ISSN: 2581-1274

WebGIS-Based Mapping of Blood Donor Communities in Metro City

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ARTICLE INFO

Article history:
Published
August 2, 2025

Keywords:
WebGIS
Database
Metro City
Blood donor distribution
PMI

ABSTRACT

The availability of sufficient blood supplies is essential for fulfilling medical requirements, particularly in emergency scenarios. In Indonesia, the Indonesian Red Cross (Palang Merah Indonesia, PMI) is tasked with managing blood supplies across various regions, including Metro City. However, the current donor data management system at PMI Metro City is not yet fully optimized, potentially undermining efforts to meet local blood demands. Inconsistent donor data management poses significant challenges to blood transfusion processes, especially during emergencies. To address these inefficiencies, this study aims to develop a database system integrated with a Web-based Geographic Information System (WebGIS). The proposed WebGIS platform provides an interactive and informative visualization of blood donor distribution across Metro City. The system development follows a structured methodology comprising several phases: planning, data identification, WebGIS development using PHP, HTML, CSS, JavaScript, and Leaflet, and web hosting. The key outcomes of this research include a well-structured database and an interactive web-based map for identifying donor locations. The WebGIS system enhances PMI's capacity to optimize blood supply strategies, particularly for urgent medical needs, by improving real-time visibility and management of donor data.

I. Introduction

Blood donation plays an important role as one of the humanitarian activities aimed at maintaining the availability of blood stock for medical needs. Blood donation is a voluntary activity where an individual donates their blood to be stored as stock, which will later be transfused to someone in need [1]. Maintaining an adequate blood supply in blood banks is essential for promptly addressing urgent medical needs, including surgeries and the treatment of critically ill patients.

PMI is responsible for organizing and facilitating blood donation activities throughout Indonesia [2]. The data collected by PMI consists of eligible blood donors' information. The eligibility criteria for blood donation include: being between 17-60 years old, having a minimum weight of 45 kg, having a blood pressure between 100-180 (systolic) and 60-80 (diastolic), signing the blood donor registration form, and passing screening for weight, hemoglobin levels, blood type, and a medical examination by a doctor [3]. Currently, the donor data collected by PMI Metro City is not yet fully optimized. The presentation of the data lacks clarity regarding the time range of data collection, addresses of donors are incomplete, and there is no accumulation of donors by region. Poor data management can hinder PMI's ability to identify and analyze donor distribution effectively.

In this regard, the development of a structured blood donor database is essential. The purpose of building this database is to organize the data in a way that facilitates easy, fast, and accurate retrieval of desired information [4]. Geographic Information System (GIS) is a system that integrates spatial data and attribute data, allowing users to obtain meaningful geographic-based information for decision

making. Unlike other information systems that focus primarily on attribute data, GIS has the advantage of directly linking attributes to spatial forms, making it suitable for various mapping and planning purposes. [5]

The system will organize donor data based on various criteria such as donor name, address, blood type, Rh factor, gender, age, and donation frequency, enabling PMI to implement the right strategies to increase blood stock. To maximize the functionality of the database, WebGIS (Web Geographic Information System) is used to visualize the distribution of blood donors in Metro City. WebGIS is a web-based map that integrates geographic data with an existing database, enabling the creation of interactive and informative map visualizations [6]. The developed WebGIS allows donors to be grouped based on their region. Similar approach has been applied to develop a self-made healthcare services map for districts in Indonesia [7]. Additionally, the WebGIS features a structured database system, making it an effective tool for PMI to manage blood donor data.

This research focuses on the development of a database system integrated with a web map (WebGIS) in Metro City to enhance the management of blood donor data by PMI. The system allows for the identification of donors based on geographic locations. With this approach, PMI can improve operational efficiency and expand service coverage, potentially serving as a model for blood donor data management in other regions with similar needs.

II. Method

A. Location and Materials

This research is conducted in Metro City, Lampung Province. The city has a population of 165,368 people and a total area of 6,874 hectares, divided into 5 districts and 22 sub-districts. The data used in the research consists of blood donor information obtained from the PMI of Metro City, and administrative data of Metro City from the Geospatial Information Agency (Badan Informasi Geospasial, BIG).

B. Stages in Reseacrh

Several stages in this research include:

- Blood donor data collection from PMI Metro City:
  This step involved obtaining blood donor data from the PMI in Metro City. The process included submitting an official data request letter through ITERA to PMI Metro City. Once approved, PMI provided the donor data in Excel format. The data contained donor identities (name, address, date of birth, and gender) and blood donation information (blood type and rhesus factor).

