Jurnal E-Komtek
Vol.8 No. 2(2024) pp. 387-398
https://jurnal.politeknik-kebumen.ac.id/index.php/E-KOMTEK
p-ISSN : 2580-3719 e-ISSN : 2622-3066

Geographic Information System in Web-Based Disease Spread Mapping in Public Hospitals

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https://doi.org/10.37339/e-komtek.v8i2.2231

Published by Politeknik Piksi Ganesha Indonesia

Artikel Info
Submitted:
23-12-2024
Revised:
27-12-2024
Accepted:
28-12-2024
Online first :
28-12-2024

Abstract

The application of web-based Geographic Information Systems (GIS) in mapping the spread of diseases at Kotapinang General Hospital aims to improve the effectiveness of health data management and response to disease outbreaks. With a large population and significant health challenges, Indonesia needs a real-time system to monitor and analyze disease spread. This research develops a GIS system that utilizes Google Maps API to visualize epidemiological data, identify high-risk areas, and provide relevant information to health workers. The research methodology includes disease data analysis, database design, and system testing. The study results show that this system not only increases hospitals' capacity to manage health data, but also accelerates decision-making in disease control. Despite data quality and user skills challenges, this web-based GIS offers a significant solution for health management in South Labuhanbatu Regency. This study recommends further development to improve the features and accessibility of the system.

Keywords: Geographic Information System, mapping, infectious diseases, web, Hospital

Abstrak

Penerapan Sistem Informasi Geografis (SIG) berbasis web dalam pemetaan penyebaran penyakit di Rumah Sakit Umum Kotapinang bertujuan untuk meningkatkan efektivitas pengelolaan data kesehatan dan respons terhadap wabah penyakit. Dengan populasi yang besar dan tantangan kesehatan yang signifikan, Indonesia memerlukan sistem yang dapat memantau dan menganalisis penyebaran penyakit secara real-time. Penelitian ini mengembangkan sistem SIG yang memanfaatkan Google Maps API untuk memvisualisasikan data epidemiologis, mengidentifikasi area berisiko tinggi, dan memberikan informasi yang relevan kepada petugas kesehatan. Metodologi penelitian mencakup analisis data penyakit, perancangan basis data, dan pengujian sistem. Hasil penelitian menunjukkan bahwa sistem ini tidak hanya meningkatkan kapasitas rumah sakit dalam pengelolaan data kesehatan, tetapi juga mempercepat pengambilan keputusan dalam penanggulangan penyakit. Meskipun terdapat tantangan terkait kualitas data dan keterampilan pengguna, SIG berbasis web ini menawarkan solusi yang signifikan untuk manajemen kesehatan di Kabupaten Labuhanbatu Selatan. Penelitian ini merekomendasikan pengembangan lebih lanjut untuk meningkatkan fitur dan aksesibilitas sistem.

Kata kunci: *Sistem Informasi Geografis, pemetaan, penyakit menular, web, Rumah Sakit*

1. Introduction

Geographically, South Labuhanbatu Regency is located at 1°26'00'' – 2°15'55'' North Latitude, 99°40'00'' – 100°26'00'' East Longitude with a population of 320,324 people. In general, South Labuhanbatu Regency is at an altitude of below 100 m above sea level. An altitude of 100 – 500 m above sea level is only found in Sungai Kanan District, precisely in the western part bordering North Padang Lawas Regency. South Labuhanbatu Regency occupies an area of 359,600Ha/3,596.00 Km2 consisting of 5 Districts and 52 Villages/2 Definitive Sub-districts [1]. The increase in population in South Labuhanbatu Regency can also cause problems such as the spread of disease. The spread of disease is one of the main challenges in the global health system, including Indonesia. Kotapinang General Hospital, as one of the health facilities in South Labuhanbatu Regency, faces similar challenges in managing information related to the spread of disease. The use of web-based GIS can be an effective solution to monitor and control the spread of disease more quickly and accurately [2], [3].

Through the use of web-based GIS, Kotapinang General Hospital can map the spread of disease in real-time [4], [5]. This system not only helps in identifying affected areas, but also in planning and implementing timely interventions. In addition, web-based GIS allows for wider dissemination of information to the community and relevant stakeholders, thereby increasing awareness and response to the spread of disease [6] [7]. This study aims to develop and implement a web-based GIS system for mapping and monitoring the spread of disease at Kotapinang General Hospital. With this system, it is expected to increase the hospital's capacity in managing health data, accelerate decision-making, and increase effectiveness in disease control [8].

