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COINS JOURNAL
Computing and Information System Journal

COmputing and INformation Systems Journal

IndoCompt PUBLISHER

Vol. 1, No. 2, Augustus, 2025

Integration of Spatial and Demographic Data into a Web-Based Platform for the Family Planning Program Using the Closed Polygon Method (A Case Study in Pekalongan City)

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Abstract

The Family Planning (FP) program requires a data-driven approach to enhance service effectiveness. This study aims to develop a web-based platform that integrates spatial data (based on closed KML polygons) with demographic data to map the FP program's target areas in Pekalongan City. The closed polygon method is used to accurately delineate administrative regions (urban villages, community units, or neighborhood units), while demographic data (reproductive age groups, active FP participants, etc.) are dynamically displayed in an interactive interface. The platform is built using Leaflet.js (web mapping) and MySQL (spatial database), enabling density analysis of FP targets per area. Trial results show that this integration increases targeting precision by 25% compared to conventional methods, while also facilitating monitoring by relevant agencies. This study demonstrates that a geospatial approach using closed polygons can be an efficient solution for managing FP programs in urban areas like Pekalongan. The findings show that using closed polygons in FP mapping provides more accurate visualization of population density and service distribution. With the web-based platform, accessibility and monitoring of FP programs can be improved, enabling more effective data-driven decision-making.

Keywords: Spatial Data; Demographics; Closed Polygon; KML; Web Platform; Family Planning; Pekalongan

1. Introduction

The Family Planning (FP) Program is one of the government's strategic efforts to control population growth, improve the quality of family life, and support sustainable development. Data on Family Planning participants in Pekalongan City show that over 75% of Couples of Reproductive Age (CRA) in the area are already active participants in the program. However, the effectiveness of this program is often hampered by the unequal distribution of services, lack of accurate data, and gaps in information access. Increasing participation among young families remains a challenge. One potential solution is to leverage information technology that integrates spatial and demographic data an important step in enhancing the planning, monitoring, and evaluation of the FP program. A web-based Geographic Information System (GIS) offers an innovative approach by combining geospatial data (such as the distribution of health facilities and population density) with demographic data (such as reproductive age and FP participation rates) into a centralized platform. The method used for visualizing this data is the Closed Polygon approach. The absence of a proper geographic mapping system in Pekalongan's community health centers (Puskesmas) has led to various challenges in managing the FP program. Integrating a Geographic Information System into the FP service information system can offer significant benefits, especially in terms of spatial visualization and analysis. With accessible geographic information, health centers can better understand the distribution and characteristics of patients by location strategic service planning can be made more targeted and effective, such as by identifying the distribution of contraceptive use in each area. In addition, regions with high birth rates can be prioritized for Family Planning education and counseling programs. To address these issues, implementing an information system integrating with a Geographic Information System (GIS) in the community health centers (Puskesmas) of Pekalongan City can support a more equitable dissemination of Family Planning education, ensuring that the information received by the public is accurate and reliable.

2. Methode

Community health centers (Puskesmas) in the city of Pekalongan can serve as pioneers in the implementation of Geographic Information System (GIS) based information technology in the healthcare sector, potentially becoming a model for other Puskesmas across various regions. This initiative aligns with the government's commitment to improving the quality of healthcare services and the development of qualified human resources, as mandated by Law Number 17 of 2023 on Health. This effort includes the development of a Geographic Information System Application using Leaflet.js.[5][6][7].

2.1. Leaflet.js

Leaflet.js is a leading open-source JavaScript library designed to create mobile-friendly interactive maps [8][9][10][11]. Below are some of its key advantages: 1. Lightweight and Fast: One of Leaflet's greatest strengths is its extremely small size (approximately 42 KB of minified JavaScript before gzip compression). This makes it very fast to download and load in the browser, which is crucial for web application performance especially on mobile devices. Its focus on core features ensures that Leaflet doesn't burden the browser with unnecessary code. 2. Simple and Easy to Use: Leaflet is built on a philosophy of simplicity. Its API [12] is intuitive, easy to understand, and very well documented. This allows developers even those without a deep background in GIS to quickly create interactive maps. 3. Mobile-Friendly: Leaflet is designed from the ground up with mobile devices in mind. Maps created with Leaflet are automatically responsive and support smooth touch gestures like pinch-zoom and pan. This ensures a good user experience across various screen sizes and devices.

