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Bridging Medical Licensing and Spatial Information: An Interactive WebGIS for Medan City

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ABSTRACT

Purpose of the study: This study aimed to develop a web-based Geographic Information System (WebGIS) for mapping licensed medical practices in Medan City. It specifically sought to integrate geographical visualization, medical licensing information management, location-based searching, and route presentation to support public information access and administrative monitoring.

Methodology: The system was developed through a system development research approach using the Waterfall model, comprising requirements analysis, design, implementation, testing, and maintenance. Data were collected through interviews, field observations, and document analysis at DPMPTSP Medan City. Development used PHP, Laravel, MySQL, JavaScript, Leaflet, GeoJSON, QGIS 3.10.14, XAMPP 7.4.8, and Google Maps. Functional testing employed Black Box Testing.

Main Findings: The system provides an interactive map of licensed medical practices, with district-based and practice-category mapping, location search, doctor and licensing details, and route visualization. Its administrative interface supports viewing, adding, editing, and deleting medical practice and related records. All 32 Black Box test items were recorded as successful, with no failed items, confirming that the tested functions operated as expected.

Novelty/Originality of this study: The study's originality lies in integrating individual medical practice licensing attributes and geographical locations within one municipal WebGIS. Unlike mapping systems focused mainly on healthcare facilities or spatial accessibility, this application combines licensing details, district and category visualization, route information, and administrative record management. This context-specific integration addresses the information-management needs identified at DPMPTSP Medan.

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1. INTRODUCTION

The integration of geographic information systems (GIS) into public administration has created opportunities to improve spatial data management, information accessibility, and evidence-based decision-

making across various government services. In the healthcare sector, geographical information is particularly important for identifying healthcare provider locations and understanding their spatial distribution [1]-[3]. Accurate information about medical practice locations can support public access to healthcare services while strengthening institutional oversight of healthcare-related activities [3]-[5]. However, administrative databases that primarily present information in tabular formats provide limited opportunities for users to understand the geographical distribution of healthcare providers [6]-[8]. Consequently, web-based GIS offers a practical technological approach to integrating administrative records with spatial visualization and location-based information.

In Medan City, the management of licensed medical practice information by the Investment and One-Stop Integrated Service Office (DPMPTSP) previously relied on Microsoft Excel for recording and maintaining licensing data. This approach presented challenges in searching administrative records, identifying license validity, and understanding the geographical distribution of licensed medical practices [9]-[11]. Furthermore, the absence of an integrated spatial information platform limited the ability of the public to identify licensed doctors operating in different districts [12]-[14]. Administrative officers also faced difficulties in obtaining a geographical overview of licensed medical practices for monitoring purposes [13]-[15]. These conditions indicate the need for an integrated information system that connects medical licensing records, geographical locations, and license validity information.

A web-based geographic information system can address these limitations by integrating administrative databases with interactive digital mapping functionalities [16]-[18]. The proposed system combines Leaflet JavaScript Library for map visualization, GeoJSON for encoding geographical data, and Laravel with MySQL for application development and database management. Geographic coordinates are incorporated to represent medical practice locations and enable their visualization across districts in Medan City. The system also provides search functionality, practice-category filtering, district-based mapping, detailed licensing information, and route visualization. Through these integrated features, the platform is designed to facilitate public information access and support DPMPTSP officers in managing and monitoring licensed medical practices.

Recent studies have demonstrated the growing application of GIS for healthcare facility mapping, geographical accessibility assessment, and healthcare infrastructure planning. Jumadi et al. [19] investigated the spatiotemporal accessibility of COVID-19 healthcare facilities in Jakarta, highlighting the importance of integrating geographical and temporal dimensions. Leosari et al. [20] employed spatial analysis to evaluate healthcare accessibility and geographical disparities across archipelagic communities in Maluku. Hartomi [21] developed a web-based GIS for mapping clinics and treatment centers to facilitate healthcare facility monitoring in Pekanbaru. Similarly, Prananingrum et al. [22] developed a web-based clinic GIS using QGIS and Agile methodology, demonstrating the potential of usability-oriented spatial information platforms for healthcare planning.

Although previous studies have established the importance of GIS for healthcare mapping and accessibility assessment, their primary emphasis has been on healthcare facilities, spatial accessibility, and geographical distribution. These approaches do not necessarily address the administrative requirements associated with individual medical practice licensing and its validity status [23], [24]. Furthermore, geographical visualization alone does not fully integrate public information access with administrative functions for maintaining and updating licensing records. Therefore, an important research opportunity remains in connecting spatial mapping capabilities with medical licensing information and institutional data management. Addressing this opportunity requires a system that simultaneously considers geographical visualization, licensing attributes, public information services, and administrative monitoring requirements.

The originality of this research lies in integrating medical practice location mapping with licensing information management within a web-based GIS platform. Unlike conventional geographical mapping approaches, the proposed system incorporates individual licensing attributes, including permit numbers, registration information, and license validity periods. The platform also combines district-based visualization, medical practice categorization, location searching, and route information within an integrated interface. Furthermore, the system provides differentiated access for public users and administrators, supporting both information retrieval and administrative data management. This integration offers a contextual contribution to the development of location-based public information systems for medical practice licensing at the municipal level.

Providing accessible and geographically organized medical licensing information is important for improving public information availability and supporting transparent local government administration. The availability of integrated spatial and licensing records can also provide administrative officers with a more structured overview of licensed medical practices across different districts [25]-[27]. In this context, the development of a web-based GIS represents a relevant technological response to the limitations of conventional tabular data management. Accordingly, this study aims to design and develop a web-based GIS for mapping licensed medical practices in Medan City using Leaflet, GeoJSON, Laravel, and MySQL. Specifically, it seeks

to integrate geographical visualization, licensing information management, location-based searching, and route presentation to support public information access and DPMPTSP administrative monitoring.

2. RESEARCH METHOD

2.1. Research Design and Location

This study employed a system development research approach to design and implement a web-based Geographic Information System (GIS) for mapping licensed medical practices in Medan City, Indonesia. The research focused on integrating medical licensing information with geographical visualization to facilitate public access to licensed medical practice locations and support administrative monitoring [28].