- Data selection:
  This step involved processing the acquired data to ensure it could be displayed according to the donor's administrative village. The selection process included: Checking donor locations by administrative village, verifying blood types, and Reviewing blood donation history. The selected donor data including: donor name, donor location (administrative village), blood type, and rhesus factor. This data was prepared for mapping to create a distribution map of blood donors in Metro City. The data was also used in building the database for the WebGIS.

- WebGIS development:
  This process, which involved several steps: start from building the framework, determining the web design, configuring Leaflet, and testing the web application
  a. Framework development:
     This step involved: Downloading and installing the necessary programs, Configuring the framework, testing to ensure the program runs smoothly. The framework was used to help web developers write code easily, quickly, and in a structured manner [8]. In this study, the framework used to develop the WebGIS is CodeIgniter 3.

b. Web design:
This step focused on: Arranging the layout of menus to be displayed in a structured manner and Enhancing the web appearance to attract users. The design process used a text editor and programming languages such as PHP, HTML, and CSS [9].
c. Leaflet configuration:
This process, which included: Downloading Leaflet from its official website, Initializing the map, Displaying the map, Adjusting the map display and Testing to ensure the map functions properly. Leaflet was chosen for its speed and small file size, making it ideal for interactive web maps [10].

- Inputting donor data into the database:
This step involved: Integrating geographic and attribute information into the system using Leaflet, Using GeoJSON format for efficient and flexible representation of geographic features, and Inputting data on administrative village boundaries in Metro City, linked with blood donor data.

- Hosting:
This step, which involved: Uploading data from the local website to a web server for public access. Hosting is the location where all the content of a website is stored [11]. In this study, Rumah Web was chosen as the hosting service due to its affordability and ease of use, along with the utilization of the provided domain and free SSL certificate.

- Website testing:
This final development stage included: Comprehensive testing of system functionality and performance, Identifying and correcting potential issues such as programming errors, data inconsistencies, or compatibility problems, Repeated testing and refinement until the system functioned as expected. If testing is unsuccessful, the process loops back to the framework development stage for further refinement and problem-solving. If testing is successful, the WebGIS development will be completed.

III. Results and Discussion

A. Blood Donor Information in Metro City Through a Database System

The results of this study provide information on blood donors in Metro City in the form of a database. The information includes the names of sub-districts, villages, blood type categories, and the total number of donors. The total number of donors in Metro City is 4,194. Among the blood types, type O has the highest number of donors, with 1,472 individuals, while type AB has the lowest, with 301 donors.

Table 1. Distribution of Blood Donors in Metro City

District	Sub-District	Blood Type A	Blood Type B	Blood Type AB	Blood Type O	Total
Metro Barat	Ganjar Agung	53	68	13	58	192
	Ganjar Asri	83	104	26	125	338
	Mulyojati	73	83	16	74	246
	Mulyosari	22	23	3	18	66
Total District Metro Barat		231	278	58	275	842
Metro Pusat	Hadimulyo Barat	63	77	15	78	233
	Hadimulyo Timur	46	52	11	74	183
	Imopuro	60	45	18	70	193
	Metro	115	99	30	149	393
	Yosomulyo	69	108	15	99	291
Total District Metro Pusat		353	381	89	470	1293

District	Sub-District	Blood Type A	Blood Type B	Blood Type AB	Blood Type O	Total
Metro Selatan	Margodadi	14	28	3	14	59
	Margorejo	48	37	9	67	161
	Rejomulyo	19	21	5	32	77
	Sumbersari	14	16	5	18	53
Total District Metro Selatan		95	102	22	131	350
Metro Timur	Iring Mulyo	96	117	28	155	396
	Yosodadi	68	92	25	75	260
	Yosorejo	60	78	19	82	239
	Tejo Agung	57	65	6	65	193
	Tejosari	22	25	9	41	97
Total District Metro Timur		303	377	87	418	1185
Metro Utara	Banjarsari	68	71	19	71	229
	Karangrejo	24	33	8	39	104
	Purwoasri	10	27	4	21	62
	Purwosari	28	40	14	47	129
Total District Metro Utara		130	171	45	178	524
Total Keseluruhan		1112	1309	301	1472	4194

The distribution of blood donations in various sub-districts in Metro City shows that there are disparities between regions, with some areas having higher concentrations of donors compared to others. According to Table 1, Metro Pusat has the highest number of total donors (1,293), followed by Metro Timur (1,178), and Metro Barat (842). This trend suggests that these regions may have a more active donor base or better-organized blood donation activities compared to other sub-districts such as Metro Selatan (350 donors) and Metro Utara (524 donors).