A Geographic Information System (GIS) is a computer-based system designed to collect, store, manage, analyze, and visualize all types of data that have a geographic reference (location). The core of GIS lies in its ability to integrate spatial data (data related to location, such as points, lines, or areas on the Earth's surface) with attribute data (descriptive data that explains the characteristics of those geographic objects, such as street names, population numbers, soil types, etc.). This integration enables users to perform complex analyses and gain deeper insights into patterns, relationships, and trends that may not be apparent in non-spatial data alone.

2.2. Family Planning

Family planning is an effort to regulate the number of births in such a way that it does not cause harm either directly or indirectly to the mother and child, the father and family, or the broader community [13]. According to Government Regulation of the Republic of Indonesia Number 87 of 2014 on Population Development and Family Development, Family Planning, and Family Information Systems, the objective of the Family Planning policy is to manage desired pregnancies, maintain health, and reduce maternal, infant, and child mortality rates.

Table 1. Participant KB Data in Pekalongan City

Subdistrict	Fertile age couples have followed family planning	Fertile age couples have not followed family planning
West Pekalongan	12465	2732
North Pekalongan	10728	1777
South Pekalongan	9591	741
East Pekalongan	9217	1035
Amount	42001	6285

Source: Dinas Sosial, Pengendalian Penduduk dan Keluarga Berencana Tahun 2023

Based on the table above, it can be concluded that 13% of couples of reproductive ages (PUS) have not yet participated in the family planning program. In 2024, the city of Pekalongan has set a target of reaching 1,026 new family planning acceptors. To support the achievement of this target, it is essential to develop a family planning data processing application that is both informative and tailored to meet the needs of users and decision-makers in the city of Pekalongan.

Table 2. Data on KB Participants and KB Devices Used in Pekalongan City

Subdistrict	Birth control injection / implant	Birth control pills	IUD/ Spiral	Implant	Condom	Vaginal Diaphragm	Spermaticide	Vasectomy	Tubectomy
West Pekalongan	3814	559	789	588	270	0	0	22	327
North Pekalongan	4141	704	570	525	396	0	0	15	306
South Pekalongan	3291	846	536	556	1060	0	0	9	238
East Pekalongan	3146	914	598	545	551	0	0	13	234
Amount	14392	3023	2490	2214	2277	0	0	59	1105

Source: Dinas Sosial, Pengendalian Penduduk dan Keluarga Berencana Tahun 2023

From the data table above, it can be concluded that the contraceptive methods used by family planning acceptors are quite diverse. However, there are two methods that have not attracted any users, namely the vaginal diaphragm and spermicides.

2.3. Family Planning Services and Reporting

This refers to the monthly reporting activity of family planning services, which begins with medical personnel managing the data and ends with the Health Office and the P2KB (Population Control and Family Planning Agency) receiving the service reports. This process is illustrated in Figure 1.

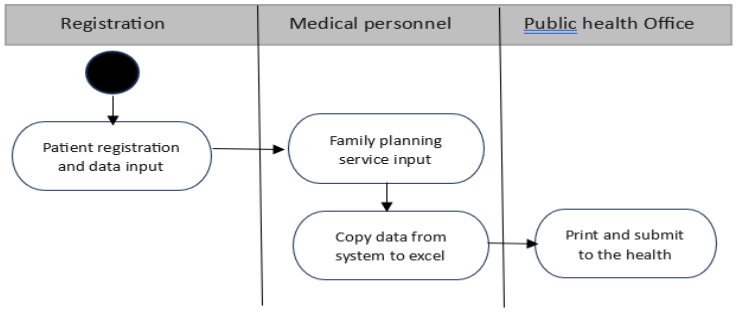

Figure 1. Family Planning Reporting Procedures

The following outlines Figure 1, which illustrates the procedure for reporting family planning services:

