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Designing A Digital-Based Surveillance Information System Prototype for Epidemiological Investigation of Avian Influenza (H5N1) In Bali Province

[1]I Gusti Ngurah Agung Surya Pratama, [1]Putu Putri Agustini, [1]I Dewa Agung Ayu Ari Shinta Dewi, [2]I Made Subrata*, [2]Ngakan Putu Anom Harjana, [2]Sang Gede Purnama, [3]Romy Muhammad Dary Mufa

Corresponding Author: * madesubrata@unud.ac.id

[1] Bachelor of Public Health Study Program, Faculty of Medicine, Udayana University, Denpasar, Bali, Indonesia

[2] Department of Public Health, Faculty of Medicine, Udayana University, Denpasar, Bali, Indonesia

[3] Department of Veterinary Medicine, Faculty of Veterinary Medicine, Udayana University, Denpasar, Bali, Indonesia

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ABSTRACT

Avian Influenza (AI) is an infectious disease that can attack birds and humans caused by a virus. Until April 2023, the number of human victims infected with AI disease in the world reached 874 people (confirmed AI cases), with 458 of them dying (CFR = 52%). Health Surveillance is a systematic and continuous observation activity of data and information about the incidence of disease or health problems and conditions that influence the increase and transmission of disease or health problems. The aim of the research is to design a digital-based AI epidemiological surveillance system in Bali Province. The research design used in this research is a research and development (R&D) approach with a prototyping development model. Acceptance tests were carried out on 130 surveillance officers with the PSSUQ questionnaire. The results obtained were in the form of a prototype AI epidemiological investigation information system application with acceptance test results regarding system quality (2.37), information quality (2.43), and the overall system (2.37) showing very good results. Meanwhile, acceptance of the quality of the design or appearance of the prototype is in the good category (2.37). This value is classified based on the norm scale of the PSSUQ questionnaire. Conclusion: Therefore, this AI epidemiological investigation

surveillance information system is worthy of further development.

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Keywords
Avian influenza
Surveillance information system
Prototype

Introduction

Avian influenza (AI) is a contagious disease that can affect both poultry and humans, caused by the influenza A virus. This virus is a single-stranded, negative-sense RNA virus classified within the Orthomyxoviridae family. The virus has two surface glycoproteins, hemagglutinin (HA) with subtype H5 and neuraminidase (NA) with subtype N1, hence the virus is also known as the H5N1 virus [1]. Influenza A (H5N1) first emerged in 1997 in China, specifically in the Hong Kong Special Administrative Region. At that time, an outbreak of Avian Influenza (AI) occurred in poultry, which also infected humans. There were 18 human cases, six of which resulted in death (CFR = 33.3%). By 2003, AI caused by the H5N1 subtype had spread to various countries worldwide, including China, Vietnam, Thailand, Cambodia, Indonesia, Turkey, Iraq, Egypt, and Azerbaijan. In December 2007, two new countries, Pakistan and Myanmar, reported human AI cases. The latest report from Cambodia on February 24, 2023, confirmed two AI cases, with one fatality. As of April 2023, the global number of confirmed human AI cases reached 874, with 458 fatalities (CFR = 52%) [2].

In Indonesia, the first laboratory-confirmed human AI cases were reported in early July 2005 from Tangerang Regency, Banten Province. There were two confirmed H5N1 cases and one probable case, all of which were fatal [3]. A virus with a new variant of clade 2.3.4.4b has been discovered and spread from Europe to Indonesia, where this variant has been detected in South Kalimantan, Indonesia [4]. In Bali, 12 (20%) of the 60 samples studied at Beringkit Market tested positive for H5N1 antigen antibodies. Furthermore, 14 (23.3%) of the 60 poultry samples tested positive for H5N1 antibodies at Galiran Market [5]. These results indicate that transmission and spread of the FB virus in animals in Bali is still occurring and has the potential to spread to humans.

Health surveillance is the systematic and continuous observation of data and information on disease events or health problems and the conditions that influence the increase and transmission of diseases or health problems [6]. Surveillance is conducted to obtain and provide information that guides effective and efficient control and mitigation actions [7]. Disease surveillance can be carried out through epidemiological investigation activities.

Currently, the WHO, in collaboration with the World Organization for Animal Health (WOAH) and the Food and Agriculture Organization of the United Nations (FAO), conducts surveillance of human-animal interactions, assesses risks, and coordinates responses to zoonotic influenza outbreaks and other public health threats [8]. Global AI surveillance has been implemented in several countries, but data collection and recording have not been standardized, posing a challenge to global AI surveillance activities [9]. Integrated surveillance activities for case detection and identification are necessary to prevent severe pandemics [10]. Transmission of the AI virus from wild birds to domestic animals is nearly impossible to prevent, making continuous and integrated surveillance essential for virus control and management [11].