The system development process adopted the Waterfall model, which consists of requirements analysis, system design, implementation, testing, and maintenance [29], [30]. Qualitative data collection techniques were employed to identify the existing administrative problems and determine the functional requirements of the proposed system [31], [32]. The research was conducted in collaboration with the Medan City Investment and One-Stop Integrated Service Office (DPMPTSP), particularly in relation to the management of licensed medical practice records.

The research object comprised medical practice licensing records officially issued or managed by DPMPTSP Medan City. The geographical coverage was limited to the administrative area of Medan City, with the mapping organized according to districts (kecamatan) and medical practice categories. The system was designed to display the locations of licensed medical practices and their associated licensing information.

3.2. Data Collection

Data were collected through interviews, field observations, and documentation. These techniques were used to understand the existing licensing administration process, identify the information required by system users, and obtain the geographical and administrative data necessary for system development.

Interviews were conducted with two institutional informants: the Head of the Data and Information Processing Section and an information technology specialist at DPMPTSP Medan City. The interviews explored the existing procedures for managing medical practice licensing records, difficulties in retrieving licensing information, requirements for geographical mapping, and the expected functions of the proposed GIS.

Observations were conducted on licensed medical practice locations in Medan City using location records provided by DPMPTSP. This activity was intended to examine the geographical distribution of medical practices and support the identification of their corresponding coordinates.

Documentary data were obtained by examining relevant administrative archives, licensing guidelines, official decisions, and other documents associated with medical practice permits. Previous studies related to GIS and medical practice information systems were also reviewed to inform the system design.

The collected information was subsequently organized into administrative attributes and geographical attributes. Administrative attributes included doctor names, license numbers, practice facility names, practice categories, registration numbers, and license validity dates. Geographical attributes included practice addresses, district classifications, latitude, and longitude coordinates.

Table 1. Data sources and collection techniques

	Source or informant	Information obtained	Purpose
Interviews	Head of Data and Information Processing Section, DPMPTSP	Licensing procedures, administrative problems, and information requirements	Identify system requirements
Interviews	DPMPTSP information technology specialist	Technical requirements and system management needs	Determine system functionality
Observation	Licensed medical practice locations	Practice addresses and geographical conditions	Support location identification
Documentation	DPMPTSP administrative records	Doctor identities, permit information, practice facilities, and validity periods	Construct the licensing database
Spatial data acquisition	Indonesia Geospatial Portal and Google Maps	District boundary shapefiles and location coordinates	Support geographical visualization
Visual documentation	Google Street View	Images of medical practice locations	Provide supplementary location information

2.3. System Development Procedure

The system was developed using the Waterfall model. This model was selected because the development process followed sequential stages, beginning with the identification of user requirements and

continuing through system design, implementation, testing, and maintenance. The development procedure consisted of five stages.

1. Requirements Analysis

The first stage involved identifying the limitations of the existing licensing information management process at DPMPTSP Medan City. The existing system relied on Microsoft Excel, which presented limitations in geographical visualization, location searching, and monitoring license validity. Interviews, observations, and document analysis were used to identify the requirements of public users and administrators.

The resulting requirements included displaying the geographical distribution of licensed medical practices, searching for practice locations, presenting doctor and licensing information, filtering locations by district and practice category, and providing administrative functions for managing licensing records.

2. System Design

The system design stage translated the identified requirements into a technical and functional structure. Unified Modeling Language (UML) was used to represent system interactions and processes through use case, activity, and sequence diagrams. A class diagram and database design were also prepared to define the relationships among the main system entities.

The principal entities included users, applicants, districts, practice categories, and medical practice records. Interface designs were developed for public-facing pages and administrator functions. The spatial component was designed to display district boundaries and medical practice locations using geographical coordinates.

3. System Implementation

The implementation stage involved developing the web application using PHP with the Laravel framework and MySQL as the database management system. JavaScript and the Leaflet library were used to implement interactive geographical visualization.

District boundary data obtained in shapefile format (.shp) from the Indonesia Geospatial Portal were converted into GeoJSON before being integrated into the web application. The latitude and longitude coordinates of medical practice locations were obtained through Google Maps. These coordinates were then associated with the corresponding licensing records and displayed as location markers on the interactive map.

4. System Testing

The developed application was tested using the Black Box Testing method. This approach examined whether system functions produced outputs consistent with the specified requirements. Testing focused on public access, administrator authentication, medical practice data management, geographical visualization, location searching, licensing information display, and route presentation.

The testing procedure was intended to identify functional errors and verify whether the implemented features operated according to their expected behavior.

5. Maintenance

Maintenance was identified as the final stage of the Waterfall model. This stage concerns system installation, operational monitoring, correction of potential errors, and further improvements after testing. The inclusion of this stage describes the development model adopted in the research; actual long-term maintenance activities should only be reported if supported by implementation records.

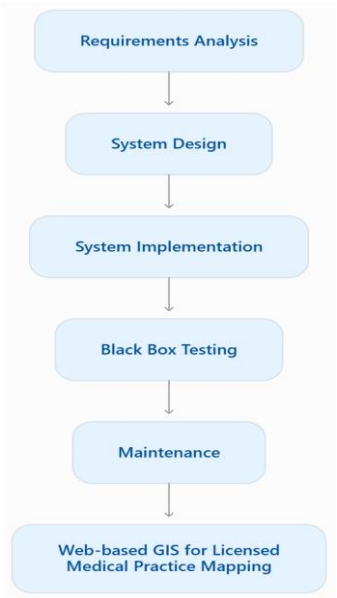


Figure 1. Waterfall-based system development procedure

3.4. System Architecture and Implementation

The proposed system integrated administrative licensing records, geographical data, and web-based mapping components. The architecture consisted of a database layer, an application layer, and a geographical visualization layer. The database layer stored medical practice records and related administrative information. The application layer processed user requests and supported data management, while the visualization layer presented geographical information through an interactive map.

