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BLACKBOX TESTING OF THE GIS-BASED INTEGRATED HEALTH POST (POSYANDU) PERFORMANCE MAPPING APPLICATION

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Abstract— *The Family Planning - Integrated Health Service Post (Posyandu) plays an important role in providing primary health services at the community level in Indonesia, especially in monitoring maternal and child health. However, traditional management and performance evaluation of Posyandu often faces challenges such as limited data accuracy, inefficient reporting, and a lack of integrated monitoring tools. This research aims to develop a Geographic Information System (GIS)-based application to improve the mapping and performance assessment of Posyandu. In contrast to previous GIS health mapping systems, this study makes a unique contribution by integrating automated performance classification based on Posyandu success indicators as well as real-time analytics to support more responsive decision-making. This research uses the Research and Development (R&D) method with the Waterfall approach. The resulting application integrates performance dashboard features, GIS-based location mapping, and data management modules. Blackbox Testing and User Acceptance Test (UAT) are conducted to ensure the functionality and reliability of the system. The functional test results through 10 black box test scenarios show a 100% success rate, while the UAT results achieve an average score of 100% confirming the usability of the system. The app allows cadres to manage data efficiently and provide transparent information to the health office. This study concludes that this GIS-based application significantly improves data management and performance visualization, thereby strengthening the role of Posyandu in public health services.*

Keywords: *Decision Support, Geographic Information System, Health Information System, Performance Mapping, Posyandu.*

Intisari— *Pos Pelayanan Keluarga Berencana - Kesehatan Terpadu (Posyandu) berperan penting dalam memberikan pelayanan kesehatan primer di tingkat masyarakat di Indonesia, khususnya dalam pemantauan kesehatan ibu dan anak. Namun, pengelolaan tradisional dan evaluasi kinerja Posyandu sering menghadapi tantangan seperti akurasi data yang terbatas, pelaporan yang tidak efisien, dan kurangnya alat pemantauan yang terintegrasi. Penelitian ini bertujuan untuk mengembangkan aplikasi berbasis Sistem Informasi Geografis (SIG) untuk meningkatkan pemetaan dan penilaian kinerja Posyandu. Berbeda dengan sistem pemetaan kesehatan SIG sebelumnya, penelitian ini memberikan kontribusi unik dengan mengintegrasikan klasifikasi kinerja otomatis berdasarkan indikator keberhasilan Posyandu serta analitik real-time untuk mendukung pengambilan keputusan yang lebih responsif. Penelitian ini menggunakan metode Penelitian dan Pengembangan (R&D) dengan pendekatan Waterfall. Aplikasi yang dihasilkan mengintegrasikan fitur dasbor kinerja, pemetaan lokasi berbasis GIS, dan modul manajemen data. Pengujian kotak hitam (Blackbox Testing) dan Uji Penerimaan Pengguna (UAT) dilakukan untuk memastikan fungsionalitas dan keandalan sistem. Hasil pengujian fungsional melalui 10 skenario pengujian kotak hitam menunjukkan tingkat keberhasilan 100%, sementara hasil UAT mencapai skor rata-rata 100% yang mengonfirmasi kegunaan sistem. Aplikasi ini memungkinkan kader mengelola data secara efisien dan memberikan informasi transparan kepada dinas*

kesehatan. Penelitian ini menyimpulkan bahwa aplikasi berbasis SIG ini secara signifikan meningkatkan pengelolaan data dan visualisasi kinerja, sehingga memperkuat peran Posyandu dalam pelayanan kesehatan masyarakat.

***Kata Kunci**: pendukung keputusan, sistem informasi geografis, sistem informasi kesehatan, pemetaan kinerja, posyandu*

INTRODUCTION

Integrated Service Posts (Posyandu) constitute a fundamental component of Indonesia's primary healthcare system, particularly at the village and sub-district levels. These community-based services play a vital role in monitoring maternal and child health, supporting early detection of nutritional issues, and ensuring continuity of preventive care. Despite their importance, the current management and performance monitoring of Posyandu remain constrained by fragmented reporting mechanisms, limited integration of data systems, and the absence of real-time, spatially informed decision support for local health authorities [1]. From a theoretical perspective, the integration of Geographic Information Systems (GIS) into public health should not be viewed merely as a visualization tool, but as part of a broader Health Information System (HIS) ecosystem that supports evidence-based decision-making [2], [3], [4]. Within this context, GIS functions as a Spatial Decision Support System (SDSS), enabling the transformation of raw administrative data into spatial intelligence [5].

