Original Research Article

Development of digital surveillance for the COVID-19 and Dengue co-epidemic (SMART-CODEN) in Indonesia

Abstract

Background: The co-epidemic case of COVID-19 and Dengue is a public health problem that needs attention. It is necessary to develop a digital-based integrated surveillance system to collect data.**Objective:**This research focuses on developing a digital surveillance design for the COVID-19 and Dengue co-pidemic, which is named SMART-CODEN. SMART-CODEN is an innovative surveillance system that combines real-time data analysis and case mapping to monitor and analyze the spread of these two diseases effectively and efficiently. **Methods:**The SMART-CODEN development process involves several SDLC stages: requirements analysis, system design, implementation, testing, and maintenance. At the needs analysis stage, in-depth interviews were conducted with health experts, technology developers, and other stakeholders to understand the needs and challenges in COVID-19 and Dengue surveillance. The information obtained is used to design systems capable of early detection, tracking, and accurate analysis.**Results:** The research results show that SMART-CODEN can increase the speed and accuracy of early detection of COVID-19 and Dengue cases compared to traditional surveillance methods. This system also facilitates health authorities in taking more rapid and targeted preventive actions and supports data-based decision-making. Implementation of SMART-CODEN can also encourage active community participation in reporting symptoms and cases, which helps reduce the rate of disease spread. **Conclusion:**Overall, this study concludes that the development of the SMART-CODEN design produces an effective and innovative surveillance system with the potential to be applied in infectious disease control.

Keywords: digital surveillance, COVID-19, Dengue, SMART-CODEN, early detection.

1. INTRODUCTION

The COVID-19 and Dengue pandemics are two significant health threats to global society [1], [2]. COVID-19, caused by the SARS-CoV-2 virus, has caused an unprecedented health crisis with far-reaching impacts on health, the economy, and social life [3], [4], [5]. However, Dengue, caused by the Dengue virus and transmitted by the Aedes mosquito, continues to be a significant health problem in many tropical and subtropical countries, including Indonesia [6], [7]. These two diseases require an effective surveillance system to detect and control their spread quickly and accurately.

The surveillance system for dengue disease in Indonesia still needs to be integrated, which is a challenge in treating this disease. With the COVID-19 pandemic, which has similar initial symptoms such as fever, the need for a rapid early detection system has become urgent [8]. Therefore, developing an integrated surveillance system to monitor and detect cases of COVID-19 and dengue is very important. It helps increase the effectiveness of public health responses and prevent disease spread more efficiently.

Digital surveillance is an innovative solution for controlling infectious diseases. By utilizing information and communication technology, digital surveillance enables the collection, analysis, and interpretation of health data in real time [9], [10]. However, developing and implementing an effective digital surveillance system requires a systematic and comprehensive approach. The System Development Life Cycle (SDLC) is a framework commonly used in information system development, which includes the stages of requirements analysis, design, implementation, testing, and maintenance[11]. This approach ensures that the system developed meets user needs and can function correctly.

This research aims to develop a digital surveillance design for COVID-19 and Dengue, named SMART-CODEN, using an SDLC approach and qualitative methods through in-depth interviews. SMART-CODEN is expected to increase the speed and accuracy of early detection, facilitate faster and more targeted preventive action, and support data-based decision-making. Thus, this system has great potential to be widely applied to control infectious diseases in various regions.

2. METHODOLOGY

This research uses a System Development Life Cycle (SDLC) approach and qualitative methods through in-depth stakeholder interviews. The SDLC approach was used to develop the SMART-CODEN digital surveillance system design to the design and testing stages. Meanwhile, in-depth interviews were conducted with stakeholders to understand the potential and design of the system. The following are the stages of the research method used:

2.1 Needs Analysis

Conduct a literature review to understand the basic concepts of digital surveillance, technological developments in disease detection, and case studies related to COVID-19 and Dengue. Conduct in-depth interviews with ten stakeholders, including two public health experts, one technology developer, two hospital surveillance officers, one health department, two community health center officers, and two cadres, to identify needs and challenges in disease surveillance. Identify relevant stakeholders such as health experts and technology developers. Develop an interview guide with questions about needs, expectations, challenges, and potential for SMART-CODEN system design. Conduct in-depth interviews in person or virtually to collect qualitative data.