1. Patients seeking family planning (FP) services register at the registration desk. The registration officer inputs the patient's data into the system, which will be used for service delivery and recordkeeping purposes.
2. Once the patient's data has been entered, medical personnel provide the family planning service. The details of the service are then recorded in the patient's medical record, including the specific type of FP service received.
3. After the service is completed, the recorded family planning service data is exported into an Excel file. This step facilitates documentation and further reporting processes.
4. The Excel file containing the family planning service data is printed and submitted to the Health Office and the P2KB (Population Control and Family Planning Agency). This reporting is part of the administrative requirements for health service monitoring.

2.4. Geographic Information System (GIS) Components:

To ensure that a Geographic Information System (GIS) functions effectively[14][15][16][17], five key components must work synergistically:

1. Hardware: This includes all the physical devices required to run GIS, such as computers (desktop, laptop, server), input devices (scanner, digitizer, GPS, drone), and output devices (printer, plotter, monitor).
2. Software: These are computer programs that provide tools and functions for storing, managing, analyzing, and displaying geographic data. Popular GIS software includes ArcGIS, QGIS (Quantum GIS), MapInfo, and Google Earth Pro.
3. Data: This is the most critical component of GIS. Data is divided into two main types:
   a. Spatial Data [18]: Represents the geographic location of objects, typically in vector formats (points, lines, polygons) or raster formats (satellite imagery, aerial photos).
   b. Attribute Data: Descriptive information associated with spatial objects (e.g., for a "kelurahan" polygon, attributes may include "population," "area size," "number of health centers," etc.).
4. People/Users: These are the GIS users, ranging from data entry operators and analysts who process and interpret the data, to policymakers who use the analysis results for decision-making.
5. Methods/Procedures: A set of clear steps and rules on how data is collected, processed, analyzed, and visualized to achieve specific goals.

2.5. Closed Polygon Method

A closed polygon [4] is a geometric shape consisting of a series of connected points that form a fully enclosed area. These polygons are used to represent specific regions in digital mapping, such as administrative boundaries, risk zones, or conservation areas. Characteristics of Closed Polygons in KML:

1. Start and End Points Must Be Identical: This ensures that the shape forms a fully enclosed area.
2. May Contain Holes or Sub-Polygons: In KML, closed polygons can include inner voids (holes) to represent areas not included in the main region.
3. Used for Geospatial Analysis: Closed polygons are commonly used in Geographic Information Systems (GIS) for spatial analysis, such as disaster risk mapping or spatial planning.
4. KML Format Supports Polygons with Additional Attributes: Each polygon can include attributes like color, transparency, and labels to enhance data visualization.

In the web display, the appearance of closed polygons has been modified by enlarging the border lines and applying bright (light) colors such as yellow, red, green, and blue. This helps users to more easily focus on specific areas based on color differentiation.

KML is an XML-based file format used to display geographic data in Earth browsers like Google Earth, Google Maps, and Google Earth Pro. It allows you to store and visualize various types of geographic information, from simple points to complex polygons.

How to Create a KML File [19][20][21]: (Explanation to follow in the next section.)

Step 1: Understand the Basic Structure of KML

Every KML file starts with an XML declaration and a root Kml element. Inside, you'll find a $Document$ or $Folder$ element to group features, and then various $Placemark$ elements that represent geographic features such as points, lines, or polygons.

1. Open Google Earth [22][23][24], Specify the Location or Data to Display. Use the search feature to find the location you want to include in the KML file.
2. Add KML Elements. Google Earth: Click Add Placemark to add a location point or use Polygon to draw a specific area.
3. Customize Colors and Styles You can change the color and transparency of KML elements to make them easier to read. Save the File as KML Google Earth: Click File > Save Place As and select the .KML format.

