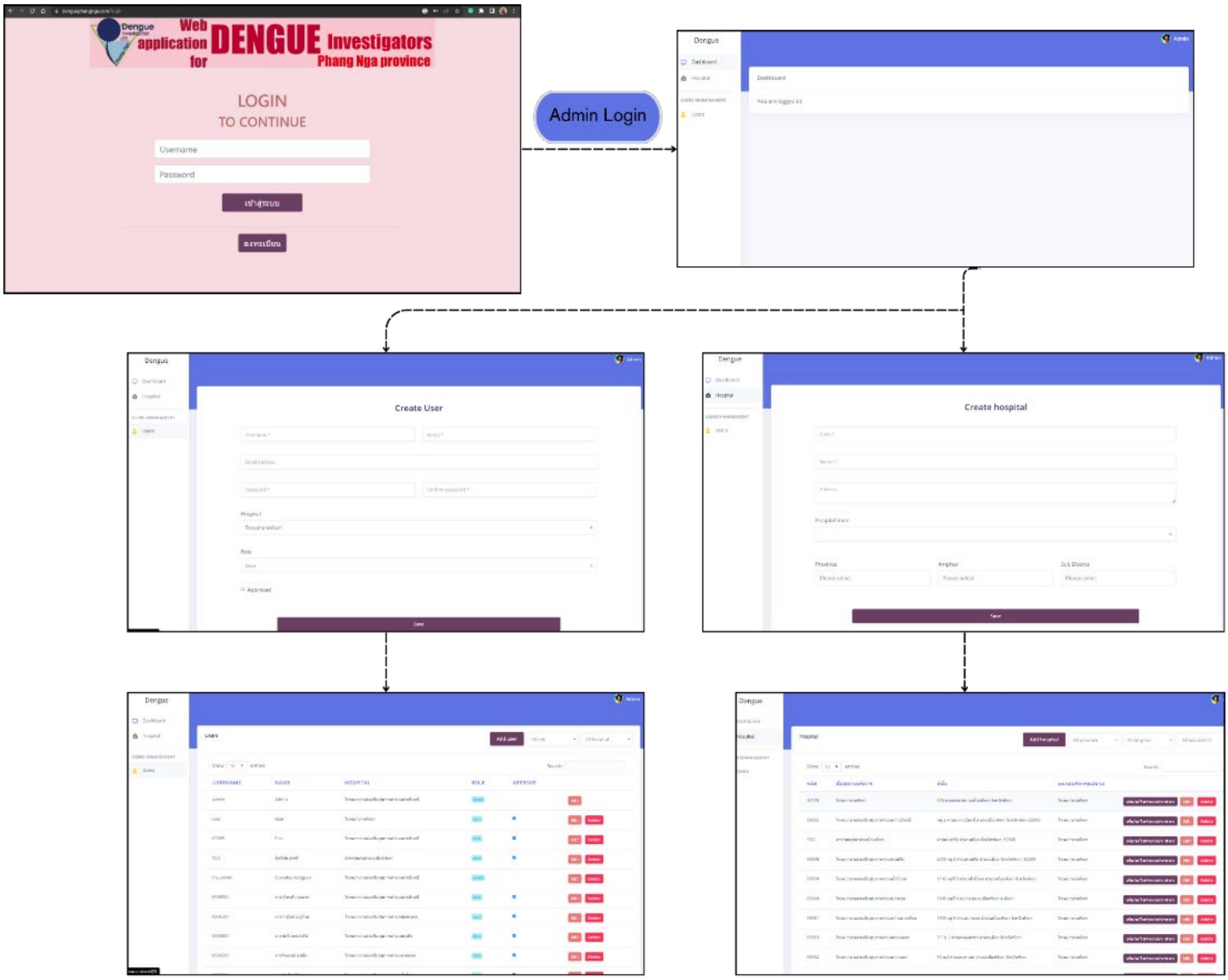

Figure 2 Administrator Part

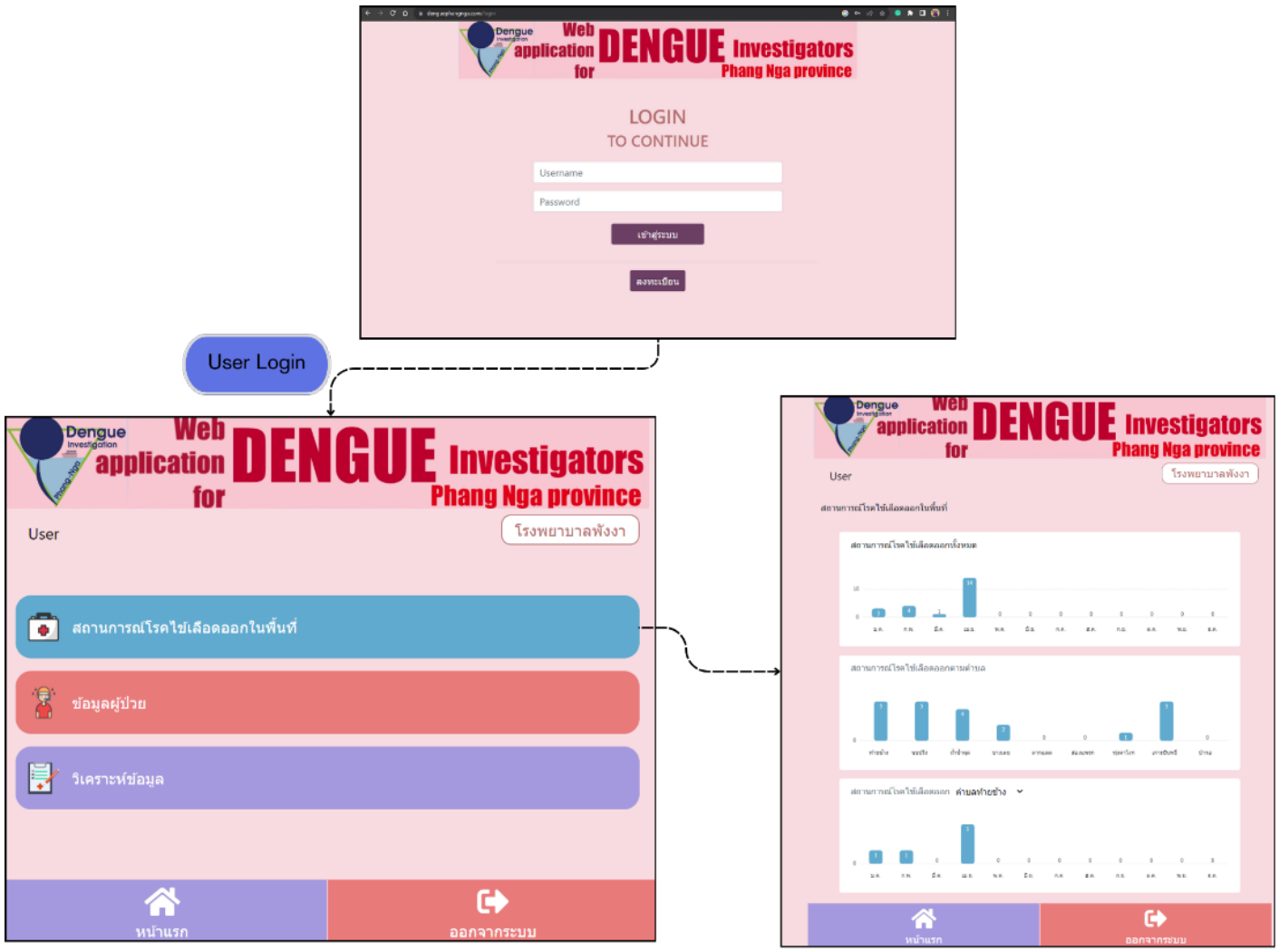

Figure 3 Situation about Dengue

Figure 4 Patient Data

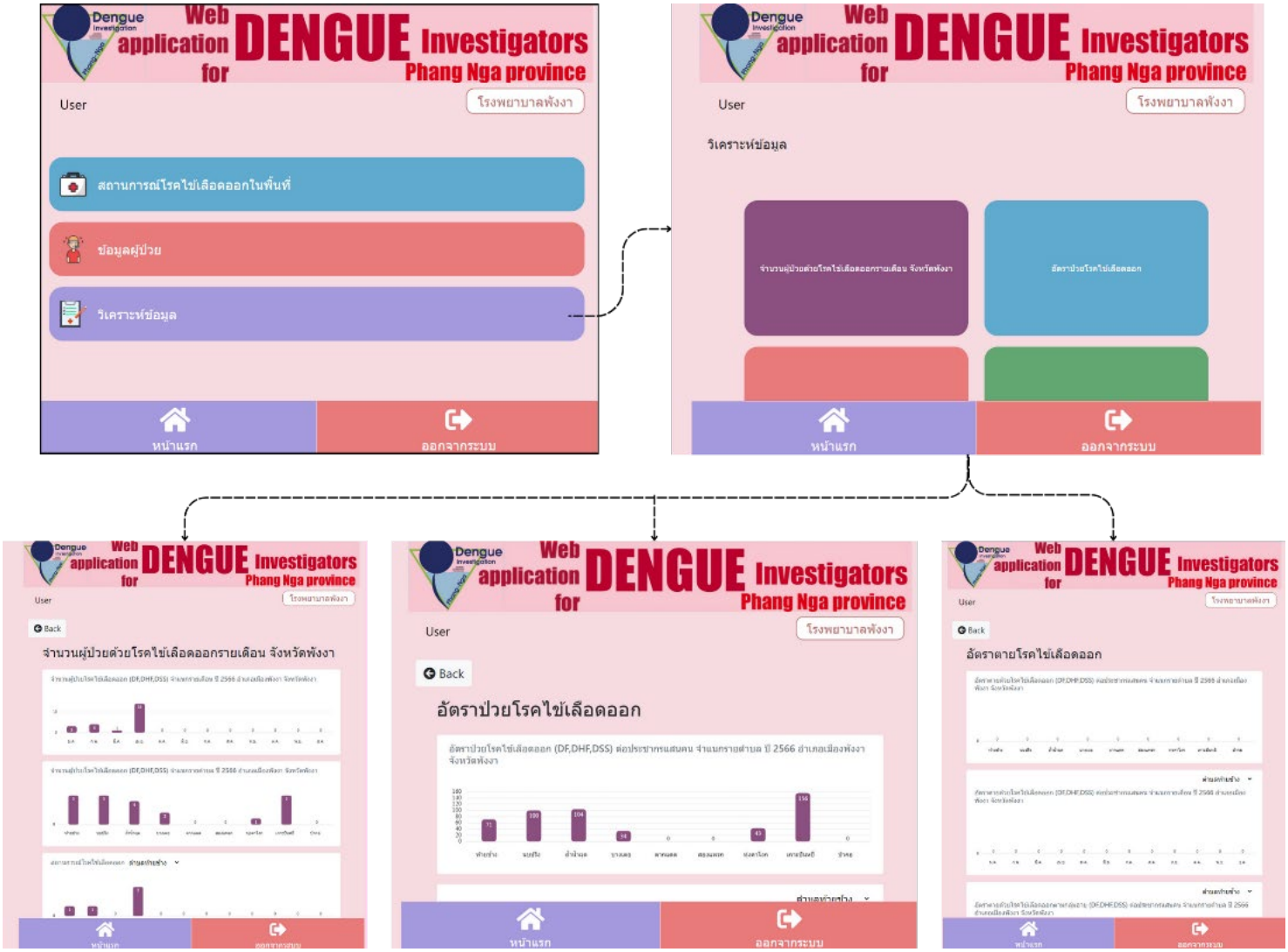

Figure 5 Data Analysis

Testing and Evaluation

An evaluation of the system included 22 participants, with a demographic breakdown of 32% male and 68% female, ranging in age from 28 to 59 years. The participants' occupational distribution consisted of 55% public health academics, 18% public health officials, and 27% nurses. The majority of participants (68.18%) held bachelor's degrees, and 63.63% had over five years of experience in disease control. Feedback from the evaluation highlighted a high level of satisfaction with the system's usability, although participants suggested the addition of more