In Indonesia, some current health surveillance activities still rely on paper-based methods. AI management guidelines also use manual data collection methods. This affects the accuracy and timeliness of the surveillance data obtained [12]. Therefore, an analysis of the needs of surveillance officers is necessary to improve field surveillance activities. Interviews with a surveillance program officer in Badung Regency revealed that manual recording is still in use and there are difficulties in recording the exact location of the incident, making it difficult to map the location of the incident. Hence, one potential improvement is to develop a digital-based surveillance system [13]. The use of digital systems for case detection and early outbreak warnings has proven effective [14]. Digital surveillance systems provide high stability and sensitivity, particularly in terms of timeliness [15]. Additionally, digital surveillance activities can assist in mapping disease occurrence locations. Mapping cases by recording the coordinates of incident locations will facilitate epidemiological observation and investigation by community health center surveillance officers [16]. Based on these factors, the researchers are interested in designing a digital-based AI epidemiological investigation surveillance system in Bali Province.

Methods

The research design used in this study follows a research and development (R&D) approach with a prototyping development model. The research activities included several steps: identifying system requirements, designing the prototype framework, developing the prototype, and evaluating the prototype. Testing was conducted with 130 surveillance officers in Bali Province using the Post-Study System Usability Questionnaire (PSSUQ). The samples in the study were selected based on the total sample method. This study has passed ethical review by the Research Ethics Committee of Udayana University, with approval number 0284/UN14.2.2.VII.14/LT/2024. This research funding was obtained from the Udayana University Superior Research Fund.

Results and Discussions

A. Identify System Requirements

The needs assessment was conducted through a literature review and in-depth interviews with surveillance officers. Two surveillance officers were involved in the need's identification process: one from the Mengwi I Community Health Center as the user and another from the Badung District Health Office as the end-user.

Based on the findings from the needs assessment, the requirements for the system to be developed were consistent between the community health center and the district/city health office surveillance officers. The desired system for conducting epidemiological investigations of Avian Influenza should allow for easy, fast, and straightforward data collection. To achieve this, implementing digital technology is essential to enhance the effectiveness of these activities.

B. Prototype System Framework

In designing the system, the determination of features to be included in the system and the outputs produced were modeled using Unified Modeling Language (UML) diagrams, specifically referred to as use-case diagrams (Fig 1).

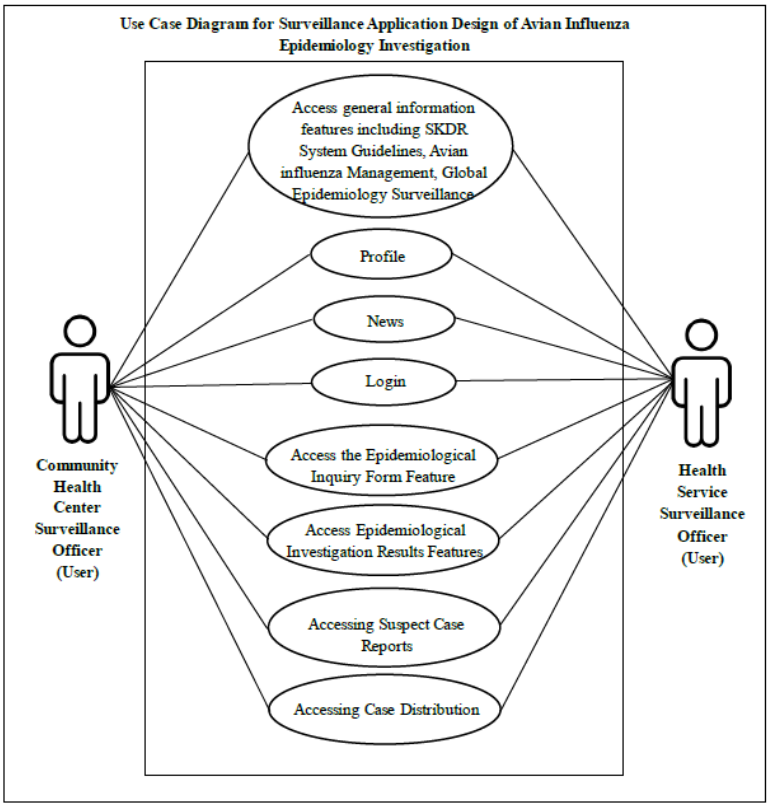


Fig. 1. Use Case Diagram Prototype Design Application for Surveillance Epidemiology Investigation of Avian influenza

Based on Figure 1, there are two groups: Community Health Center Surveillance Officers and Health Service Surveillance Officers. These features can be divided into eight groups: general information, profile, news, login, PE form, PE results, suspected case reports, and case distribution.