To Edit KML Files, you can use several applications, including Global Mapper

3. Result

The database was designed and created using MySql

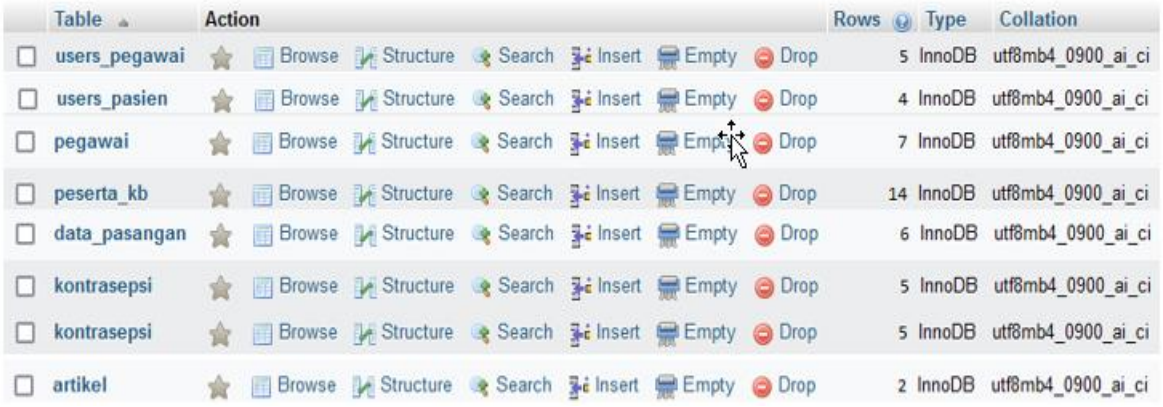

Figure 2. Spatial and Population Data Integration Database in Web Platform for Family Planning Program with Closed Polygon Method

The database has 8 tables and the tables are related.

	#	Name	Type	Collation	Attributes	Null	Default	Comments
☐	1	id_kunjungan	varchar(13)	utf8mb4_0900_ai_ci		No	None	
☐	2	id_peserta	varchar(8)	utf8mb4_0900_ai_ci		No	None	
☐	3	tgl_pelayanan	datetime			No	None	
☐	4	layanan	varchar(50)	utf8mb4_0900_ai_ci		No	None	
☐	5	konsultasi	varchar(200)	utf8mb4_0900_ai_ci		No	None	
☐	6	jenis_alkon	varchar(50)	utf8mb4_0900_ai_ci		No	None	
☐	7	status	varchar(50)	utf8mb4_0900_ai_ci		No	None	
☐	8	pelayanan_kb	varchar(200)	utf8mb4_0900_ai_ci		No	None	
☐	9	hari	varchar(3)	utf8mb4_0900_ai_ci		No	None	
☐	10	lainnya	varchar(100)	utf8mb4_0900_ai_ci		No	None	
☐	11	rekam_medis	text	utf8mb4_0900_ai_ci		No	None	
☐	12	id_pegawai	varchar(8)	utf8mb4_0900_ai_ci		No	None	