The system used Laravel and PHP to manage application processes and MySQL to store licensing records. Leaflet JavaScript Library was employed to display interactive maps, while GeoJSON represented the geographical features converted from shapefile data. Google Maps was used to obtain the latitude and longitude coordinates of medical practice locations.

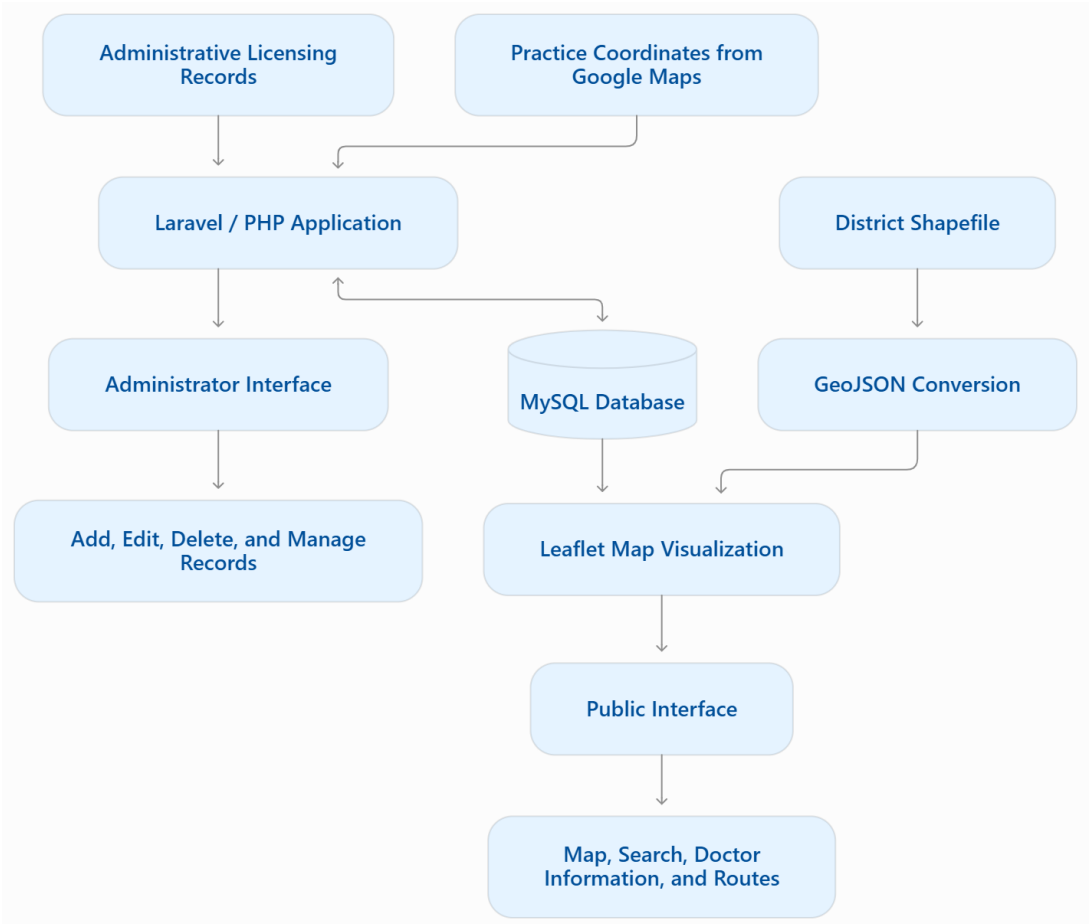


Figure 2. Conceptual architecture of the web-based GIS

The spatial data processing procedure involved converting district boundary shapefiles into GeoJSON format and associating medical practice coordinates with their corresponding administrative records. The resulting geographical information was displayed as district boundaries and location markers. Each marker was linked to information about the relevant medical practice, including the doctor's name, permit number, practice facility, and license validity period.

Table 2. Data attributes used in the GIS database

Attribute category	Data fields	Function
Doctor information	Doctor's name	Identify the licensed practitioner
Licensing information	License number, registration number, permit validity date	Present licensing details
Practice information	Practice facility name, practice category	Classify medical practices
Administrative location	District and practice address	Identify the administrative location
Spatial information	Latitude and longitude	Represent geographical coordinates
Supporting information	Contact number, email, practice photograph	Provide supplementary information

Table 3. Software and technologies used in system development

Technology/software	Role in the research
PHP	Server-side programming language
Laravel	Web application framework
MySQL	Relational database management
JavaScript	Client-side application functionality
Leaflet JavaScript Library	Interactive map visualization
GeoJSON	Encoding and representation of geographical data
Quantum GIS (QGIS) 3.10.14	Supporting geographical data processing
XAMPP 7.4.8	Local web server environment
Visual Studio Code	Application development environment
Google Chrome	Web application access and testing
Google Maps	Retrieval of practice location coordinates
Google Street View	Supplementary visual documentation

3.5. System Features and User Access

The system was designed to provide different functions according to user roles. Public users could access geographical information without logging in, whereas administrators were required to authenticate before managing licensing records. The administrator structure included administrator and super administrator roles, with the super administrator having additional user-management privileges.

The public interface provided access to the geographical distribution of licensed medical practices by district and practice category. Users could search for medical practice information, view details associated with individual map markers, and access route information from the DPMPTSP office to the selected practice location.

The administrator interface supported the management of medical practice records and related reference data. These functions included adding, editing, viewing, and deleting records, as well as managing district, practice-category, applicant, and user information.

Table 4. System functions based on user roles

User role	System functions	Access characteristics
Public user	View the map and distribution of medical practices	No authentication required
Public user	Filter locations by district and practice category	Public access
Public user	Search for medical practice locations	Public access
Public user	View doctor and licensing information	Public access
Public user	View routes to selected practice locations	Public access
Administrator	View, add, edit, and delete medical practice records	Authentication required
Administrator	Manage district, practice-category, and applicant data	Authentication required
Super administrator	Manage system users and administrative functions	Higher-level access privileges

The functional relationship between users and the system was represented through UML use case and activity diagrams during the design stage. These diagrams described the interaction between public users, administrators, and the system's principal functions.