Furthermore, based on the Digital Health Information System Adoption perspective, the effectiveness of such systems depends on their ability to integrate multidimensional data particularly operational performance indicators with geographic attributes to support actionable insights [2], [4], [6]. Existing studies on GIS in public health demonstrate three dominant thematic applications. First, GIS is widely used for analyzing the spatial distribution and accessibility of health facilities, enabling policymakers to evaluate service coverage and infrastructure gaps [2], [4], [5], [6], [7] [8], [9], [10], [11], [12]. Second, GIS has been extensively applied in epidemiological surveillance, particularly in mapping and monitoring the spread of diseases such as dengue, COVID-19, and stunting [13], [14], [15], [16], [17], [6]. Third, GIS has supported large-scale health information integration, including immunization tracking and national health monitoring systems [2], [4], [18]. While these applications highlight the analytical strength of GIS, they are predominantly descriptive and focus either on "where services or diseases are located" rather than "how well services perform."

Recent studies have further demonstrated the growing importance of GIS-based health information systems in supporting operational monitoring, service evaluation, and evidence-based decision-making. The integration of spatial visualization with health service indicators enables health authorities to identify underserved areas, monitor program performance, optimize resource allocation, and improve public health planning [4], [5] [11]. In addition, GIS technologies have increasingly been utilized to support immunization monitoring, health facility accessibility analysis, and digital health information management at regional and national levels [2], [8], [9], [18]. These developments indicate a shift in the role of GIS from a purely descriptive mapping tool toward a more strategic decision-support platform. However, most existing implementations remain focused on disease surveillance, immunization tracking, and health facility distribution, with limited attention given to evaluating the operational performance of community-based health services such as Posyandu.

This limitation reveals a critical research gap. Previous GIS applications focus on disease spread or facility mapping[2], [9], [13], [15], [16], [17], [19]; none incorporate operational performance indicators for Posyandu**.** As a result, existing systems are insufficient for performance-based evaluation because they fail to integrate dynamic service metrics—such as participation rates, service coverage, and cadre activity—into spatial representations. Consequently, decision-makers can identify the geographic presence of Posyandu but lack the ability to assess their operational effectiveness in a spatial context [20]. The absence of performance-integrated GIS systems has significant implications. Spatial information that only reflects facility distribution is inadequate for supporting strategic interventions, as it does not reveal disparities in service quality or program effectiveness. Without incorporating performance indicators into spatial analysis, local health authorities face difficulties in prioritizing interventions, allocating resources efficiently, and monitoring program outcomes in a targeted manner.

To address this gap, this study proposes the development of a GIS-based Posyandu performance mapping application that integrates operational

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indicators into a spatial framework. By positioning the system as a Spatial Decision Support System (SDSS), this research extends the role of GIS from descriptive mapping toward evaluative and decision-oriented analysis. Given the critical role of this system in supporting public health decision-making, ensuring its functional reliability is essential. Therefore, blackbox testing is employed to validate the system's functionality, particularly in ensuring the accurate synchronization between performance data and geographic visualization [21]. This approach ensures that the system operates consistently with user requirements and can serve as a reliable tool for data-driven health policy decisions.