Furthermore, the distribution of blood types in each sub-district also highlights some interesting findings. Blood type O, the universal donor, has the highest total number of donors across all sub-districts, with 1,472 donors. This is followed by blood types B, A, and AB, respectively. The high number of blood type O donors is particularly beneficial for blood banks as this type can be transfused to any patient in urgent situations. The concentration of blood donors across various sub-districts can provide a valuable reference for the PMI to allocate resources effectively and ensure a sufficient supply of each blood type, particularly in areas with lower donor numbers. The blood donor distribution map shown in Table 1 can be seen in Figure 1.

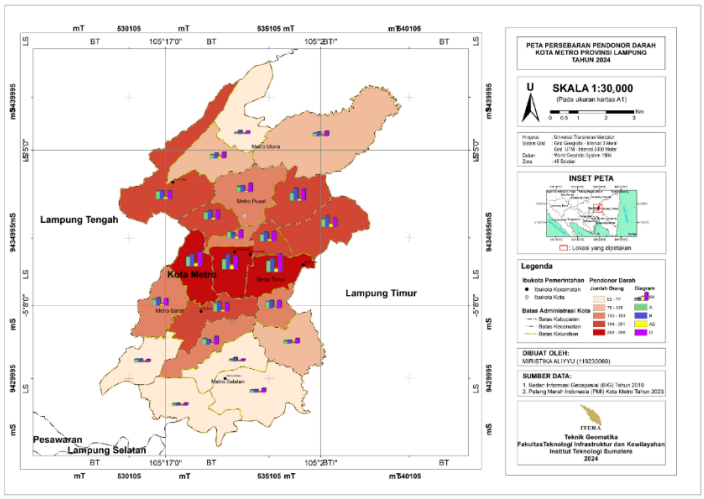

Fig 1. Map Diagram of Blood Donor Distribution in Metro City

Figure 1 illustrates a map showing the spatial distribution of blood donors, highlighting differences in distribution across sub-districts, with a higher concentration of donors in the city center, marked by taller bar graphs in dark red areas. In general, blood type O is dominant in most sub-districts, followed by types A and B, while type AB consistently remains the least prevalent. The spatial pattern indicates a gradient from the city center to the outskirts, where the number of donors tends to decrease as the distance from the city center increases. This reflects factors such as population density or significant differences in the accessibility of blood donation facilities to the public. The following table presents the distances between sub-district offices and the blood donation office (PMI).

Table 2. Distance from PMI to District Offices

District	Latitude	Longitude	Distance
Metro Pusat	-5.116143744	105.3056624	0,6 Km
Metro Barat	-5.135221028	105.2948158	2,6 Km
Metro Selatan	-5.156818509	105.3025772	4,5 Km
Metro Timur	-5.120245344	105.3277688	1,9 Km
Metro Utara	-5.093641138	105.2857515	3,7 Km
PMI Kota Metro	-5.116875926	105.3106621	-

The table of distances from PMI to sub-district offices (Table 2) shows that the distances range from 0.6 km to 4.5 km. Metro Pusat, which has the closest proximity to the PMI office (0.6 km), also has the highest number of blood donors, which could indicate that proximity to the PMI office plays a role in donor engagement. On the other hand, Metro Selatan, which is 4.5 km away from the PMI office, has the lowest number of donors (350). This correlation suggests that geographical accessibility may influence blood donor participation. Sub-districts closer to the PMI office tend to have more donors, possibly due to ease of access to the donation facility. Therefore, in sub-districts that are farther from the PMI office, such as Metro Selatan, it may be beneficial for PMI to set up mobile donation units or establish temporary blood donation centers to increase accessibility and donor participation.

B. WebGIS-Based Visualization of Blood Donor Distribution in Metro City

The developed WebGIS presents various information, including the number of blood donors in each administrative village *(kelurahan)* categorized by blood type. It also features interactive elements such as Home, Map, and About Me menus. The WebGIS can be accessed at the following URL: https://petadonormetro.site.

- **Menu Home**

This menu displays the homepage of the website. It consists of three main sections: a header at the top, the main content in the center, and a footer with additional information at the bottom. The layout of the Home menu on the WebGIS can be seen in figure 2.