2.2 System Design

Based on the interviews and results from the needs analysis, the SMART-CODEN system architecture will be designed, including main components, data flow, and functionality. Developed an initial prototype of SMART-CODEN to obtain feedback from stakeholders. This prototype will be tested iteratively to ensure it meets the identified needs. Analyze interview data to determine the main features and functions needed in the SMART-CODEN system. Design a system architecture with main components such as early detection modules, case tracking, and real-time data analysis. Develop an initial prototype based on the design that has been prepared and obtain feedback from stakeholders for iterative improvements.

2.3 Trial Implementation

Implement approved system designs into functional software for the testing phase. This development involves basic programming and integration of critical components. Conduct system testing on a limited scale to identify and fix bugs and evaluate initial system performance. Developed an initial version of the system based on the refined design. Conduct

trials on a limited scale to evaluate basic functionality and system performance. Gather feedback from early users and make necessary improvements.

2.4 Data Collection and Analysis

An interview guide will be used to collect data from stakeholders regarding the potential and design of the SMART-CODEN system. Data from in-depth interviews were analyzed using thematic analysis methods to identify main themes related to needs, challenges, and potential solutions. Data from in-depth interviews will be used to understand stakeholder needs and expectations for SMART-CODEN in depth. Analyze data using thematic analysis methods to identify main patterns and themes that will be used to improve the system.

3. RESULT

3.1 Needs Analysis

The needs survey results for COVID-19 and Dengue surveillance show several vital findings that reflect the main challenges and needs in the public health surveillance system. The following is a summary of findings using a qualitative approach based on excerpts from in-depth interviews with several key informants.

The Need for an Effective Reporting System

Many respondents emphasized the importance of a fast and effective reporting system for COVID-19 and Dengue. The initial case report had the same fever symptoms. The doctor who made the diagnosis was still confused about whether it was dengue fever or COVID-19. Primary health services will conduct laboratory examinations for COVID-19, perform a swab test, and then confirm with PCR. On the first day of dengue hemorrhagic fever, an NS1 test can be carried out; then, on the third day of fever, a blood platelet test can be carried out. Reporting of dengue fever and COVID-19 cases is still not integrated. The reporting system is still separate, so the mapping of the distribution of COVID-19 and dengue cases is not visible.

> *"We need a reporting platform that can be accessed and responded to quickly to disseminate information without delay." [PHC, 1]*

"For patients with fever, at the beginning of treatment, it is usually still unclear, but after a swab test or PCR examination, the diagnosis is confirmed" [hospital officer, 1].

"The reporting system differs between dengue fever and COVID-19, even though they both have fever symptoms. There is no integration of reporting between dengue fever and COVID-19" [Health Department,1].

Limited health personnel

Several informants noted that the main obstacles were limited human resources and diagnostic tools. The COVID-19 pandemic has caused many health workers in hospitals to be diverted to treating COVID-19 patients. The limited number of health workers means that the ability to trace case contact history and quarantine is limited.

"The personnel in health services to assist in handling COVID-19 are still limited, especially tracer officers who are available to report contact history. If COVID-19 cases increase, staff will be overwhelmed. The condition worsens when the policy is unclear, such as quarantining people or families" [PHC, 2].

"The shortage of staff and test equipment makes it difficult for us to carry out comprehensive surveillance, especially in remote areas." [PHC, 1]

The Importance of Education and Training

There is a significant need for ongoing education and training for health workers. In the face of new disease diagnoses, the competency of health service personnel to carry out early detection needs to be improved. Moreover, training needs to be carried out when using new technology.