3.6. System Testing and Evaluation

System testing was conducted using Black Box Testing to examine the functional suitability of the developed application. The method focused on the relationship between user inputs and the outputs generated by the system without examining the internal source code. The testing was intended to determine whether each function operated according to its specified requirements. The testing scope covered the main public and administrative functions. Public functions included map visualization, district and practice-category filtering, searching, displaying licensing details, and route presentation. Administrative functions included authentication and the management of medical practice records and supporting data.

Table 5. Proposed Black Box Testing scenarios

No.	Function tested	Test scenario	Expected output
1	Public homepage	Open the web application	Homepage and geographical map are displayed
2	District-based mapping	Select a district	Medical practice locations for the selected district are displayed
3	Practice-category mapping	Select a practice category	Locations are filtered according to the selected category
4	Location search	Enter a search keyword	Relevant medical practice records are displayed

No.	Function tested	Test scenario	Expected output
5	Location details	Select a map marker	Doctor and licensing information are displayed
6	Route presentation	Select a destination location	Route information from DPMPTSP to the selected location is presented
7	Administrator login	Enter valid credentials	Administrator dashboard is displayed
8	Invalid login	Enter incorrect credentials	Access is denied and the login page is displayed again
9	Add medical practice data	Submit a new record	The record is saved and displayed in the system
10	Edit medical practice data	Update an existing record	The updated information is stored and displayed
11	Delete medical practice data	Delete an existing record	The selected record is removed from the displayed dataset
12	Supporting data management	Manage district and practice-category records	Changes are reflected in the relevant system data

Each test scenario was assessed by comparing the expected output with the actual system response. A function was classified as successful when the observed output corresponded to the expected output. The results were documented to identify functions that operated correctly and those requiring correction. Important methodological distinction: Table 5 is a structured presentation of test scenarios derived from the system's documented functions. It is not a substitute for the original Black Box Testing results. The article's final version must report the actual outcomes from the thesis testing records rather than assuming that all scenarios passed.

3.7. Data Analysis

The analysis was conducted descriptively by examining the existing licensing information management process, the system requirements, the implementation of the geographical mapping functions, and the results of functional testing. Interview and observation findings were used to identify administrative problems and translate them into system requirements [33], [34]. The geographical data were organized according to district boundaries and medical practice categories. Doctor practice records were associated with their respective latitude and longitude coordinates to support location visualization. The system was then examined in terms of its ability to display geographical distribution, retrieve licensing information, and provide location-based functions. The functional testing results were analyzed by comparing the expected outputs with the actual outputs for each test scenario. The findings were used to determine whether the implemented functions operated according to the defined system requirements.

3. RESULTS AND DISCUSSION

3.1. Analysis of the Existing Licensing Information System

The analysis of the existing system identified limitations in the management and presentation of medical practice licensing information at the Medan City Investment and One-Stop Integrated Services Office (DPMPTSP). Before the proposed system was developed, licensing records were managed by the relevant administrative section using Microsoft Excel. The records contained information such as license numbers, application numbers, license validity dates, applicants' names, medical practice categories, practice facility names, and practice addresses. However, the information was primarily presented in tabular form and did not provide an integrated geographical representation of medical practice locations.

This condition limited the ability of administrators to monitor the geographical distribution of licensed medical practices. It also made it difficult for members of the public to identify the locations of medical practices and access related licensing information through a geographical interface. Therefore, a web-based Geographic Information System (GIS) was proposed to integrate licensing records with spatial information and provide location-based access to medical practice data.

Table 1. Comparison of the Existing and Proposed Systems

Aspect	Existing system	Proposed GIS
Data management	Microsoft Excel	Web-based database
Data presentation	Tabular records	Interactive geographical map
Location information	Practice addresses	Map coordinates and location markers
Data classification	Administrative records	District and practice-category mapping
Public access	Limited geographical information	Public access to maps and practice details
Administrative management	Conventional data processing	Web-based data management

The comparison indicates that the proposed system was designed to address the absence of geographical visualization and integrated public access in the previous data-management process. Its main contribution is the integration of licensing information and geographical presentation within a single web-based application.

4.2. Development of the Web-Based Geographic Information System

The developed system integrates medical practice licensing records with spatial data to produce an interactive map of licensed medical practice locations in Medan City. The application was implemented using PHP with the Laravel framework and MySQL as the database management system. Leaflet JavaScript Library was used to display geographical information, while GeoJSON supported the presentation of spatial features. QGIS was used to process supporting spatial data, and geographical coordinates were obtained using Google Maps.

The administrative boundaries of Medan City were incorporated into the map to support geographical classification. The map interface uses different polygon colors to distinguish districts, while markers represent the locations of medical practices. The implementation data consisted of five sample records per district, as specified in the thesis. Thus, this figure describes the implementation sample rather than the total number of licensed medical practices in Medan City.

The system provides two main access levels: public visitors and administrators. Public visitors can access the geographical information without logging in, whereas administrators must authenticate themselves before managing the licensing records. The administrative access structure also distinguishes between administrators and super administrators, with the latter having additional privileges for managing user accounts.