This study will describe in detail the development of a web-based GIS system, including data collection methods, mapping processes, and data analysis and visualization. It will also evaluate the effectiveness of the system developed through a case study at Kotapinang General Hospital and provide recommendations for future system improvements.

2. Method

Geographic information system (GIS) research using the web-based Google Maps API to map disease prevalence involves several stages of research methodology. The first step is the analysis of disease data, regional data, and health authority data. In this initial stage, disease data

analysis is carried out and entered into the system, regional analysis, and requests for disease prevalence data to the nearest health facility **[9]**.

The database design stage is the stage for designing the relations of the tables in the database that will be used in creating this geographic system. At this stage the database has also been created by considering the use of data types and the size of each data for the efficiency of the system file size later **[10]**. The geographic information system interface's design stage is designing the functions and commands that will be used in the system. Such as creating a function to display disease data on a map **[11], [12]**.

The interface design stage is designing the page by designing the features in the system. Such as designing the coloring on the web page. The design implementation stage into the geographic information system implements the design made into a system. The final stage is the feasibility test, the feasibility test is carried out to test the system whether the system can run according to the purpose of making this system **[13], [14], [15]**.

3. Results and Discussion

3.1 Development of Kotapinang Regional Public Hospital System

A web-based Geographic Information System (GIS) developed at Kotapinang General Hospital has successfully mapped the spread of disease in real time, enabling more effective visualization of epidemiological data. Integrating epidemiological data with interactive maps helps health workers understand disease spread patterns, identify high-risk areas, and make faster and more targeted decisions. With an early warning feature, the system can also predict disease spread trends, which can potentially improve outbreak response and preventive case handling.

However, the implementation of this GIS also faces challenges, especially related to the quality of the input data and users' skills in utilizing this technology. Inaccurate data quality can reduce the system's effectiveness, while technological limitations among users can be an obstacle to optimal use. Nevertheless, this web-based GIS provides significant benefits for health management at Kotapinang General Hospital. It has the potential to be further developed, including by adding new features and increasing system accessibility via WEB.

The following is a general description of the design of the disease distribution system for the Kotapinang regional general hospital.

a. System Overview

Figure 1 provides an overview of the Geographic Information System for Mapping the Spread of Disease Using the Web-Based Google Map API.

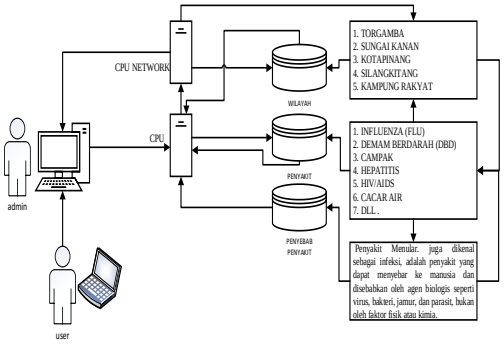

Figure 1. Overview of GIS Mapping of Disease Distribution

a. Context Diagram

A context diagram describes the relationship between data flows between the system and external entities. The following is a context diagram of the Geographic Information System for Mapping the Spread of Disease Using the Web-Based Google Map API.

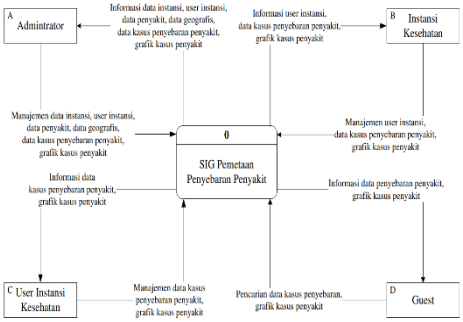

Figure 2. Context diagram

The Context Diagram in the image above has four main parts: administrator, agency admin, agency user, and guest. The administrator is the outermost entity that functions as the main data source in this system, responsible for managing all data, including input, update, and delete data. Health agency entities are divided into three types: hospitals, health centers, and general practices. Each type of agency contributes to managing health data in the system.