"Continuous training is needed so that health workers remain up-to-date with the latest protocols in handling COVID-19 and Dengue cases" [Hospital officer, 2]

"The training I received two years ago was insufficient to deal with this pandemic. We need more training sessions and regular updates." [Hospital officer, 1]

Funding support

Funding for handling COVID-19 is also limited. Most of the staff involved in the COVID-19 task force are local volunteers. The availability of social assistance is also limited to those who can get it. Operational efforts for COVID-19 data collection activities require quite a lot of funds and personnel. So, operational assistance for this activity can be an obstacle to collecting data.

> *"Funding for epidemiological reporting and surveillance activities in the field is still limited. Most of the volunteer activities help in case tracing. All health workers are involved in the COVID-19 task force; social assistance is limited. With this limited funding, we must be able to calm the public from panic" [Health Department, 1]*

Cross-sectoral collaboration

Strong collaboration between various health agencies is essential. In handling cases of COVID-19 and dengue, outbreaks co-occurred. Coordinating facilities, personnel, funding, and policies are needed to control it. Collaboration and cooperation between cross-sectors is needed.

> *"Collaboration between hospitals, clinics, and health services must be strengthened to ensure accurate data and rapid action." [data officer, 1]*

3.2 Utilization of Technology Integrated reporting system for COVID-19 and dengue

Technology is said to be the key to improving surveillance. A system for reporting cases of dengue and COVID-19 is needed so that mapping of areas at risk of co-epidemic COVID-19 and dengue can be carried out. Easy and widely applicable reporting system. The application system will also help provide digital education to the public, allowing them to report cases directly to officers and provide consultations.

> *"A surveillance application system is needed that is easy to learn and useful in monitoring COVID-19 and dengue" [public health expert, 1]*

> *"If you create a surveillance system like this, the public should also have access to digital educational media, be able to report cases in the field directly, and have consultations with officers" [health cadre, 1]*

"Data integration between laboratories and health services is still not optimal, which results in a slow response to the outbreak." [Health Data Analyst]

3.4 SMART-CODE application design

The source of reporting COVID-DHF cases is the hospital reporting system using the Hospital Early Alert System (SKDRS) menu. Reporting COVID-DHF cases can be done through the application and then continued in an integrated manner to the city health service and community health center. The public can also report cases of COVID-DHF in the surrounding environment. The report is entered into the application system and followed up by surveillance officers to ensure its correctness. Larva monitoring officers (jumantik) report online the density of larvae. The results of epidemiological investigation activities are reported in real time. They can be accessed by community health centres and health services so that they can immediately make decisions to take appropriate preventive measures. The SMART-CODEN application can intervene through an educational menu that provides educational videos to carry out dengue control efforts. Through an integrated system with jumantik activities, providing digital education and routine larvicide to the community can influence the density of larvae in the environment.