C. Designing Prototypes

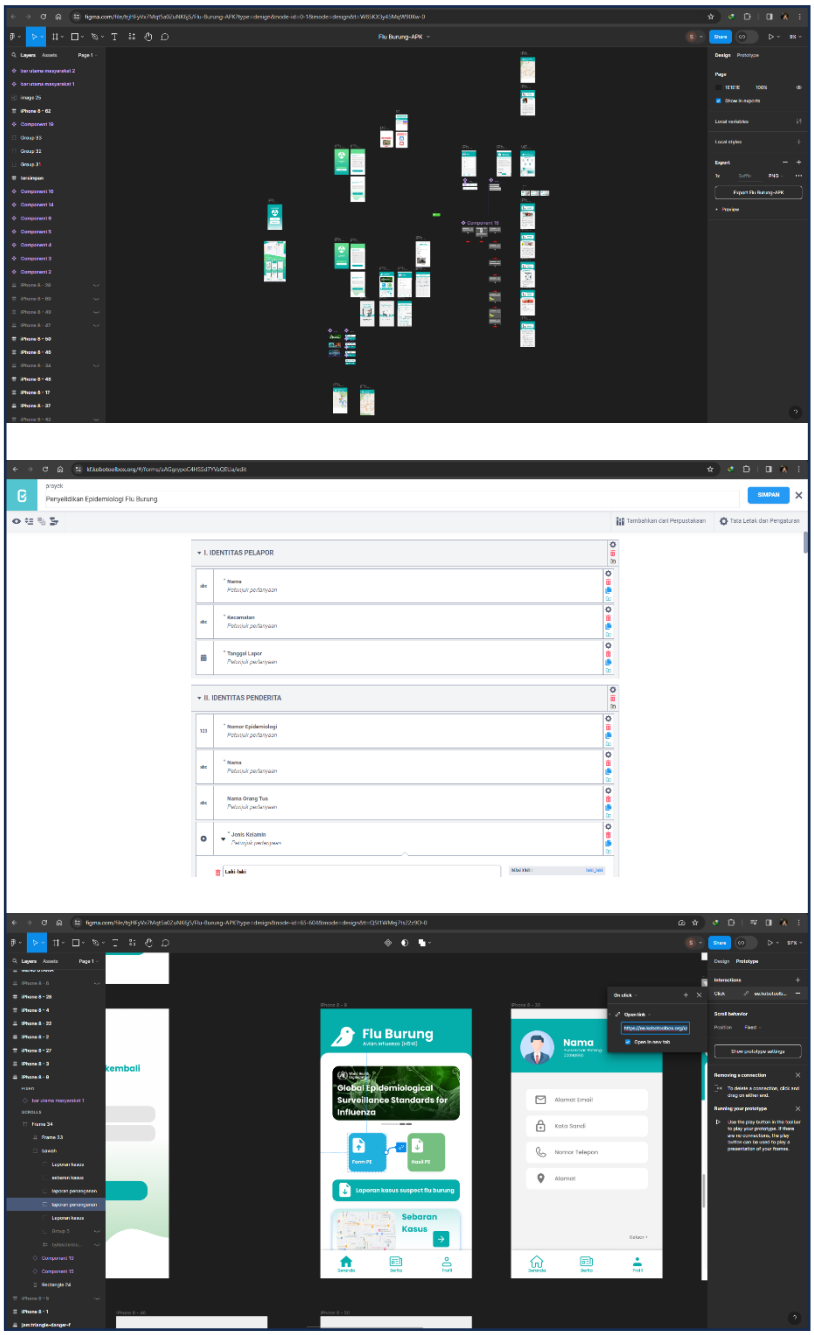


Fig. 2. Flow of Designing a Prototype Application for an Epidemiological Investigation Surveillance System for Avian Influenza

In developing the system, the researcher utilized Figma for the design process and KoboToolbox for creating the epidemiological investigation forms and storing the database. The prototype design involved several stages: first, the user interface prototype was designed using Figma; second, the Avian Influenza epidemiological investigation forms were created using KoboToolbox; third, the links to the Avian Influenza epidemiological investigation forms were integrated with the user interface design (Figure 2).