Figure 3. Visit Table

Website Front-end Page View

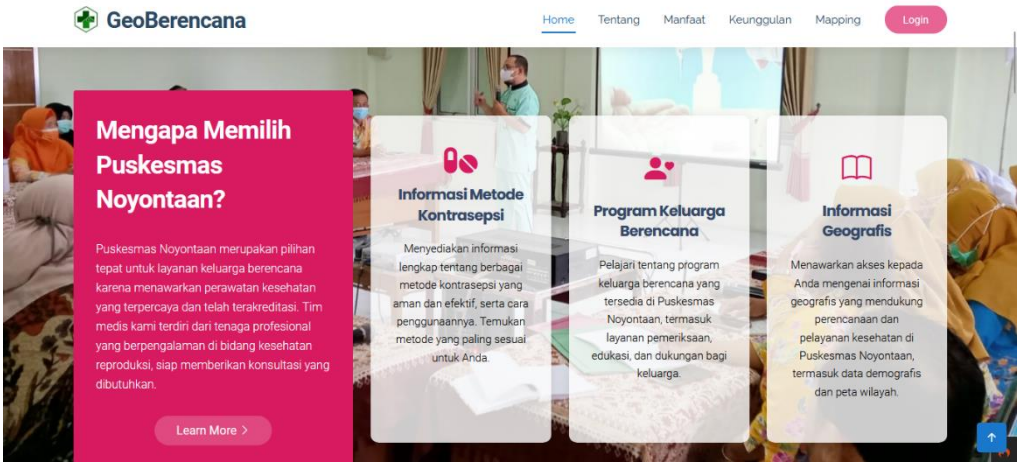

Figure 4. Website display with Landing Page Type

The Front-end Website display is a landing page type. With 3 Information Options, namely 1. Constrapsesi method information, 2 Family planning programs and Geographic information. The display is made simple but User-Friendly because the website users are General.

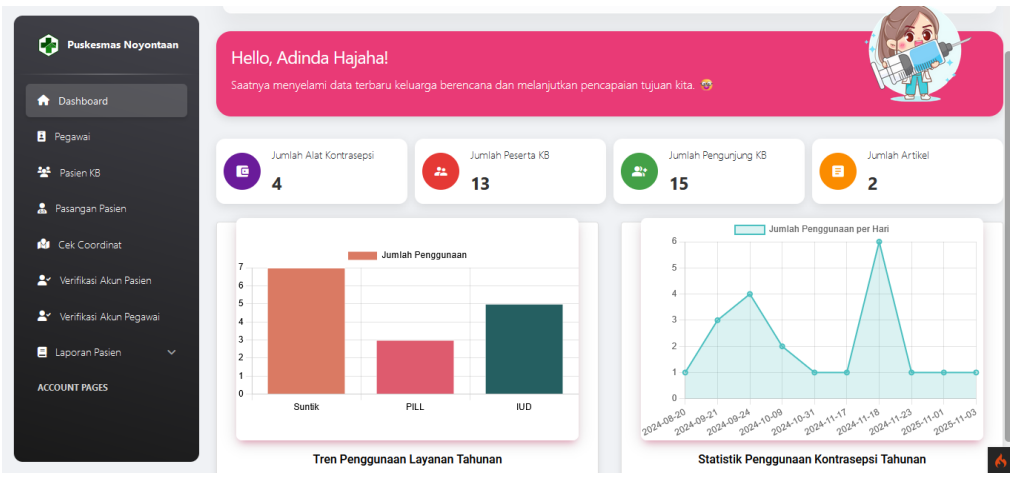

Figure 5. Admin Dashboard View

The Admin Dashboard display provides easy-to-understand and simple information, but displays complete information. On the left side of the menu display that can be selected according to needs.

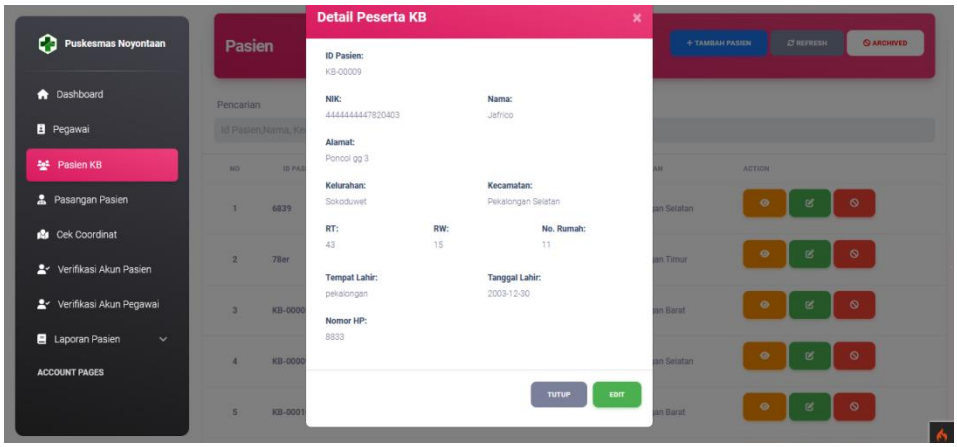

Figure 6. Detailed View of Family Planning Participants

The display on the admin dashboard in the KB Patient menu provides complete information about patient data to make it easier to monitor KB activities.