MATERIALS AND METHODS

Research Framework and Theoretical Linkage

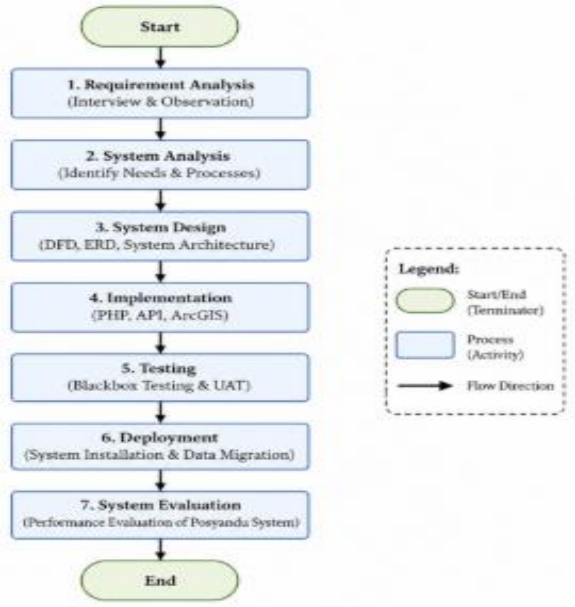
This study adopts a Research and Development (R&D) approach to design and evaluate a GIS-based application for Posyandu performance mapping. The research is theoretically grounded in the Digital Health Information System (DHIS) **and** Spatial Decision Support System (SDSS) frameworks. Previous GIS applications in public health primarily focus on disease spread analysis **or** health facility location mapping, which are largely descriptive and static. In contrast, this study explicitly addresses a critical gap: none of these systems incorporate operational performance indicators of Posyandu into spatial visualization**.** As a result, existing systems allow policymakers to identify *where* services exist, but not *how well they perform*. By integrating DHIS and SDSS, this research transforms routine administrative data into actionable spatial intelligence. The SDSS approach enables the combination of attribute data (performance indicators) with geographic coordinates, producing a system that supports prescriptive decision-making, such as identifying low-performing Posyandu areas and prioritizing interventions.

System Development Life Cycle (SDLC)

The system was developed using the Waterfall model, consisting of five sequential stages: (1) requirements analysis, (2) system design, (3) implementation, (4) testing, and (5) evaluation. The selection of the Waterfall model over Agile or Rapid Application Development (RAD) is based on the characteristics of public health information systems. Unlike commercial applications, public health systems require:

- high data integrity**,**
- strict documentation**,** and
- compliance with government reporting standards**.**

The Waterfall model ensures that all system requirements—especially health indicators and reporting logic—are fully validated before implementation, reducing the risk of data inconsistency and misinterpretation. Additionally, system requirements in this study were relatively stable, as they were derived from standardized Posyandu reporting procedures, making iterative approaches less necessary. System design is represented using UML diagrams, including Data Flow Diagrams (DFD) for process visualization and Entity Relationship Diagrams (ERD) for database structure.



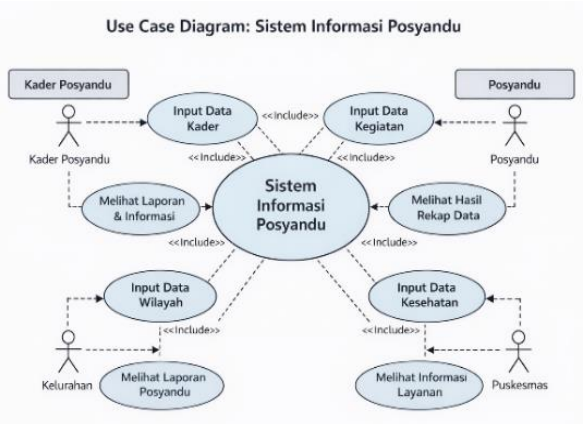
Source: (Research Results, 2025)

Figure 1. System Development Flow Using the Waterfall Model

This research uses the Waterfall Model software development model. This model was chosen because it provides systematic and structured development stages, starting from needs analysis, system design, implementation, testing, to system maintenance. In the context of the development of public health information systems, a structured approach is essential to ensure that the needs of users and operational standards of health services can be clearly accommodated from the initial stage.

Compared to other development methods such as Agile Software Development or Rapid Application Development, the Waterfall model is more suitable for this study because the system needs have been defined relatively stably through needs studies at Posyandu and health centers. In

addition, the developed system is part of a health information system that requires clear documentation and validation at each stage of development to ensure the reliability of the system and ease of evaluation by stakeholders. The Posyandu Geographic Information System Plan is illustrated using UML (Unified Modeling Language) to illustrate the performance data flow (Figure 2), while the database structure is represented through the Entity Relationship Diagram (ERD) in Figure 3. To strengthen the needs of the system, a thematic analysis was carried out on the results of observations and interviews with users (Health Office).



Source: (Research Results, 2025)

Figure 2. Use Case SIG Posyandu

Source: (Research Results, 2025)

Figure 3. ERD SIG Posyandu Data source

Data Collection and Thematic Analysis

Data Collection

This study uses both primary and secondary data:

1. Primary data**:** obtained through field observations and structured interviews with 10 Posyandu cadres and health center officers.
2. Secondary data**:** obtained from health office reports, Posyandu records, and spatial data (administrative maps and geographic coordinates).