D. Evaluation Of Prototype Acceptance Tests

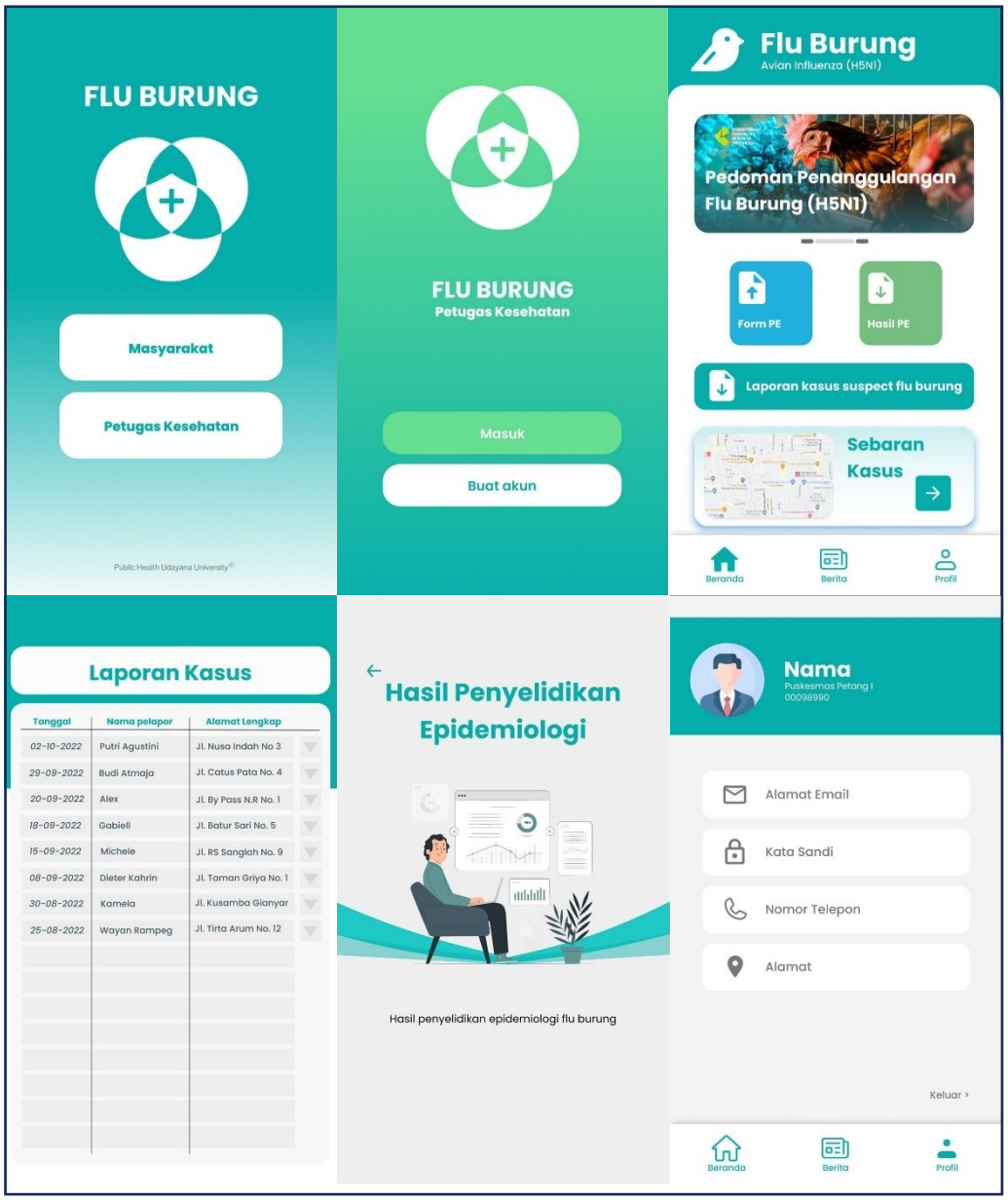


Fig. 3. Display of the Prototype Application for Surveillance Investigation of Avian Influenza Epidemiology

Figure 3 shows the interface of a prototype application for avian influenza epidemiological surveillance designed by researchers. The image includes the front page for selecting application users, the application login page, the homepage menu, the case report page, the initial view of the epidemiological investigation results page, and the profile menu page within the application.