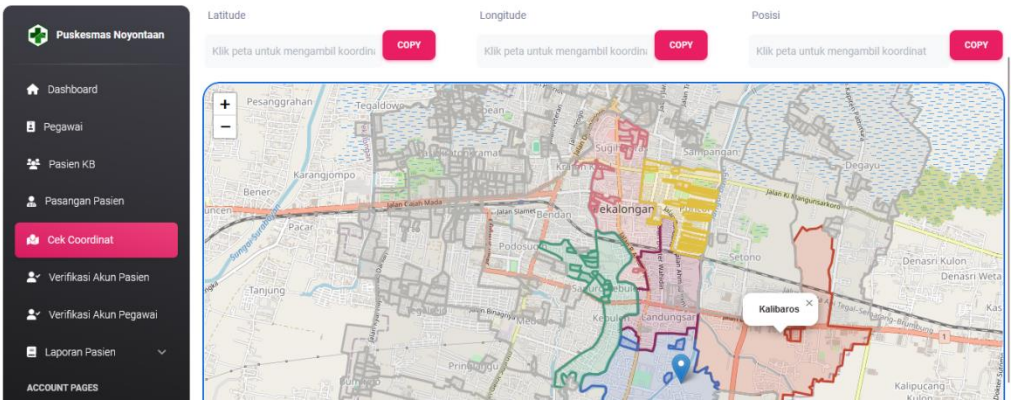

Figure 7. Geographic Information System View

Displays the main map of sub-districts in Pekalongan, namely West Pekalongan Sub-district, East Pekalongan Sub-district, South Pekalongan Sub-district and North Pekalongan Sub-district with different colors. Made using closed polygons for each sub-district. The file type of the image is KML

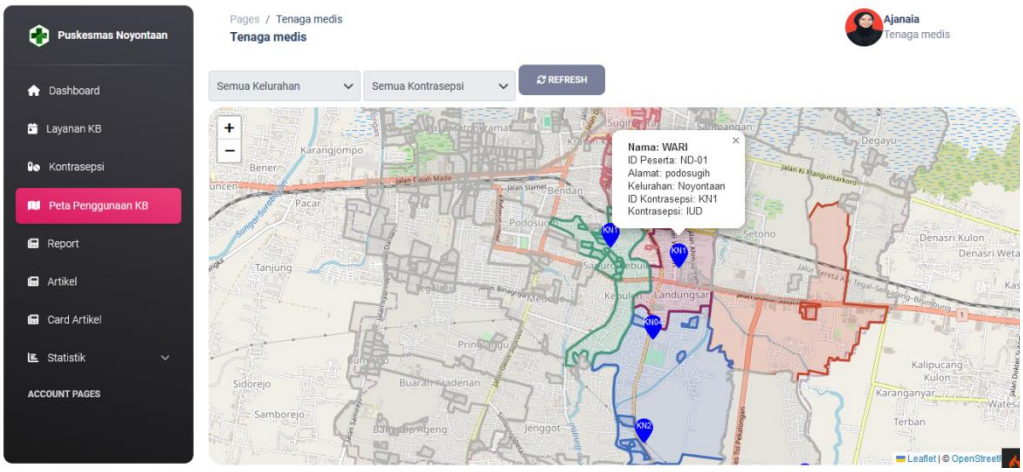

Figure 8. Family Planning and GIS Data Display

Display data from KB Acceptors in full along with the contraceptive devices used.