Thematic Analysis Procedure

To strengthen qualitative validity, thematic analysis was conducted systematically through:

1. Data familiarization
2. Initial coding
3. Theme categorization
4. Interpretation

The results are summarized as follows:

Table 1. Thematic Analysis Procedure

Sample Quote	Code	Category	Theme
"Data often lost"	Data loss	Recording issue	Administrative inefficiency
"Too much manual data"	Manual workload	Process limitation	Administrative inefficiency
"Difficult to make reports"	Reporting difficulty	Skill limitation	Human resource constraints
"Never used digital apps"	Low digital literacy	Technology gap	Technology readiness
"Willing to be trained"	Training interest	Positive attitude	Adoption readiness

Source: (Research Results, 2025)

This analysis shows three main themes:

1. Administrative inefficiency (manual recording, data loss)
2. Human resource limitations (lack of training, reporting difficulties).
3. Technology readiness (low usage but high willingness to adopt).

Data Source

The research data sources consist of:

1. **Primary Data**
   obtained through direct observation at several Posyandu in the research area, interviews with Posyandu.
2. **Secondary Data**
   Data were obtained from Health Service reports, village profiles, and documents recording child growth and development and Posyandu activities. In addition, spatial data in the form of village/sub-district administrative maps and Posyandu location coordinates were collected for GIS mapping purposes.

Data collection technique

Data collection is carried out using several techniques, namely:

1. Field observation to obtain a picture of the real conditions of Posyandu and location

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coordinate data.
2. Structured interview with Posyandu cadres and health workers to obtain information regarding the service process and challenges faced.
3. Documentation regarding Posyandu performance records, number of toddler visits, maternal and child health activities, and additional programs implemented.

The data obtained were analyzed using two approaches:
1. Descriptive Analysis, to describe the performance of Posyandu based on indicators of number of visits, immunization coverage, and child nutritional status.
2. GIS-based Spatial Analysis, using QGIS/ArcGIS software.
3. Posyandu performance data is processed and mapped according to location coordinates, resulting in a thematic map that visualizes performance variations between regions.

The results of the analysis are then used to assess differences in Posyandu performance, identify areas with potential health problems, and form the basis for recommendations for service improvements.

RESULTS AND DISCUSSION

Based on the results of interviews and observations, it was found that the underlying system development (Table 1) was found. Data shows that 70% of Posyandu cadres have never received data processing training. 100% posyandu activities (Table 2) still rely on manual recording. On average, cadres have difficulties with the current system (Table 3). The posyandu cadres are 100% very interested in participating in digital training (Table 4). This interest is enough to operate a web-based system without intensive mentoring.

Table 2. General Data of Respondent

Respondent	Q1: How Long Have you been a Cadre	Q2: Ever received data management training
R1	5 Years	No
R2	3 Years	Once
R3	8 Years	No
R4	10 Years	No
R5	4 Years	Basic
R6	6 Years	No
R7	2 Years	No
R8	7 Years	No
R9	5 Years	Short Training
R10	9 Years	No

Source: (Research Results, 2025)

Table 3. Posyandu Implementation and Problem

Respondent	Q1: Routine Activities at Posyandu	Q2: How to Record Data	Q3: Problems in Recording & Reporting ?
R1	Weighing, Immunization, PMT	Manual Record Book	Data often lost
R2	Weighing, Immunization, Counseling	Record Book and Paper	Slow in compiling
R3	Weighing, PMT, Counseling	Large Record Book	Too much manual data
R4	Weighing, Elderly Services, Counseling	Manual Record Book	Forgot old data
R5	Weighing, PMT, Immunization	Manual Form Sheets	Difficult to make reports
R6	PMT, Weighing	Integrated Health Post Record Book	Not neat
R7	Weighing, Counseling	Manual Record Book	Difficult to compile
R8	Immunization, Weighing	Excel Files	Must be rewritten
R9	Weighing, PMT	Simple Record Book	Irregular
R10	Weighing, Counseling	Handwritten Notes	No data backup

Source: (Research Results, 2025)

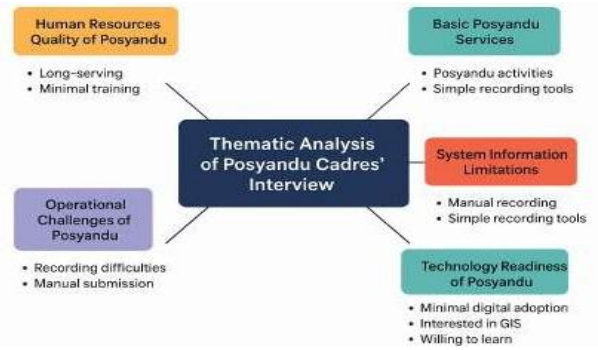
Table 4. Thematic Data from Interviews with Posyandu Cadres