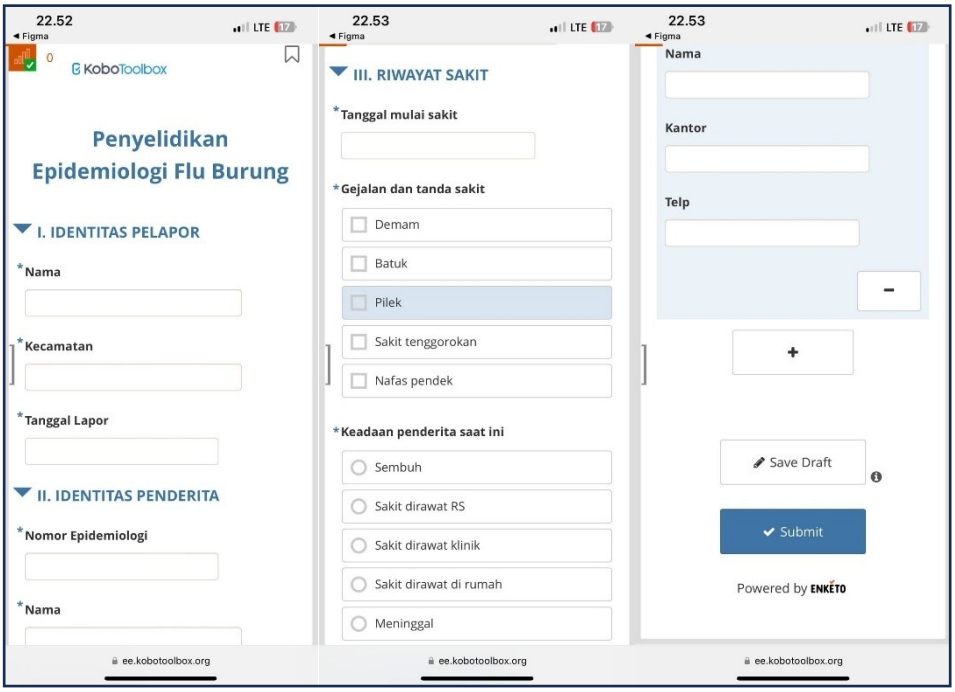


Fig. 4. Display of the Avian influenza Epidemiology Investigation Form

Figure 4 displays the digital epidemiological investigation form for avian influenza, created by researchers using KoboToolbox. The image shows several sections of the form. The form is divided into several parts: reporter identification, patient identification, illness history, contact history, specimen collection, investigation contacts, and the epidemiological investigation team. The researchers also added a location question to facilitate event mapping. There are two buttons at the end of the form: save draft to save the data without sending it to the server, allowing for offline data entry, and submit to save and send the data to the server for online data entry.

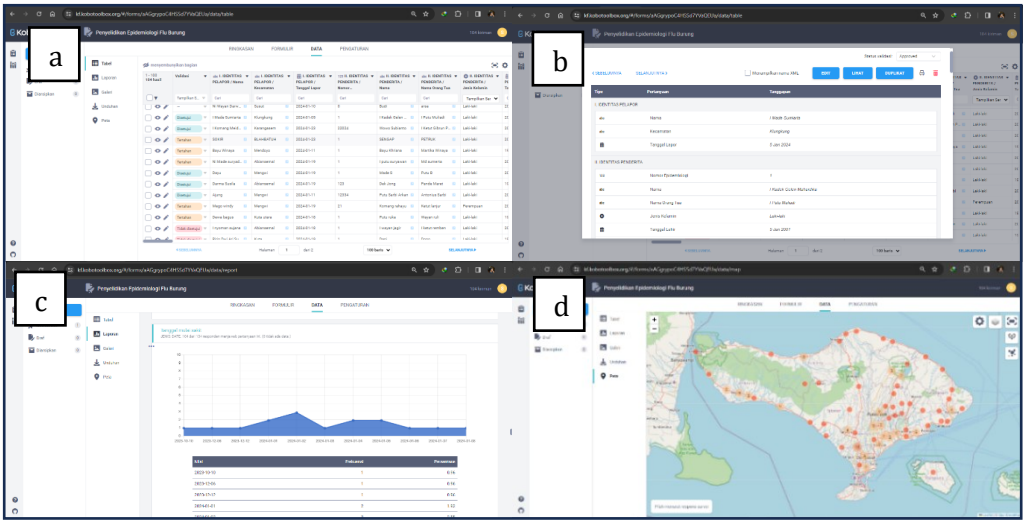


Fig. 5. Display of the Database and Disease Outbreak Map

Figure 5 shows the database view of the epidemiological investigation form using KoboToolbox, filled out by research participants with fictitious data. This database can be accessed within the project created in KoboToolbox by selecting the Data menu. In this menu, data can be viewed in table format and as reports. (a) The data displayed in the table format are the records that have been successfully submitted to the server. These records are shown sequentially according to the date of input. The second column contains a data validation field, which is used to filter the data submitted to the server, making it easier to identify approved, pending, or rejected records. (b) Additionally, it is possible to view individual forms fully completed according to the questions in the form. This view offers three options: to edit the data, view the data, or duplicate the data. (c) For a summary or overall view of the data for each question, the report menu provides this feature. The page displays the data results for each question in the form, with outputs including frequencies, percentages, text summaries, charts, and graphs. Access to this database is restricted to account holders or accounts authorized to access the generated data. Due to the limitations of the study, this database is currently only accessible to researchers or through accounts created by the researchers. (d) The map image shows the disease distribution generated from the data in the epidemiological investigation form using KoboToolbox. This map can be accessed via the Map menu found under the Data menu in KoboToolbox. The data indicates the distribution of cases investigated by local health centers and district/city health office.