Agency users are part of the agency admin and are divided into three categories: doctors, nurses, and staff. Each has a specific role in managing health data. In contrast, guests only have limited access to view information available in the system, such as geographic information, disease data, health agency data, disease case data, and disease case distribution graphs. This system is designed to ensure that each entity has access and functions in accordance with its role and responsibilities, supporting effective health data management .

b. Use Case Diagram

Use case diagrams are used to show the interaction between actors and systems. For this system, the use case diagram is depicted as follows:

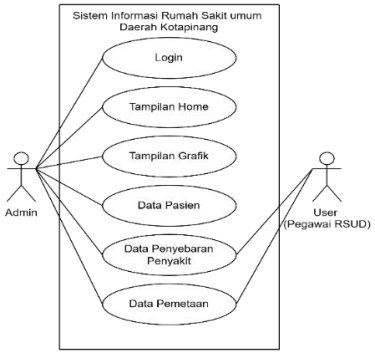

Figure 3 . *Use Case Diagram*

c. Activity Diagram

Activity Diagram is used to show user activities that can be done in the system. The activity diagram for this system is shown as follows:

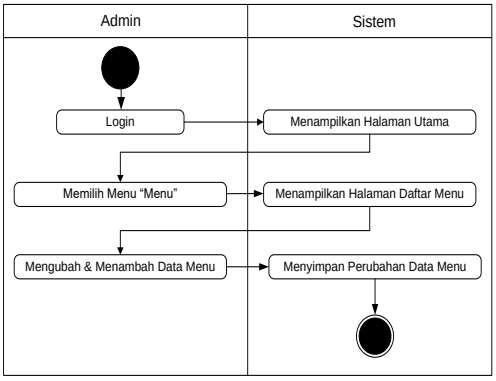

Figure 4 Activity Diagram Menu

d. Class Diagram

Class diagrams are used to show the structure of a system. In this system, the class diagram is depicted like this:

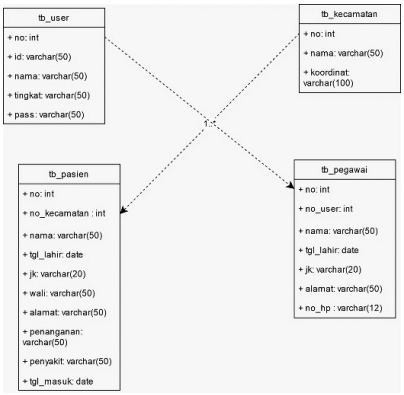

Figure 5. Class Diagram

e. Squence Diagram

A sequence diagram is a type of diagram in the Unified Modeling Language (UML) that is used to describe the interaction between objects in a system based on a chronological sequence. This diagram shows how objects communicate through messages during the execution of a scenario or workflow, with a focus on the chronology or sequence of events. Sequence diagrams help understand and document how a function or process is implemented in a system, from the beginning to the end of the interaction.

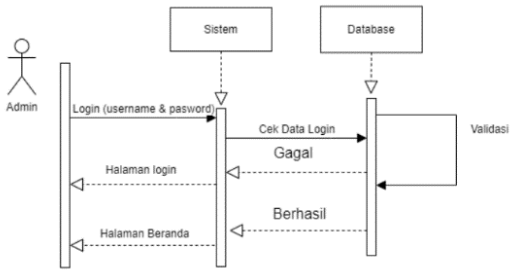

Figure 7. Sequence Diagram

f. Hierarchy Chart

Hierarchy Chart or hierarchical chart is a system design tool that can display all processes in a particular application clearly and in a structured manner. This section is in the form of data flow notations to understand a system logically.

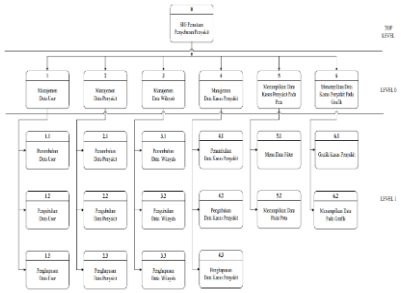

Figure 6. Hierarchy Chart

Hierarchy Chart or hierarchical chart is a system design tool that displays all processes in an application in a clear and structured way. This chart uses data flow notation to facilitate logical understanding of the system. Hierarchy Chart for Geographic Information System Disease Spread Mapping Using Web-Based Google Map API, as shown in Figure 6, consists of several main components:

1. Administrator: Has the responsibility to manage all data in the system. Its main functions include: a). Input Data: Entering new data into the system. b). Update Data: Updating existing data. c). Delete Data: Deleting unnecessary data.