No	Data Snippets (Quotes or Answer)	Initial Code	Initial Theme	Main Theme
1	The majority of cadres have served for 2–10 years	Length of service	Cadre Experience	Quality of Human Resources at Integrated Health Posts
2	Most of the cadres have never received data management training.	Minimal training	Limitations of Knowledge	Quality of Human Resources at Integrated Health Posts
3	Routine activities: weighing, immunization, PMT, consultation	Integrated Health Post Activities	Health services	Basic Services of Integrated Health Post
4	Recording is still manual using books	Manual recording	Manual System	Limitations of Information Systems
5	Reporting media: books,	Simple recording tool	Traditional Means	Limitations of Informatio

No	Data Snippets (Quotes or Answer)	Initial Code	Initial Theme	Main Theme
	forms, manual reports			n Systems
6	Constraints: missing data, difficult to summarize, disorganized	Recording difficulties	Data Issues	Operational Challenges of Posyandu
7	Data submission is still manual to the Community Health Center	Manual delivery	Conventional Process	Operational Challenges of Posyandu
8	Almost everyone doesn't use digital applications yet	Minimal digital adoption	Technology Limitations	Integrated Health Post Technology Readiness
9	Positive response to map-based systems (GIS), as long as it is easy	Interested in GIS	Innovation Support	Integrated Health Post Technology Readiness
10	Everyone is willing to be trained if there is a digital system	Ready to learn	Development Enthusiasm	Integrated Health Post Technology Readiness

Source: (Research Results,2025)

Visualization of the thematic analysis of Posyandu cadres is shown in Figure 4.



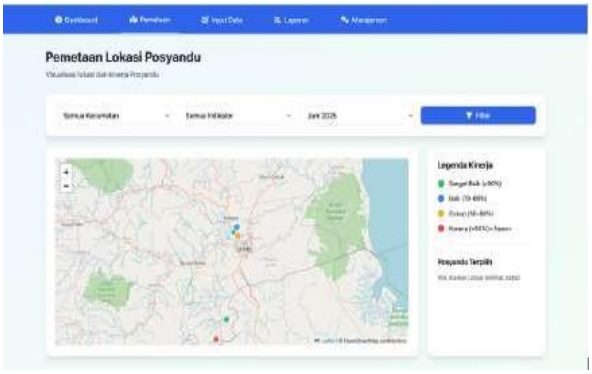
Source: (Research Results, 2025)
Figure 4. Visualization of Thematic Analysis of Posyandu Cadres

GIS Implementation

This GIS implementation produces an interactive Posyandu data processing application for Posyandu managers and cadres. This application consists of a dashboard in Figure 5, Figure 6: Posyandu Mapping, Figure 7: Data Input, Figure 8: Reports, and Figure 9: Management.

Source: (Research Results, 2025)
Figure 5. GIS-Based Posyandu Performance Dashboard

On the dashboard, community health center staff can monitor integrated health post (Posyandu) data and the status of Posyandu performance (Good, Needs Attention, and Poor). From this data, the community health center can quickly take action on the Posyandu. The graph also shows the trend of community engagement with Posyandu, as well as the Posyandu performance graph (Very Good, Good, Sufficient, and Poor). Mapping of Posyandu in Muaro Jambi Regency can be seen in the submenu of Figure 4. The existence of Posyandu can be seen on the map for all sub-districts. The percentage of Posyandu performance can be seen (Very Good, Good, Sufficient, and Poor).



Source: (Research Results, 2025)
Figure 6. Posyandu Mapping

Management of integrated health post (Posyandu) activities, such as weighing, height measurement, immunization, etc., is depicted in Figure 5. Data Input. Begin by inputting the name of the Posyandu, the month of activity, the number of toddlers who came, the number of immunizations, the number of weighings and height measurements, vitamin administration, and recording indications of stunting, etc.