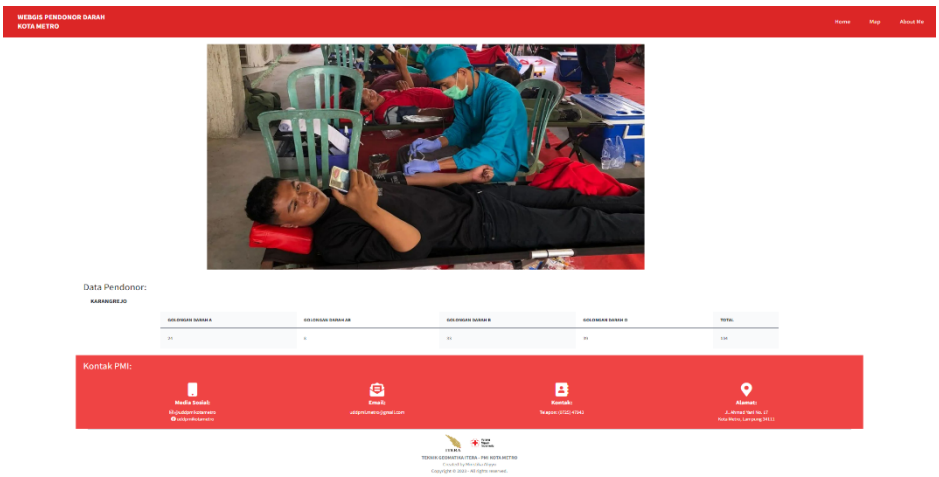

Fig. 2. Display of the Home Menu in WebGIS

Figure 2 shows the Home menu of the website titled "WEBGIS PENDONOR DARAH KOTA METO" in the top left corner. In the top right corner, there are three main menu options: "Home" (the default view), "Map" (to display the map), and "About Me" (which provides a brief biography of the website creator). These menus remain visible as users navigate between pages. The central area of the Home menu features interactive photos of PMI Metro City activities, which change every 3 seconds. It also includes a table with donor data, organized by village and blood type. At the bottom, contact information for PMI is provided, including phone number, address, email, and social media, all of which are clickable. The lower section also displays the logos of Institut Teknologi Sumatera and PMI. These elements remain visible as users navigate to different pages.

- **Menu Map**

The Map menu contains a web map displaying the spatial distribution of blood donors in Metro City. It includes several features, such as a legend, inset map, layers, search function, zoom in, zoom out, and a home button. The Map page interface on the WebGIS is shown in Figure 3.

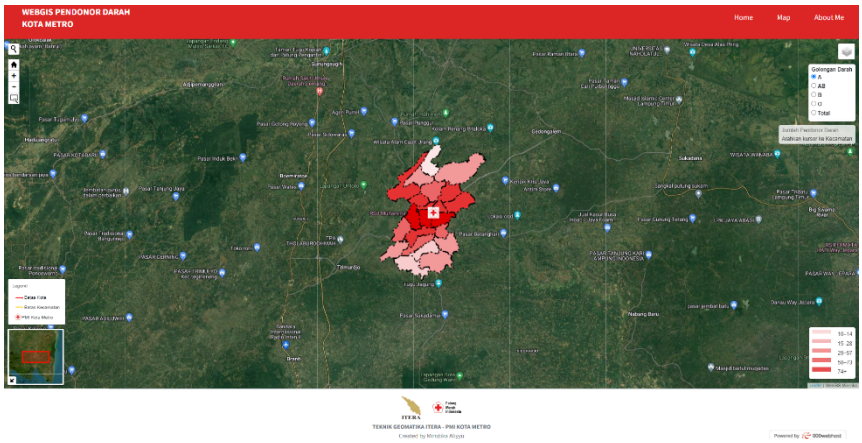

Fig. 3. Display of the Map Menu in WebGIS

Figure 3 shows the donor map with administrative boundaries of Metro City overlaid on the base map. On the right side of the “Map” page, there are features including: layers to change the base map, display administrative boundaries, and show donor data by blood type. Directly below the layers, an information box displays the number of blood donors in each sub-district when the cursor hovers over the map. At the bottom of the page is a scale bar indicating donor quantities by color. In the top left corner of the “Map” page, there is a “search” feature for locating specific areas or cities. The “home” button, depicted as a house icon, returns users to the predefined main view. Zoom in and zoom out features adjust the map scale. Additionally, the bottom section includes a legend showing administrative boundaries and the location of PMI office, as well as an inset map for reference.

- **Menu *About Me***

This menu is the final section of the website. The "About Me" page on the WebGIS provides information about the website creator.

IV. Conclusion

Based on the results and discussions of this study, the following conclusions can be drawn:

1. The total number of blood donors in Metro City is 4,194, with a distribution among blood types as follows: type A has 1,112 donors, type B has 1,309 donors, type AB has 301 donors, and type O has 1,472 donors.
2. The study successfully established a WebGIS for blood donors in Metro City. This WebGIS is accessible at https://petadonormetro.site/ . The developed WebGIS effectively performs its intended functions and is connected to a database.

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