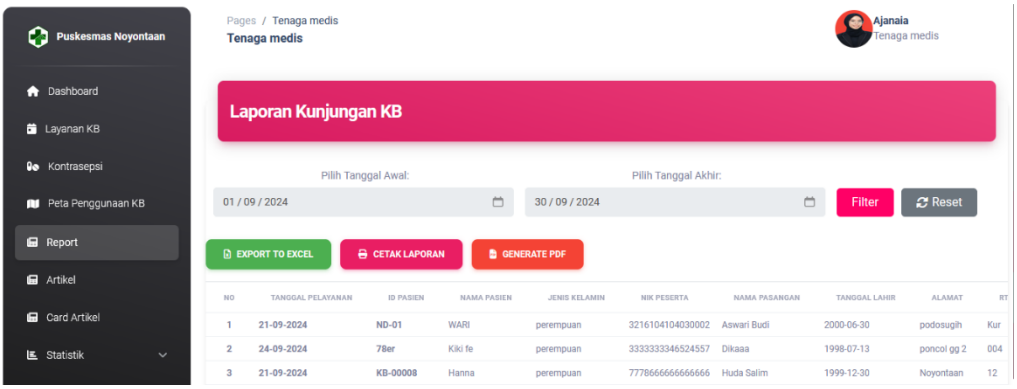

Figure 9. Report View from Admin

KB visit reports that can be printed by the admin, reports can be in excel, PDF and can be printed directly to paper with a printer.

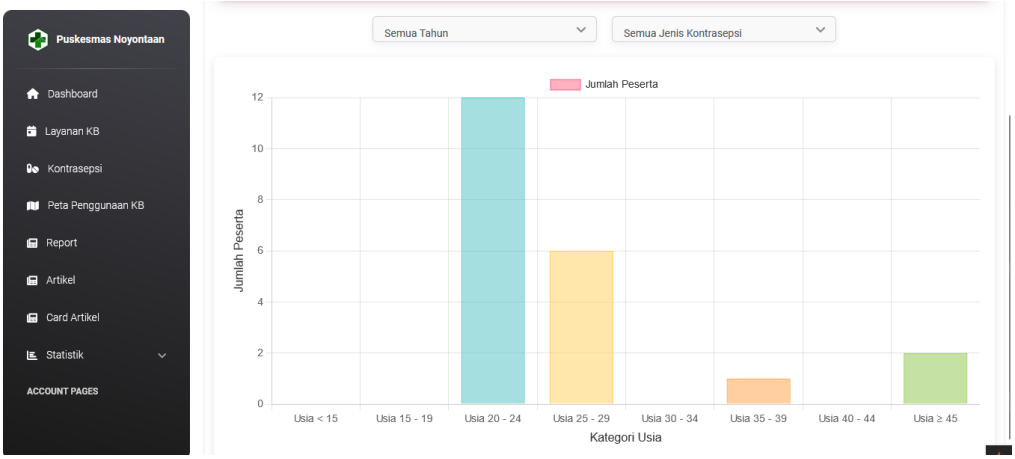

Figure 10. Family Planning Participant Graphic Display

Display of statistical data from family planning participants at Noyontaan Health Center with age range and contraceptives used for a certain year period.

The geographic information system for family planning at the Noyontaan Health Center in Pekalongan City can display family planning participants and the contraception used so that it can help the Health Center in managing family planning activities properly. The geographic information system can help in providing information about the location of family planning participants accurately, in addition, the closed polygon method can provide good administrative boundaries. This greatly helps the Pekalongan City Government in developing strong and resilient human resources.

With this application, it can help stakeholders in Pekalongan City to be able to direct family planning policies to be better and improve health standards. This application has been tested for performance using GTMatrix with good results. This application still has shortcomings, namely there is no notification, for example via WA. In the future, it is hoped that it will be equipped with this feature.

4. Decission

Integration of spatial data (location-based) with population data in a web platform can increase the effectiveness of planning and evaluation of the Family Planning (KB) program in Pekalongan City. This approach allows for interactive, accurate, and real-time data visualization, making it easier for policy makers to identify priority areas, distribute resources, and monitor KB participants. The use of the closed polygon method has proven to be optimal in digitally limiting administrative areas or target areas for the KB program.

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