features to improve integration and enhance decision-making support capabilities. These insights provided valuable direction for further development of the system.

Table 2 The evaluation of satisfaction results for processing and usage of web application

Questions	Mean
Functionality	
1. The dashboard has appropriate statistics displayed.	4.59
2. Data analysis/statistics are appropriate.	3.05
3. Able to use statistics to manage data appropriately.	3.24
4. Individual Case Investigation information is appropriate and adequate in data analysis and reporting.	4.55
5. Reports are suitable. The information in the report is complete.	4.68
Usability and Web Accessibility	
1. The screen in the presentation is beautiful.	4.68
2. Screen formatting is easy to use.	4.73
3. The menus/buttons that appear on the screen are suitable.	4.68
4. The style of the text is beautiful.	4.50
5. The size and color of the text are appropriate.	4.59
6. Procedures and methods of use are appropriate.	4.68
7. Record keeping is appropriate. Easy to use	4.64
8. The system is safe.	4.64

Discussion

This study highlights the development and implementation of a web application designed to enhance dengue investigation efforts in Phang Nga Province, Thailand. The application addresses inefficiencies inherent in the traditional paper-based system, such as delayed reporting and fragmented data. By integrating real-time data collection, analysis, and reporting functionalities, this system offers a practical solution to improving local outbreak management and decision-making processes.

The challenges faced by dengue surveillance systems are well-documented. According to the World Health Organization (WHO), delays in reporting and fragmented data often hinder timely responses to outbreaks.[1] These issues were also evident in Phang Nga Province, where paper-based systems limited the capacity for effective disease management. The web application developed in this study aligns with WHO recommendations to strengthen health information systems by facilitating real-time reporting and comprehensive data analysis.

Globally, the need for advanced technologies to support dengue surveillance has been recognized. Bhatt et al. emphasized the global distribution of dengue and the necessity for innovative tools to mitigate its burden[2]. While systems like Brazil's dengue surveillance program incorporate GIS technology to provide spatial visualizations of outbreaks[4], the system developed in this study focuses on dashboard analytics and statistical summaries tailored to local needs. Although it does not currently feature geographic mapping, the application has the potential to integrate such tools in the future, enhancing its utility for spatial analysis and outbreak monitoring.

Environmental factors also play a critical role in dengue transmission. Studies such as Morin et al. underscore the influence of climatic variables like temperature and rainfall on disease outbreaks[3]. While this application allows for the collection of environmental data, future iterations could benefit from predictive modeling capabilities to forecast outbreaks based on climate patterns. Incorporating such features would align the system with global advancements in disease surveillance and help address the increasing challenges posed by climate change.

The stakeholder-driven approach adopted in this study was pivotal to its success. Franco-Trigo et al. and McLeod Jr and Clark emphasized the importance of stakeholder involvement in the development of health information systems to ensure alignment with real-world needs.[14, 15] In this study, 22 members of the CDCU team provided input through

collaborative workshops, ensuring that the application met operational requirements. This participatory design process enhances the likelihood of system adoption and user satisfaction, consistent with findings from other health information system initiatives.

From a technical perspective, the use of Agile Software Development Lifecycle (SDLC) methodologies provided a structured yet flexible approach to system development. Open-source technologies such as MySQL and PHP ensured cost-effectiveness while supporting scalability. As highlighted by de Vicente Mohino et al., secure and iterative development processes are essential for creating reliable public health tools.[9] However, additional measures, including advanced encryption and secure APIs, are recommended to strengthen data security and privacy in future versions.