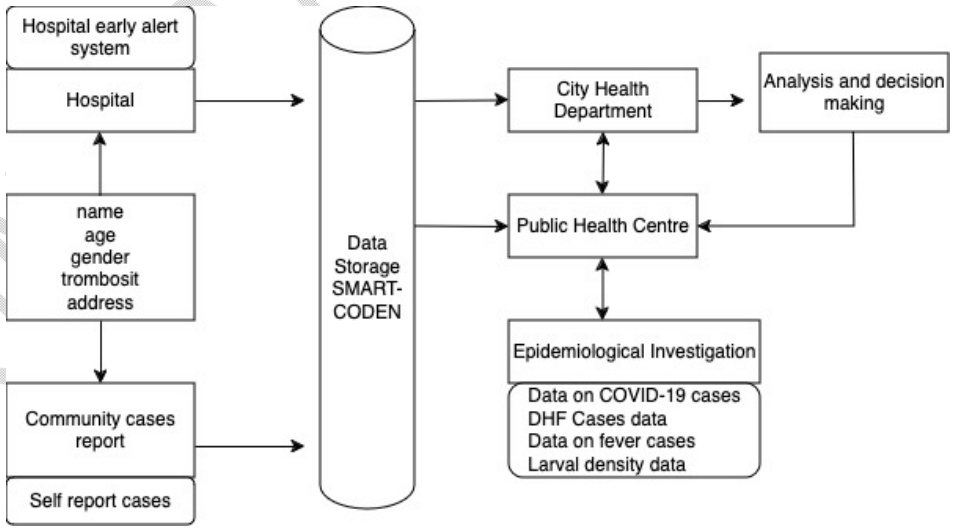

Figure 1. SMART-CODEN DATA FLOW

The SMART-CODEN application was created according to the needs of each user of this application. Each user has been prepared with a special menu to fill in according to their needs. The use of this menu is as follows:

Reporting fever cases

Officers and the public can report fever incidents that occur in their area. Through this menu, early precautionary detection of fever incidents can be carried out, followed by further laboratory examinations to correctly diagnose the possibility of being infected with dengue, COVID-19, or other infectious diseases.

COVID-19 Surveillance

In this menu, data is collected on COVID-19 surveillance reporting to find potential risks to respondents related to close contact with COVID-19 patients in the last 14 days, having been infected with COVID-19, experiencing symptoms of fever/cold/shortness of breath in the last seven days, never had a vaccine, had a chronic disease.

COVID-19 vaccine history

This menu lists the history of vaccines carried out so far. Place, date, and type of vaccine are collected. This vaccine history data is important to know how many people have received it and what type of vaccine they received. Have received the vaccine and booster vaccine several times. With this data, analyses can be carried out regarding vaccine coverage and herd immunity.

SMART-CODEN educational videos

This menu provides access to educational videos about efforts to control COVID-19 and dengue. Through this menu, application users can access educational videos to increase knowledge regarding efforts to control dengue hemorrhagic fever and COVID-19. In this way, users can easily get educational videos through digital applications.

Case distribution map

This menu provides a map of the spread of COVID-19 cases. During the COVID-19 pandemic, the spread of COVID-19 in the area is necessary to identify high, medium, and low-risk areas. Knowing the area mapping can prioritize problems to carry out control efforts.

Contact officer

This menu provides officer contacts. In dealing with the co-epidemic of COVID-19 and dengue fever, fast and appropriate action is needed. The officer's role in making decisions is needed quickly. For this reason, application users who need direct access to information from officers are provided with an officer contact menu.

The SMART-CODEN application gives users access to report, obtain information, map vulnerable areas, and contact officers. Through active surveillance from the community, data will be collected continuously and sustainably to develop control strategies.

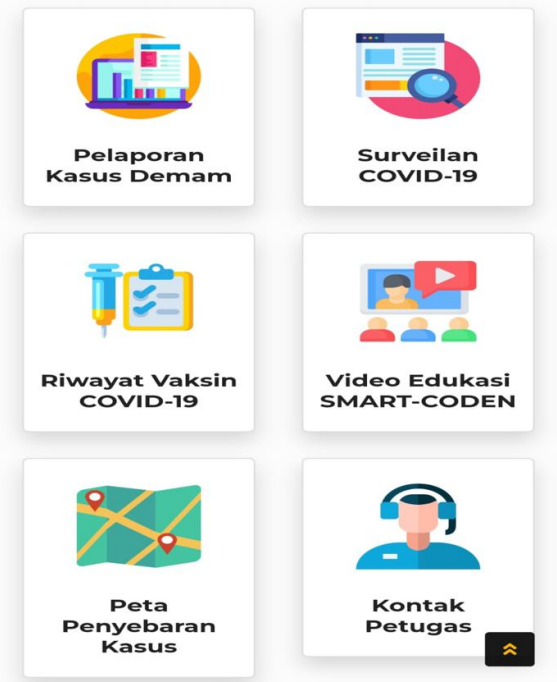

Table 1. Themes and subthemes, challenges and potential for developing the SMART-CODEN system