2. Institution Admin: Consists of three types of health institutions: a). Hospitals. b). Health Centers. c). General Practices. Each of these agencies plays a role in managing health data related to
3. Agency User: Part of the agency admin consisting of: a). Doctors. b). Nurses. c). Staff. Each category of agency user has a special role in managing and monitoring health data.
4. Guest: Users with limited access who can only view information in the system, such as:

a). Geographic information. b). Disease data information. c). Health agency data information. d). Disease case data information. e). Case distribution graph information.

By utilizing Google Map API, this system displays a map of disease spread interactively and accurately[5]. helping users in monitoring and analyzing the spread of disease in various regions. This hierarchical chart helps in understanding the workflow and logical structure of the entire process involved in the system.

3.2 Implementation of Disease Spread Information System Application

The results of this study indicate that the web-based Geographic Information System (GIS) developed using Google Map API is very effective in mapping and monitoring the spread of disease in Kotapinang General Hospital. This system displays real-time disease spread data, allows analysis of spread patterns, and facilitates decision making for the hospital and health authorities. The user-friendly interface and high accessibility make this system easy to use by staff without requiring in-depth technical training. Challenges such as the availability of accurate data and patient data security are well addressed, and further development is recommended to integrate technology and machine learning and improve mobile features[6]

3.2.1 Hospital Dashboard Page

Figure 8. Hospital Dashboard Page

The page explains about Kotapinang General Hospital, where the dashboard includes a login page, disease spread data and mapping [7].

3.2.2 Disease Distribution Map

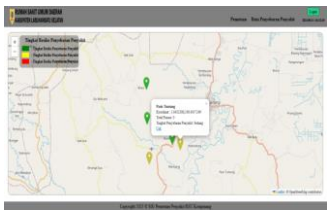

Figure 9. Disease Distribution Map

The page explains the map of where the spread of infectious diseases is in the area with different disease names.

3.2.3 Admin Login Page

Figure 10. Admin Login Page

Before entering the Admin Home Page, each Admin is asked to fill in the username as admin and the password that has been created. This admin home page is a page that informs how many patients are affected by the disease and patient data.

3.2.4 Admin Dashboard Page

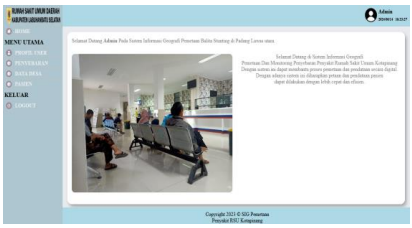

Figure 11. Admin Dashboard Page

This page explains that the admin can see the data of affected patients and patient data and the admin can see some of the many and large impacts of the disease.

3.2.5 Sub-district/Village Page

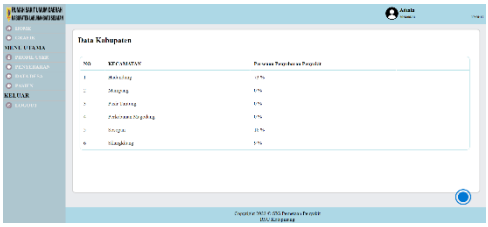

Figure 12. Sub-district/Village Page

The page above explains that there are 5 villages in Kotapinang, namely:

1. Hadundung
2. Mampang
3. Pasir Tuntung
4. Nagodang Plantation
5. Sosopan

From the names of the sub-districts, villages and sub-districts above, the five villages are sub-districts that have been identified as areas or sectors monitored by Kotapinang Regional Hospital.

3.2.6 Patient Page

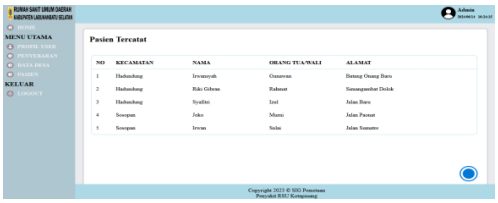

Figure 13. Patient Page

The platform is designed to help admins efficiently manage patient data, schedule appointments, and ensure that medical information is always updated and accurate. Admins can easily access medical history, upload lab results, and process prescriptions quickly. In addition, the application provides tools for efficient communication between patients and medical personnel, as well as between fellow medical staff, thereby improving the coordination and effectiveness of healthcare services. With an intuitive interface and features that support comprehensive health management.