The web application's modular design offers significant scalability, enabling potential expansions to other provinces or diseases. Epidemiological data from the Phang Nga Provincial Health Office highlighted the increasing trend of dengue cases, which underscores the urgency of adopting modernized surveillance tools.[8] While the current application addresses immediate needs, future versions could focus on national-level integration, offline functionality for remote areas, and enhanced spatial analysis capabilities.

Despite its strengths, the system has limitations. Its reliance on stable internet connectivity could pose challenges in rural areas, as noted in previous studies.[6] Additionally, while the application provides robust statistical insights, the lack of GIS integration limits its capacity for spatial analysis of outbreaks. Addressing these gaps would enhance its functionality and align it with global best practices in disease surveillance.

In conclusion, this study contributes a localized, stakeholder-driven solution to dengue surveillance challenges in Phang Nga Province. While its immediate benefits are evident, the system's adaptability and scalability present opportunities for broader application across Thailand and beyond. Incorporating advanced features such as GIS mapping, predictive analytics, and secure data exchange would further enhance its impact, enabling it to align more closely with international standards and contribute to global efforts in combating dengue.

Conclusion

In conclusion, this study effectively addressed critical challenges in the investigation of dengue fever in Phang Nga Province through the development of a specialized web application designed to support the Dengue Fever Investigation Team. By identifying the inefficiencies of the

existing paper-based system through comprehensive stakeholder consultations and a detailed SWOT analysis, the research informed the design of an application that streamlines data collection, analysis, and reporting processes, thus improving operational efficiency.

The application utilizes MySQL and PHP, providing a solid foundation for robust database management and user-friendly web interfaces. Key functionalities, such as real-time situation updates, patient data management, and integrated analytical tools, enable both administrators and field personnel to respond more effectively to dengue outbreaks. User feedback highlighted the application's practical advantages, including enhanced data accessibility and operational efficiency. However, areas for further development were also identified, particularly in improving connectivity and integrating the system with national health databases to enhance its scalability and performance across regions.

This newly developed system represents a significant advancement in supporting public health initiatives aimed at dengue prevention and control. Its structured design not only strengthens current operations in Phang Nga Province but also offers a scalable model for broader application in other regions facing similar public health challenges. Future iterations should focus on enhancing system functionality, such as incorporating automated alerts, integrating Geographic Information Systems (GIS) for spatial analysis, and improving interoperability with national health systems, which would further optimize the system's utility in managing disease outbreaks.

The development of this web application emphasizes the critical role of technology in modernizing disease investigation efforts and fostering a proactive, adaptive approach to public health challenges. As it continues to evolve, the system holds significant potential to become a cornerstone tool in the fight against dengue fever. With continued refinement and expansion, it will contribute to the development of a more responsive and effective healthcare infrastructure capable of addressing emerging health threats in real time.

Ethical Approval Statement

This study was approved by The Ethics Committee for Human Research Faculty of Public Health, Mahidol University (COA. NO. MUPH 2021-051) Date of Approval on April 21, 2021.

Author Contributions

Author Contributions: SK conceptualized and designed the methodology and spearheaded web application development. SK also conducted research studies, analyzed the results, and contributed to drafting the manuscript. PS, JS, PK, PS, and VS guided throughout the research process and contributed to refining the design and regulations. All authors critically reviewed and approved the manuscript before submission for publication.

Acknowledgments

Gratefully acknowledge the support and contributions of the Faculty of Public Health, Mahidol University. Special thanks to the members of the Dengue Investigation Team at Phang Nga Province's Communicable Disease Control Operations Unit for their valuable insights and collaboration throughout this research. Also, thank all participants and stakeholders in this study for their time and cooperation. Additionally, thank our advisors, co-advisors, and all staff of the Department of Biostatistics for their guidance and support.

Source of Funding

The work presented in this article was self-funded.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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