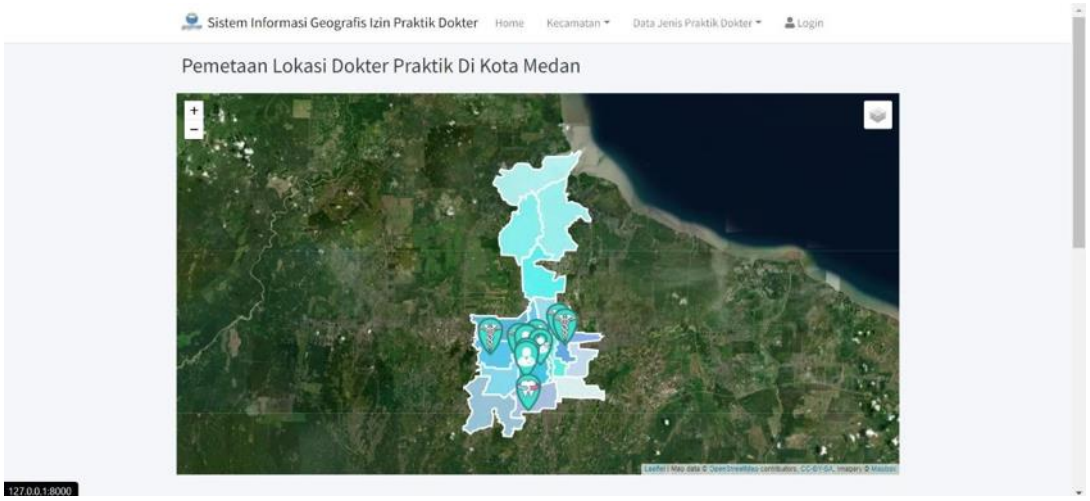


Figure 1. Main Interface of the Web-Based GIS

The main interface presents the geographical map of Medan City and provides navigation menus for accessing district-based mapping, practice-category mapping, and administrator login. The district polygons are displayed using graduated blue colors to distinguish administrative areas. This interface serves as the primary access point for users to explore the geographical distribution of medical practices.

4.3. Implementation of Geographical Mapping and Public Information Features

The public interface provides several functions for accessing medical practice location information. The first function displays the geographical distribution of medical practices through location markers on the map. When a marker is selected, the system presents basic information about the corresponding medical practice, including the doctor's name, license number, practice facility, and license validity period.

The system also provides a detailed information page containing additional medical practice information, an image, and the corresponding geographical location. This feature enables users to access information beyond the location marker displayed on the main map.

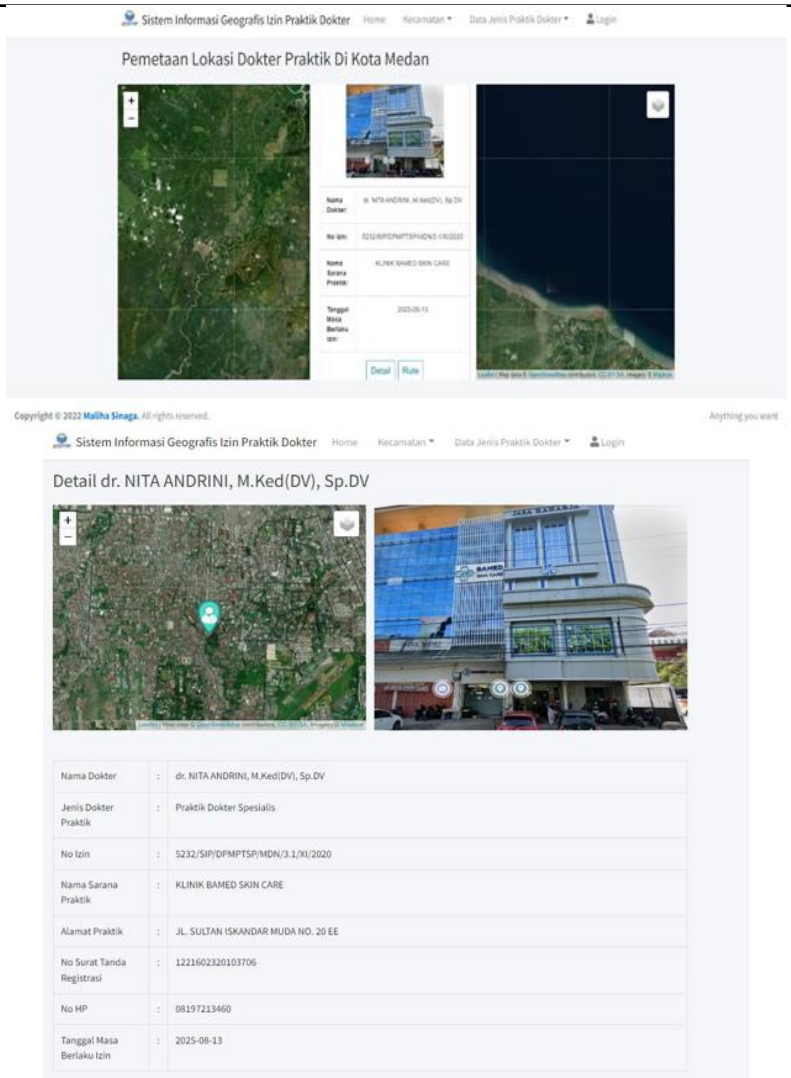
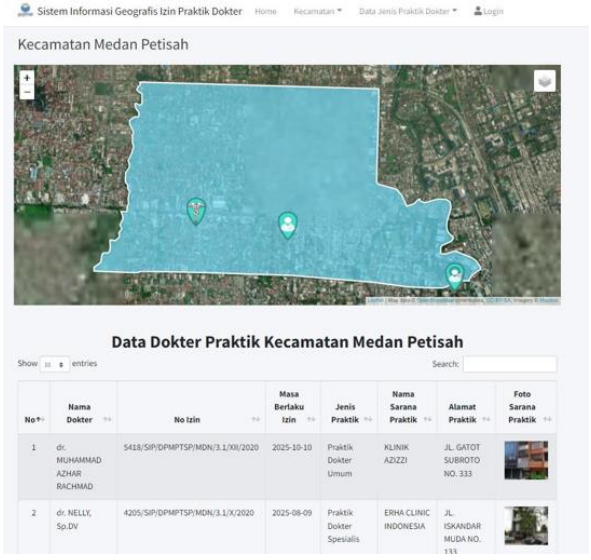


Figure 2. Medical Practice Location Information and Detail Interface

In addition to the general map, the application supports geographical visualization based on administrative districts and medical practice categories. The district-based feature displays medical practice locations according to their respective districts, while the category-based feature groups locations according to the type of medical practice. Both features are accompanied by lists of corresponding medical practices, allowing users to explore the distribution through geographical and categorical perspectives.