Table 1. Respondent Characteristics

Characteristics	Number (N=130)	Percentage (%)
Age		
Minimum	25	
Average	40,32	
Maximum	56	
Education		
Senior High School	2	1,5
Higher Education	128	98,5
Understanding of Mobile Phone Use		
Limited skills for communication only (SMS and calls)	11	8,5
Active internet use	119	91,5

Respondents were aged between 25–56 years with an average of 40.32 years, most (98.5%) had a college education, and the majority (91.5%) were active internet users, indicating a high level of readiness to operate a digital-based surveillance system, although there was still a small proportion (8.5%) whose skills were limited to basic communication via mobile phone (Table 1).

Table 2. Evaluation Results of the Prototype Using PSSUQ

No	Question	Average Score
System Quality Score		
1.	Overall, I am satisfied with how easy this system is to use.	2.27
2.	The system is simple to use.	2.31
3.	I can complete tasks and scenarios quickly using this system.	2.46
4.	I feel comfortable using this system.	2.38
5.	It is easy to learn how to use this system.	2.43
6.	I believe I can become quickly productive using this system.	2.38
Information Quality Score		
7.	The system provides clear error messages to help me fix problems.	2.48
8.	When I make a mistake using the system, I can recover easily and quickly.	2.45
9.	The information (online help, on-screen messages, and other documentation) provided with the system is clear.	2.52
10.	It is easy to get the information I need.	2.33
11.	The information is effective in helping me complete tasks and scenarios.	2.41
12.	The organization of information in the system is clear.	2.38

No	Question	Average Score
Design Quality Score		
13.	The system's interface is pleasant to use.	2.34
14.	I like using the system's interface.	2.43
15.	This system has the functions and capabilities I expect it to have.	2.35
Overall		
16.	Overall, I am satisfied with this system.	2.31

Based on the data analysis, the scores obtained from the PSSUQ questionnaire represent a lower score higher usability type, meaning that the smaller the score, the higher the usability [17]. The table above shows the average score of all respondents for each question, which can be grouped into four quality categories. In the system quality category, the lowest score was obtained in question number 1, which indicates that overall users find the system easy to use. In the information quality category, the lowest score was in question number 10, with an average of 2.33, which means that users easily find and obtain information obtained in the system assessed based on the quality of the information presented. Meanwhile, in the design quality category, the lowest score was in question number 13, with an average of 2.34, which means that the design presented is easy to use so that it is known that the images or designs presented can help in using the system. Meanwhile, in the overall category, the score was 2.31, which means that users are generally satisfied with the use of the designed system (Table 2).

Table 3. Evaluation Results of the Prototype Using PSSUQ

Scale	Rating Scale	PSSUQ Norms			Respondent Average	Description
		Lower Bound	Average	Upper Bound		
Overall Score	Questions 1-16	2.62	2.82	3.02	2.39	Very Good
System Quality Score	Questions 1-6	2.57	2.8	3.62	2.37	Very Good
Information Quality Score	Questions 7-12	2.79	3.02	3.24	2.43	Very Good
Design Quality Score	Questions 13-15	2.28	2.49	2.71	2.37	Good

Based on the data above, the average value is grouped into four categories, namely below the lower bound is said to be very good, between the lower bound and the average norm value is said to be good, between the average norm value and the upper bound is said to be less good, and above the upper bound is said to be very poor. The overall average score obtained was 2.39. This score is below the lower threshold, indicating that the overall usability of the prototype system is excellent. The system quality score from the prototype evaluation yielded an average of 2.37, which can be interpreted as very good, as it is below the lower threshold. In addition, the information quality score is also excellent, with an average rating of 2.43, which is below the lower norm threshold. The design quality score was 2.37, which is between the average and the lower threshold, indicating good design quality (Table 3).

Based on the results of the study, a design for an AI epidemiological investigation surveillance application was produced. An acceptance test was carried out on users and operators of the resulting system, which showed that overall this application was very good and worthy of development. This is the same as other research on the development of a mobile-based Dengue Hemorrhagic Fever Surveillance Information System which was successfully developed for use in surveillance activities [18]. System development using a prototyping model is carried out with the aim of absorbing information from system users according to user needs. There are several stages carried out in the prototyping model, namely the needs identification stage, the rapid design stage, the prototype making stage, and the evaluation and improvement stage [19].

Needs identification is one of the processes used to find and determine the needs of users for the information system being developed [20]. The aim of conducting a needs analysis is to produce an effective design and reduce the risk of failure during the use process [21]. Identification of these needs is an important process in developing information systems [22]. This stage is intended to ensure the needs of users and system users. What is meant by "system user" is a person who uses the results of the system or data resulting from the data collection process. Meanwhile, the "operator" is the person who enters the data obtained into the system.