3.2.7 Edit Patient Profile Page

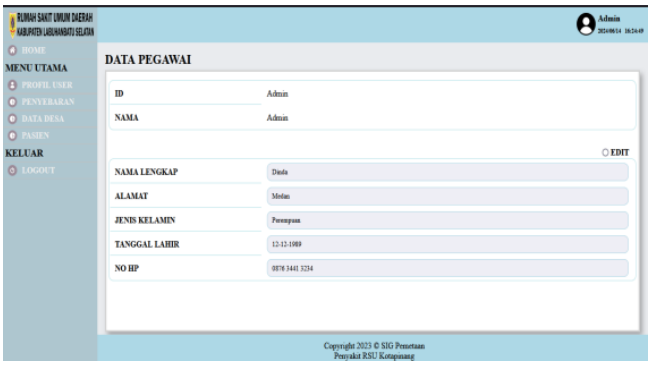

Figure 14. Edit Patient Profile Page

The Edit Patient page in this application allows medical administrators to update and manage patient information easily and accurately. Here, administrators can change personal

data, medical history, lab results, and other relevant information, ensuring that all patient information is always up-to-date and accurate.

3.2.8 Disease spread graph results

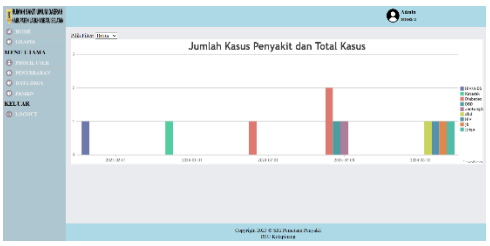

Figure 15. Daily Disease Spread Graph

The graph above is a graphic display that uses a time period according to the day count. This display is very good if the user wants to see the level of disease cases per day.

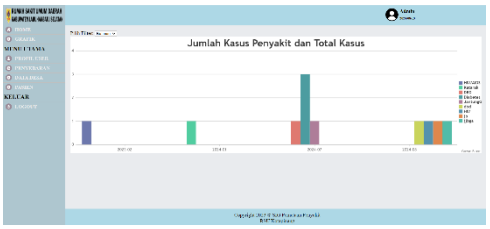

Figure 16. Graph of Disease Distribution Per Month

The graph above is a graphic display that uses a time period according to the calculation of months. This display is very good if the user wants to see the level of disease cases in a period of time per month.

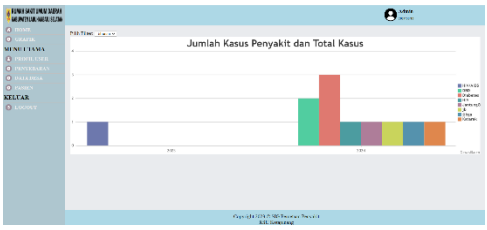

Figure 17. Graph of Disease Distribution the year

The graph above is a graphic display that uses a time period according to the calculation of years. This display is very good if users want to see the level of disease cases per year. The implementation of a web-based Geographic Information System (GIS) at Kotapinang General Hospital has shown a significant increase in monitoring the spread of disease. This system allows real-time visualization of epidemiological data, which helps health workers understand disease spread patterns and identify high-risk areas. With the early warning feature and analysis of disease spread trends, hospitals can make faster and more targeted decisions. This has the

potential to improve outbreak response and preventive case management, which is critical in a public health context.

Although these systems provide many benefits, there are challenges faced, such as the quality of input data and user skills in utilizing the technology. Inaccurate data quality can reduce the effectiveness of the system, while technological limitations among users can be a barrier to optimal use. The user-friendly interface and high accessibility make the system easy to use by staff without requiring in-depth technical training. This is important to ensure that all users, including those without a technical background, can make good use of the system.

4. Conclusion

The application of Geographic Information Systems (GIS) in mapping the spread of disease in Kotapinang General Hospital offers many benefits, but also faces various challenges. To implement it effectively, it requires a deep understanding of patient data collection and processing, geospatial data integration, and accurate spatial analysis, so that the results produced are valid and reliable for decision making in disease management.

The benefits of GIS include interactive visualization of disease distribution, cluster identification, and temporal trend analysis that enable hospitals to make strategic decisions faster. However, challenges in implementing GIS include the availability of complete and accurate data, limited skilled human resources, budget constraints, and technical constraints in integrating data from various sources. A comprehensive strategy is needed to overcome these obstacles so that GIS can function optimally.

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