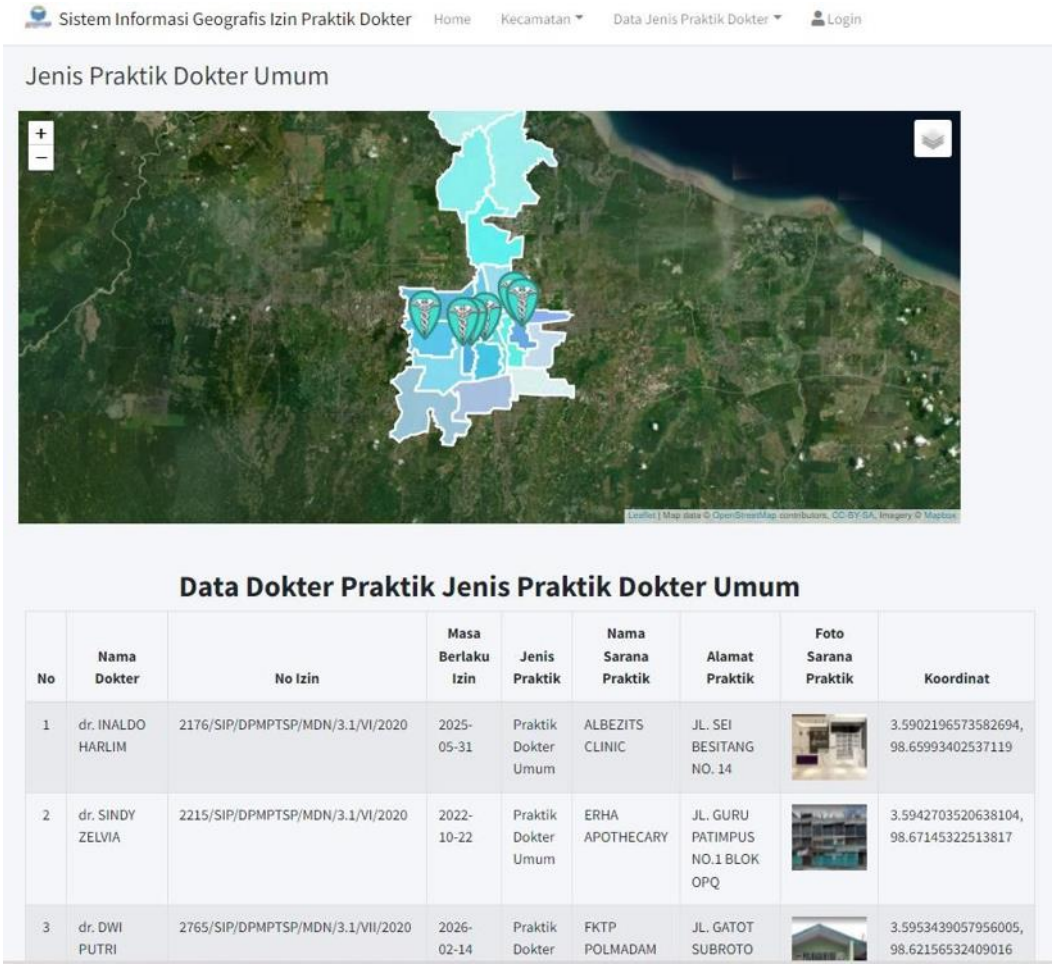


Figure 3. District-Based and Practice-Category Mapping

Another implemented feature is route visualization. The application displays a route from the DPMPTSP Medan City office as the starting point to the selected medical practice location. This function provides geographical guidance to users seeking to identify the location of a particular medical practice.

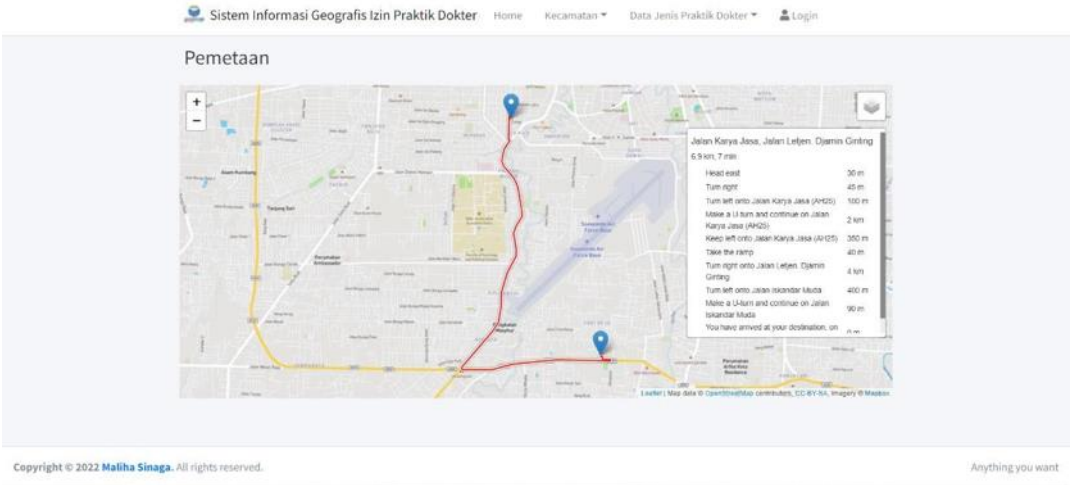


Figure 4. Route Visualization to a Medical Practice Location

Overall, these features demonstrate that the system provides more than a static geographical display. It combines location markers, medical practice details, district-based classification, category-based classification, and route visualization in a single public interface.

4.4. Implementation of Administrative Data Management

The administrative interface was developed to support the management of medical practice licensing information. Administrators access the backend through an authentication page requiring an email address and password. After successful authentication, the system displays a dashboard containing information on the number of districts, applicants, practice categories, medical practices, and registered users.