The use of technology will increase effectiveness and efficiency in monitoring or supervising the spread of disease [23]. The use of technology has been applied in various disease surveillance activities, including surveillance carried out in community health centers, so that the use of applications in national surveillance is very effective [24]. Moreover, information technology has been developed for the purpose of facilitating rabies surveillance activities [25]. It is therefore recommended that technology be employed in the

implementation of avian influenza epidemiological surveillance activities in order to enhance their effectiveness and efficiency.

Based on Figure 1, there are two groups, namely users and operators who have the same access to prototype features. These features can be divided into eight categories: general information, profile, news, login, epidemiological investigation form, epidemiological investigation results, suspected case reports, and case distribution. The general information feature includes general information used in conducting PE, such as Early Warning and Response (SKDR) system guidelines, bird flu control measures, and global epidemiological surveillance guidelines. This feature is used to make it easier for health workers to find the latest methods and information regarding the implementation of epidemiological surveillance in Indonesia and globally. Another feature in this prototype is the profile feature which contains information about the account owner. A news feature is included to make it easier to access the latest health information in Indonesia. The next feature is the login menu which can be accessed by both users and application operators. On this page the data required is email and password to log in. After accessing the main page, several other menus are available such as the epidemiological investigation form feature. This menu contains a bird flu epidemiological investigation form created in digital format using KoboToolbox. This menu can be used directly; clicking on the epidemiological investigation form menu will redirect the user to the KoboToolbox web page for that form. The process of data collection necessitates the identification of locations where disease contact events have occurred. This information can be represented visually through the use of a case distribution feature. This feature will provide the geographic location of contacts who spread the disease obtained from uploaded data

The prototype designed by researchers uses the Figma and KoboToolbox applications. The application is an application used for prototype design tools. Figma application is used to design and create the design or user interface of the prototype. The KoboToolbok application is used to create a bird flu investigation form. Figma is a design application that is designed to be used online so that it can provide convenience and increase user effectiveness and provide efficiency in its use [26], [27]. KoboToolbox is used in compiling forms because the features contained in KoboToolbox have advantages such as speeding up data collection, improving data quality, reducing costs, and being easy to control or flexible [28]. KoboToolbox is an application that is easy for users to use and can be integrated with other software to display the data obtained [29]. KoboToolbox has been used in several regions such as Yogyakarta as a surveillance data collection tool where this application has provided effectiveness in making questionnaires used for these activities [30].

Evaluation of the digital-based national surveillance application prototype for avian influenza epidemiological investigation was carried out on system operators and users. The purpose of carrying out an evaluation is to assess the usefulness of the system or application that has been developed. The evaluation stage was carried out using the PSSUQ questionnaire to determine user satisfaction with the application system used. The Post-Study System Usability Questionnaire (PSSUQ) is used to assess and evaluate user satisfaction with a computer software system or application [31]. This questionnaire assesses four aspects or values consisting of overall value, system quality value, information quality, and design quality. The evaluation was carried out on 130 surveillance officers consisting of 120 surveillance officers at Community Health Centers throughout Bali and 10 surveillance officers at the Health Service throughout Bali. The evaluation results of the system prototype developed are shown in Table 1.

The results of trials and evaluations using the PSSUQ questionnaire show that the overall average score is 2.39 which is classified as very good. This score shows that the prototype has excellent usability, making it suitable for further development. The usability of the system also influences the sustainability of the system's use by its users [32]. This overall score includes three additional assessment aspects: system quality, information quality, and design quality.

The system quality score is calculated based on the average score obtained on questions 1-6. System quality functions as an indicator of the system's ability to produce the output expected by its users and can be used as a measure of application characteristics [33]. System quality shows the expected quality of an information system and shows the quality of its benefits [34]. The evaluation results of the prototype produced an average system quality score of 2.37 which was categorized as very good. This shows that this prototype provides users with excellent quality and ease of use for conducting epidemiological investigations of avian influenza.

The information quality score is calculated based on the average score obtained from questions 7-12. Good quality information will have an impact on increasing system usage [35]. In addition, the quality of information depends on the extent to which the information is aligned with user needs, its completeness, and its clarity [36]. To assess the quality of the design, it is necessary to conduct it with system users to obtain assessments from the system users [37]. The prototype evaluation results show an average information quality score of 2.43, which is classified as very good. Therefore, the prototype is known to have an optimal level of information quality, which effectively meets the information needs of users and system operators.

The design quality score is calculated as the average of the scores resulting from questions 13-15. The design quality score is used to describe the evaluation of the visual image displayed from a system, which can increase usability and encourage increased use of information systems [38]. The evaluation results show that the prototype shows an average design quality score of 2.37 which is considered good. Thus, it can be concluded that the visual design of the prototype provides high usability, encouraging users to use the application in carrying out avian influenza epidemiological investigations.