No	Themes	Subthemes
1.	Problems with the COVID-19 reporting system	• The reporting system is not integrated • Biased reporting • Lack of staff in community health centers • Limited funding • - Limited supporting facilities
2.	Problems with the dengue reporting system	• Reporting is not integrated • Slow reporting to the puskesmas • Data bias resulting from epidemiological investigations • A lot of reporting that must be made from case data collection, larval density, weekly and monthly reporting.
3	Co-epidemic COVID-Dengue integrated reporting system	• Integrated reporting between covid-19 and dengue • Early detection of fever cases in the community • Digital surveillance system carried out by the community, community health center officers, hospitals • Digital educational media • Mapping of COVID-19 and dengue cases • Application that can make contact with officers directly

3.5 Trial Results of the SMART-CODEN Digital Surveillance Application in COVID-19 and Dengue Surveillance

System Functionality

SMART-CODEN detected COVID-19 and Dengue cases quickly by integrating real-time data from various sources, such as public reports and health data from hospitals. This system can provide early notification to health authorities about potential outbreaks in an

area. This application can analyze data in real time and present visualizations that are easy to understand. This feature helps health authorities make faster and more accurate decisions. An easy-to-use symptom reporting feature for the public increases public participation in disease surveillance. Many users report that the app interface is intuitive and easy to use.

> *"SMART-CODEN has complete functionality. This system can integrate data from various sources, provide real-time data visualization, and support case mapping." (Hospital Surveillance)*
>
> *"The reporting and monitoring features in SMART-CODEN help us in the field. We can easily enter data on new cases and disease trends in our area." (Health Cadre)*

Effectiveness in Disease Control

The SMART-CODEN system allows health authorities to respond quickly to new case reports, contributing to a reduction in overall response time. The speed of response is important in controlling the spread of COVID-19 and Dengue. With accurate data analysis, health authorities can allocate resources more efficiently, such as distributing test kits and medical personnel.

> "I am very satisfied with using SMART-CODEN. This user-friendly system has an attractive interface, making it easier for us to monitor and report cases." [PHC, 1]
>
> "We feel helped by this application because it reduces administrative burdens and increases work efficiency. The data entered is immediately saved and can be accessed anytime." [PHC, 2]

User satisfaction

Most users provided positive feedback about the app's ease of use and usefulness in reporting symptoms and accessing up-to-date information on COVID-19 and Dengue. There was a significant increase in public participation in symptom and case reporting following the launch of SMART-CODEN. Community participation shows that the community received this application well. Users feel more confident in the data presented by the application because it is transparent and real-time.

"SMART-CODEN has been proven effective in disease control. With fast and accurate data analysis, we can immediately take preventive measures and targeted treatment." (City Health Department)

"With SMART-CODEN, we can more quickly detect an increase in cases of both COVID-19 and dengue so that intervention efforts can be carried out earlier and more precisely." (Public Health Center)

Challenges and Improvements

One of the main challenges is dependence on a stable internet connection. In some remote areas, poor internet connections hinder the use of the app. Several additional features are being developed based on user feedback, such as integration with local health systems and location-based notification features. More public education about using the app and the importance of participation in digital surveillance is needed to ensure wider adoption.

4 DISCUSSION

The SMART-CODEN digital application has the potential to be used to carry out surveillance and early detection of COVID-19 and Dengue cases. This study shows a need to analyze an integrated system for surveillance of COVID-19 and dengue. This research shows that SMART-CODEN improves the speed and accuracy of data collection compared to manual surveillance methods.