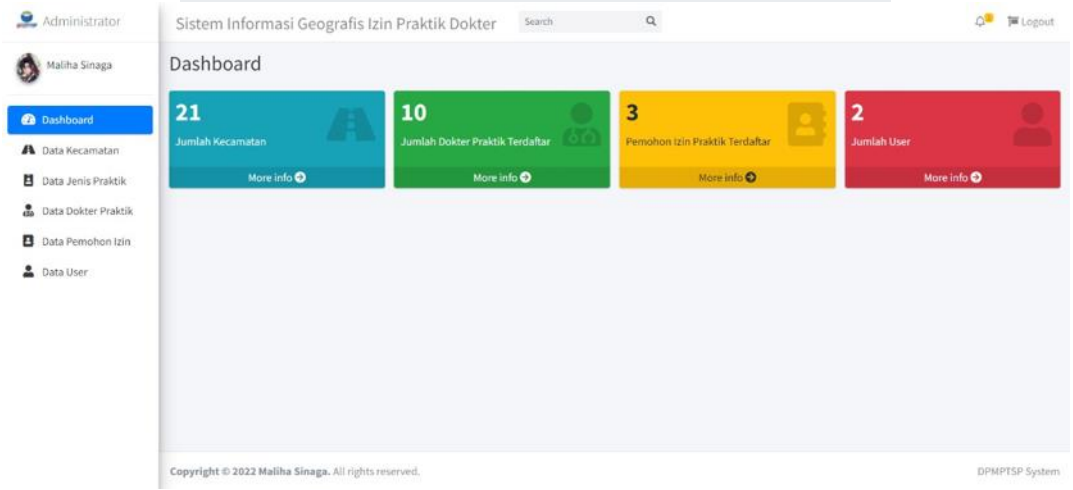


Figure 5. Administrator Login and Dashboard Interface

The backend provides data-management functions for medical practices, practice categories, districts, applicants, and system users. For medical practice records, administrators can view existing data and perform three principal operations: adding new records, editing existing information, and deleting records. The medical practice data interface displays the doctor's name, license number, license validity period, practice category, practice address, and practice facility image.

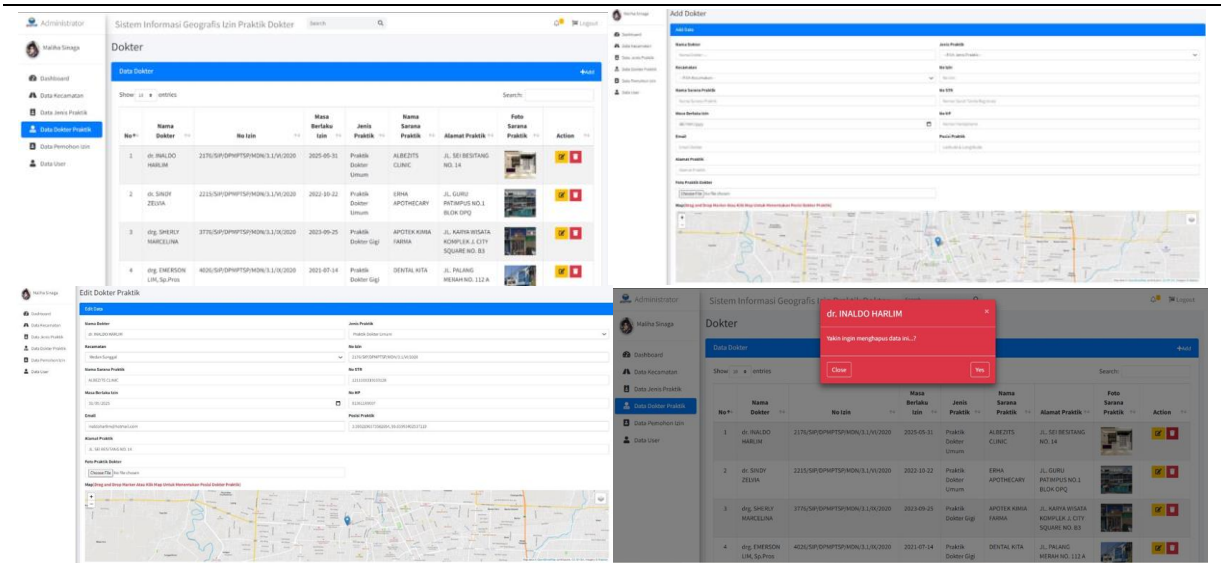


Figure 6. Medical Practice Data Management Interface

The system also provides administrative functions for managing practice categories and district information. Category records contain the practice type and its associated icon, while district records contain the district name and map color. Applicant records include applicant names, application numbers, identification numbers, license types, practice categories, completion dates, and applicant addresses. User management is available through the backend, with additional user-management privileges assigned to the super administrator.

These functions establish an administrative structure for maintaining the records required by the geographical application. The integration of administrative data management and geographical visualization allows updates to the underlying records to be managed through the same web-based system.

3.5. Functional Testing Results

The developed application was evaluated using Black Box Testing on 24 January 2022. The testing focused on verifying whether the system functions produced the expected outputs when users performed specified activities. The original testing form contained 32 test items covering public access, geographical mapping, information display, route visualization, administrator authentication, dashboard access, data management, and logout functionality.

The testing results recorded all 32 activities as successful, with no failed activities indicated in the testing form. The results are summarized in Table 2.

Table 2. Summary of Black Box Testing Results

No.	Tested functionality	Number of test items	Successful	Failed
1	Website access and main page	1	1	0
2	Overall medical practice map	1	1	0
3	District-based mapping	1	1	0
4	Practice-category mapping	1	1	0
5	Medical practice information	1	1	0
6	Medical practice details	1	1	0
7	Route visualization	1	1	0
8	Login page	1	1	0
9	Login function	1	1	0
10	Return-to-home function	1	1	0
11	Administrator dashboard	1	1	0
12–15	District data management (view, add, edit, delete)	4	4	0
16–19	Practice-category management (view, add, edit, delete)	4	4	0
20–23	Medical practice data management (view, add, edit, delete)	4	4	0
24–27	Applicant data management (view, add, edit, delete)	4	4	0
28–31	User data management (view, add, edit, delete)	4	4	0
32	Logout function	1	1	0
Total		32	32	0

Based on the recorded results, the application successfully performed all tested functions according to their expected outputs. The public interface could display the geographical distribution of medical practices, district-based and category-based maps, medical practice details, and route information. The administrative interface also provided the expected functions for accessing and managing district, practice-category, medical practice, applicant, and user records.