Overall, the prototype developed in this study was well-received and considered very user-friendly by the participants. However, based on the trial and evaluation process, several improvements need to be made. One of the suggestions is to provide initial support or orientation for using the application when it is implemented in the field. This is due to some surveillance officers still facing difficulties with using online and digital media, such as smartphones. Additionally, some participants suggested that the avian influenza epidemiological investigation form should be shortened and include explanations for each question. This is because some respondents found overlapping questions that could lead to confusion when filling out the form. However, the researcher's development of the epidemiological investigations form was already based on the standard form used by the Ministry of Health. While this prototype demonstrated high usability among surveillance officers, some users limited digital device usage may present a barrier to implementation in the field. Compared to existing systems, this system offers easy access using mobile applications and geospatial mapping, as well as timely data input. However, scalability remains a challenge because the application design is still in its early stages, providing a basic overview of the application needed by officers. Needs vary across regions, requiring further evaluation and development for national implementation. So the efforts that can be made to implement this application are by conducting small-scale trials in the regions first before being applied widely.

The limitation of this research is that the application developed is still only an application prototype so it cannot be used optimally. Based on the results obtained in the research, to implement this application, support from the relevant government is needed to create regulations that can support the development and use of this application. It is hoped that the government can create regulations that can integrate existing disease surveillance data collection into digital form. Furthermore, data security limitations need to be considered due to the patient data input into the system, making it vulnerable to data leaks. Integrating the database with the national system could be one way to strengthen data security, but it would be difficult to fully integrate, necessitating further in-depth studies and evaluations for implementation in the field.

Conclusion

Based on the research results and discussion above, the following conclusions can be drawn: The system requirements for designing the avian influenza PE surveillance information system prototype involve a system that can collect data easily, quickly, and simply. The avian influenza PE surveillance information system prototype was designed based on a needs analysis represented in the form of UML or use-case diagrams. This design includes several features in the prototype, such as general information, profile, news, login, PE form, PE results, suspected case reports, and case distribution. The prototype design process was carried out in three stages: creating the user interface using Figma, creating forms using KoboToolbox, and integrating the forms with the user interface design of the prototype. The trial and evaluation results of the prototype's acceptance by surveillance officers, who participated as research subjects, indicated that the system's quality, information quality, and overall system acceptance were rated as very good. Meanwhile, acceptance of the prototype's design and appearance was categorized as good. This indicates that improvements are needed in design quality compared to other aspects of the prototype. Further development and implementation require more in-depth and systematic research in the form of regulations for integration with national and other systems for optimal application.

Conflict of Interest

The authors declare no conflict of interest.

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Authors



I Gusti Ngurah Agung Surya Pratama is a graduate of the Public Health program at Udayana University, Bali, Indonesia. He is actively involved in health research, particularly in the fields of infectious and non-communicable disease surveillance and community health. He also frequently participates in national and international scientific events and competitions (email: gungsuryapratama1025@gmail.com).



Putu Putri Agustini is a graduate of the Public Health program at Udayana University, Bali, Indonesia. She has a strong interest in infectious disease issues and is passionate about scientific writing. She has actively participated in various essay and health research competitions, particularly in the field of infectious disease. (email: Putriagustini138@student.unud.ac.id).



I Dewa Agung Ayu Ari Shinta Dewi is a graduate of the Public Health program at Udayana University, Bali, Indonesia. She has been actively involved in student organizations and has participated in various scientific competitions, demonstrating her strong commitment to academic and leadership development. (email: arishintadw01@gmail.com)



I Made Subrata is a lecturer at the Department of Public Health and Preventive Medicine, Faculty of Medicine, Udayana University, Indonesia. His research focuses on infectious and zoonotic diseases, and he has published numerous scientific articles in national and international journals. (email: madesubrata@unud.ac.id)



Ngakan Putu Anom Harjana is a lecturer and researcher at the Department of Public Health and Preventive Medicine, Faculty of Medicine, Udayana University, Indonesia. His research focuses on epidemiology, demography, and sexual and reproductive health. In addition to his primary role at the university, he also serves as a consultant for the United Nations Population Fund (UNFPA) and as the Operational Director of Baswara Press. (email: anomharjana@unud.ac.id)



Sang Gede Purnama is a lecturer at the Department of Public Health and Preventive Medicine, Faculty of Medicine, Udayana University, Indonesia. His academic interests include environmental health, vector control, and the development of digital surveillance tools. He is actively involved in research related to public health technology and innovation. (email: sangpurnama@unud.ac.id)



Romy Muhammad Dary Mufa is a lecturer at the Faculty of Veterinary Medicine, Udayana University, Bali, Indonesia. His expertise includes zoonotic diseases, veterinary public health, and veterinary epidemiology. He is actively engaged in research related to animal and public health, with a focus on veterinary disease prevention and control. (email: romymuhammad@unud.ac.id)