Health stakeholders need a needs survey for an integrated digital system for COVID-19 and dengue. This system can report quickly and detect cases early. Through this integrated reporting, case tracking can be done quickly. Early detection of COVID-19 has also been carried out with artificial intelligence[12], and wearable technology, such as smartwatches [13], based on early self-reported symptoms to enable timely self-isolation [14]. Indonesia has also developed several approaches to early detection, such as artificial intelligence, machine learning, digital surveillance, and COVID-19 screening[15].

The study in Bangladesh also developed a digital surveillance system for handling COVID-19 to educate, screen, and track COVID-19 at the community level in Bangladesh [16]. Studies in the United States also conducted continuous sensor data collection that could provide early warning signals for COVID-19 activity [17]. However, the SMART-CODEN

application carries out integrated data collection between COVID-19 and Dengue, and there is community participation in reporting cases.

Interactive dashboards for infectious disease surveillance show improved understanding and interpretation of data by health workers [18]. This finding aligns with the SMART-CODEN dashboard, making it easier for users to understand epidemiological trends and make timely decisions. SMART-CODEN also provides case mapping and reporting from the community, which officers validate.

Digital surveillance systems can reduce the use of human and material resources in disease surveillance [19], [20]. SMART-CODEN supports these findings by showing higher data collection and analysis efficiency than traditional methods. In addition, the SMART-CODEN trial showed a significant reduction in error rate, indicating improved data quality.

Data security and privacy are critical aspects of digital surveillance systems—the importance of security protocols in digital surveillance systems to protect patient personal information [21]. SMART-CODEN implements strict security protocols, in line with the study's recommendations, to ensure patient data remains secure and confidential.

Research Strengths and Limitations

SMART-CODEN provides a comprehensive platform with advanced features such as early notification and contact tracing. This system shows increased efficiency and accuracy in COVID-19 and Dengue surveillance. Integration of data from various sources allows for more comprehensive and in-depth analysis.

The trial was carried out in a relatively short time (6 months), so it needs to be continued to ensure consistency in the results. There needs to be intensive training for users in health facilities to maximize the system's potential. Adaptation and integration with existing health information systems require additional time and resources.

Conclusion

The SMART-CODEN digital surveillance application's trial results show that this system effectively detects and tracks COVID-19 and Dengue cases in real time. This application increases response speed and efficiency in disease control and is well-received by the public. Existing challenges, such as internet connection and user education, can be overcome with further development and appropriate education strategies. Overall, SMART-CODEN has excellent potential for widespread application in infectious disease surveillance.

Reference

1. Cardona-Ospina JA, Arteaga-Livias K, Villamil-Gómez WE, Pérez-Díaz CE, Katterine Bonilla-Aldana D, Mondragon-Cardona Á, et al. Dengue and COVID-19, overlapping epidemics? An analysis from Colombia. J Med Virol. 2021;93(1):522–7.
2. Harapan H, Ryan M, Yohan B, Abidin RS, Nainu F, Rakib A, et al. Covid-19 and dengue: Double punches for dengue-endemic countries in Asia. Rev Med Virol. 2021;31(2):1–9.
3. Sarkodie SA, Owusu PA. Global assessment of environment, health and economic impact of the novel coronavirus (COVID-19). Environ Dev Sustain [Internet]. 2021;23(4):5005–15. Available from: https://doi.org/10.1007/s10668-020-00801-2
4. Singh AK, Misra A. Impact of COVID-19 and comorbidities on health and economics: Focus on developing countries and India. Diabetes Metab Syndr Clin Res Rev [Internet]. 2020;14(6):1625–30. Available from: https://doi.org/10.1016/j.dsx.2020.08.032
5. Clemente-Suárez VJ, Navarro-Jiménez E, Moreno-Luna L, Saavedra-Serrano MC, Jimenez M, Simón JA, et al. The impact of the covid-19 pandemic on social, health, and economy. Sustain. 2021;13(11):1–25.
6. Mardiati Nadjib, Ery Setiawan SP, Al. JN et. The economic burden of dengue in Indonesia. PLoS Negl Trop Dis. 2019;13(1):1–14.
7. Colón-González FJ, Gibb R, Khan K, Watts A, Lowe R, Brady OJ. Projecting the future incidence and burden of dengue in Southeast Asia. Nat Commun. 2023;14(1).
8. Alla D, Alla SSM, Vempati R, Bhatt H, Sultana Q, Bhatt S, et al. Dengue & COVID-19: A Comparison and the Challenges at Hand. Cureus. 2022;14(11).
9. Bhatia S, Lassmann B, Cohn E, Desai AN, Carrion M, Kraemer MUG, et al. Using digital surveillance tools for near real-time mapping of the risk of infectious disease spread. npj Digit Med [Internet]. 2021;4(1):1–10. Available from: http://dx.doi.org/10.1038/s41746-021-00442-3
10. Zhao IY, Ma YX, Yu MWC, Liu J, Dong WN, Pang Q, et al. Ethics, integrity, and retributions of digital detection surveillance systems for infectious diseases: Systematic literature review. J Med Internet Res. 2021;23(10):1–18.
11. Kyeremeh K. Overview of System Development Life Cycle Models. J Manag Sci.