The testing results indicate that the implemented functions operated as expected under the tested scenarios. However, Black Box Testing primarily verifies functional behavior. Therefore, these results should not be interpreted as evidence of geographical coordinate accuracy, user satisfaction, usability, or measurable improvements in public healthcare accessibility.

The findings indicate that the developed WebGIS provides an integrated approach to presenting medical practice licensing information through geographical visualization and administrative data management. Its main contribution lies in connecting licensing attributes, such as doctors' names, license numbers, practice facilities, and license validity periods, with their corresponding geographical locations. The district-based and practice-category mapping functions further enable users to examine the spatial distribution of medical practices from different classification perspectives. Meanwhile, the administrative interface supports the management of related records through viewing, adding, editing, and deleting functions. These features address the limitations of the previous spreadsheet-based system, particularly the absence of integrated geographical visualization. Nevertheless, the successful completion of the 32 Black Box test scenarios demonstrates functional conformity rather than the overall quality or effectiveness of the system. Therefore, the findings should be interpreted as evidence of successful system implementation, not as proof that the application has improved healthcare accessibility or administrative performance.

The findings are consistent with previous research emphasizing the importance of integrating geographical information into healthcare information and planning systems. Guagliardo [35] explained that the geographical distribution of healthcare providers is an important component of spatial accessibility, particularly in understanding the relationship between service locations and potential users. Similarly, Lawal and Anyiam [36] demonstrated how open geographical data and geospatial analysis can be used to examine the distribution and accessibility of primary healthcare facilities. Rekha et al. [37] further applied GIS-based spatial accessibility analysis and road network analysis to identify healthcare service disparities and potential routes to healthcare facilities. These studies primarily focused on measuring spatial accessibility through distance, travel time, population demand, and spatial modelling. In comparison, the present study focuses on developing an operational web-based information system that connects medical practice licensing records with geographical visualization, district-based classification, and public information access. This distinction is also relevant to Lin et al. [38], who demonstrated that transportation modes and travel impedance influence spatial accessibility measurements, and Ihantamalala et al. [39], who integrated geographical accessibility estimates into an e-health platform to support local healthcare planning. Furthermore, Stacherl and Sauzet [40] emphasized that robust spatial healthcare accessibility assessment requires consideration of both service availability and geographical accessibility. Consequently, the present system complements these studies by providing an administrative and informational foundation for exploring licensed medical practice locations, although it does not undertake the advanced accessibility measurement performed in those studies.

The novelty of this study lies in the context-specific integration of medical practice licensing administration and geographical information visualization within a web-based GIS application. Unlike studies that primarily investigate healthcare accessibility through spatial modelling, this research connects individual medical practice licensing attributes with geographical locations and provides public-facing information alongside administrative management functions. The integration includes district-based mapping, practice-category visualization, location-specific licensing details, route display, and backend functions for managing medical practice records. This combination addresses a practical information-management problem identified at DPMPTSP Medan, where licensing information was previously maintained in spreadsheet-based records without integrated geographical visualization. Therefore, the contribution should not be interpreted as the invention of a new GIS method, but rather as the development and implementation of a context-specific information system that links licensing records, spatial presentation, and administrative data management in one application.

The findings have practical implications for public administration and the management of medical practice licensing information. For DPMPTSP Medan, the application provides a centralized interface for organizing licensing records and examining the geographical distribution of registered medical practices. The district-based and category-based mapping functions may support administrative monitoring by making the spatial information easier to explore, while the data-management functions provide a structured mechanism for updating relevant records. For the public, access to location markers, practice details, license numbers, and validity periods offers an additional source of information when identifying licensed medical practice locations. From a system-development perspective, the findings also indicate the potential of combining web technologies, spatial databases, and interactive mapping libraries to support location-based public information services.

However, the extent to which these functions improve administrative efficiency, public decision-making, or healthcare access requires further empirical evaluation involving administrators and public users.

The findings may be relevant to other local government agencies that manage geographically distributed licensing records and require public access to location-based information. The system's general design could be adapted to other cities or licensing contexts, provided that reliable administrative records, geographical coordinates, and corresponding spatial boundary data are available. Nevertheless, the generalizability of the present findings is limited by the study's focus on DPMPTSP Medan and its specific administrative requirements. The implementation also used five sample records per district, which should not be interpreted as a complete representation of all licensed medical practices in the city. Furthermore, the evaluation was limited to 32 Black Box test scenarios and did not include usability testing, user acceptance assessment, system performance measurement, or independent validation of geographical coordinate accuracy. The route function was implemented as a geographical navigation feature, but its accuracy and optimality were not quantitatively evaluated. In addition, the system did not measure population-based healthcare accessibility, service capacity, travel-time disparities, or actual healthcare utilization. Future studies should therefore incorporate larger and regularly updated licensing datasets, spatial accuracy assessment, usability evaluation, and advanced accessibility analysis to determine the system's broader value for healthcare planning and public service delivery.

4. CONCLUSION

This study developed and implemented a web-based Geographic Information System (WebGIS) to support the geographical mapping and management of medical practice licensing information in Medan City. The system integrates doctors' licensing records, including names, license numbers, practice facilities, license validity periods, and geographical coordinates, into an interactive map accessible to both administrative staff and the public. Its features include citywide mapping, district-based and practice-category visualization, doctor information, route displays, and administrative data management. The implementation addresses the limitations of the previous spreadsheet-based system by providing integrated geographical visualization and structured record management. Functional testing confirmed that all 32 Black Box test scenarios were successfully executed, indicating that the system operated according to the specified functional requirements. However, these findings demonstrate functional feasibility rather than improved healthcare accessibility, administrative efficiency, or user satisfaction.

Future research should evaluate the system through usability testing, user acceptance assessments, and geographical coordinate accuracy validation involving administrative staff and public users. Further studies could also incorporate more comprehensive and updated medical practice data and apply spatial accessibility analysis to examine the distribution of medical services across Medan City.

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