2021;11(1):12–22.

12. Miah M, Venkatraman S. Artificial Intelligence for Early Detection and Diagnosis of COVID-19: Immense Potential of a Powerful Technology. J Health Manag. 2024;26(2):369–79.
13. Cheong SHR, Ng YJX, Lau Y, Lau ST. Wearable technology for early detection of COVID-19: A systematic scoping review. Prev Med (Baltim) [Internet]. 2022;162(July):107170. Available from: https://doi.org/10.1016/j.ypmed.2022.107170
14. Canas LS, Sudre CH, Capdevila Pujol J, Polidori L, Murray B, Molteni E, et al. Early detection of COVID-19 in the UK using self-reported symptoms: a large-scale, prospective, epidemiological surveillance study. Lancet Digit Heal [Internet]. 2021;3(9):e587–98. Available from: http://dx.doi.org/10.1016/S2589-7500(21)00131-X
15. Nur Aisyah D, Lokopessy AF, Naman M, Diva H, Manikam L, Adisasmito W, et al. The Use of Digital Technology for COVID-19 Detection and Response Management in Indonesia: Mixed Methods Study. Interact J Med Res. 2023;12:e41308.
16. Sarker F, Chowdhury MH, Ratul IJ, Islam S, Mamun KA. An interactive national digital surveillance system to fight against COVID-19 in Bangladesh. Front Digit Heal. 2023;5(May).
17. Radin JM, Quer G, Pandit JA, Gadaleta M, Baca-Motes K, Ramos E, et al. Sensor-based surveillance for digitising real-time COVID-19 tracking in the USA (DETECT): a multivariable, population-based, modelling study. Lancet Digit Heal [Internet]. 2022;4(11):e777–86. Available from: http://dx.doi.org/10.1016/S2589-7500(22)00156-X
18. Schrarstzhaupt IN, de Souza Bragatte MA, Kawano-Dourado L, de Oliveira LR, Vieira GF, Diaz-Quijano FA, et al. Interactive monitoring dashboards for the COVID-19 pandemic in the world anticipating waves of the disease in Brazil with the use of open data. Rev Bras Epidemiol. 2024;27:1–10.
19. Maddah N, Verma A, Almashmoum M, Ainsworth J. Effectiveness of Public Health Digital Surveillance Systems for Infectious Disease Prevention and Control at Mass Gatherings: Systematic Review. J Med Internet Res. 2023;25:1–30.
20. Yeung AWK, Torkamani A, Butte AJ, Glicksberg BS, Schuller B, Rodriguez B, et al. The promise of digital healthcare technologies. Front Public Heal. 2023;11(September).
21. Thapa, Camtepe. Precision health data: Requirements, challenges and existing techniques for data security and privacy. Comput Biol Med. 2021;129.