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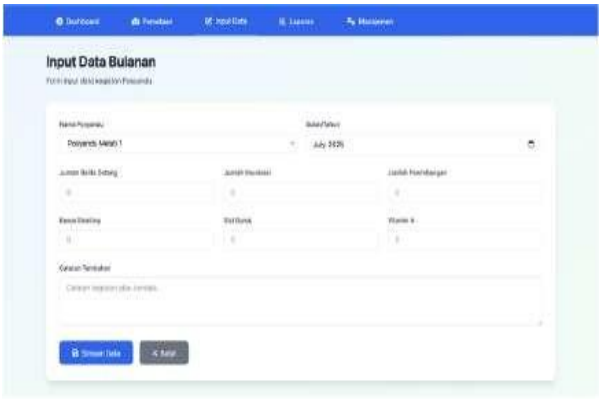
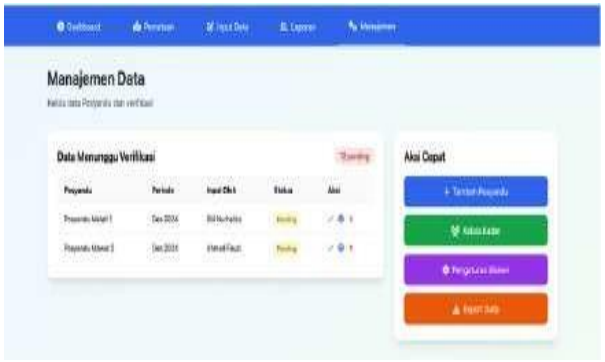


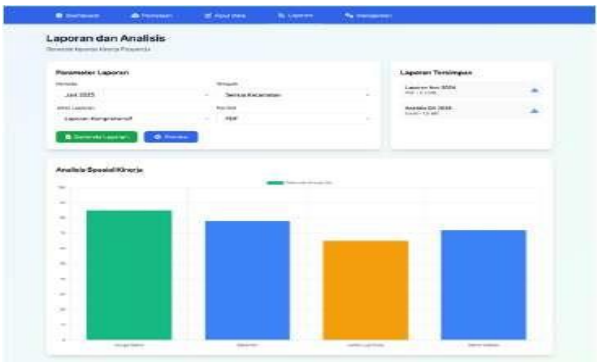
Source: (Research Results, 2025)
Figure 7. Data Input

Data input can be performed for all integrated health posts (Posyandu), by entering the name of the Posyandu and then entering the required data. All input data will then be saved in the database. Integrated health post (Posyandu) management includes adding new Posyandus, managing cadres, system settings, and data export. This is shown in Figure 6. Management.



Source: (Research Results, 2025)
Figure 8. Posyandu Management

This application provides reports and analysis that can be used by all elements visible at the integrated health post (posyandu) in making policies.



Source: (Research Results, 2025)
Figure 9. Report & Analysis

As described in the research method, system testing will be carried out using black box testing and user acceptance testing (UAT), as shown in Table 5 and Table 6.

Table 5. Black Box Testing

Module	Test Case (Input)	Expected Output	Result
Login & Authentication	Username + Password is correct	Successfully logged in to the dashboard	Pass
Login & Authentication	Incorrect username/pass word	Incorrect Username/Password' error message	Pass
Login & Authentication	Empty	'Field is required' error message	Pass
Integrated Health Post Performance Dashboard	Click the dashboard menu	Displaying Posyandu performance graphs	Pass
Integrated Health Post Performance Dashboard	No data	Displays the message 'No data yet'	Pass
Integrated Health Post Performance Dashboard	Input data for cadres/pregnant women/toddler	Dashboard updates charts according to data	Pass
Integrated Health Post Mapping (GIS)	Click the map menu	Map of the area with Posyandu points displayed	Pass
Integrated Health Post Mapping (GIS)	Click on one of the dots	Detailed Posyandu information appears	Pass
Integrated Health Post Mapping (GIS)	No coordinates	'Location not yet available' error message	Pass
Data Input & Management	Fill out the cadre form	Cadre data is stored in the database	Pass
Data Input & Management	Fill out the nutrition form	Nutritional data is stored and can be displayed	Pass
Data Input & Management	Required fields are empty	Field validation error message	Pass
Data Input & Management	Change existing data	Data updated successfully	Pass
Reports & Analysis	Click the report button without filter	Displaying all reports	Pass
Reports & Analysis	Complete data input	Performance analysis appears (graphs, tables)	Pass

Source : (Research Results, 2025)
Note: Pass = The function works according to the expected system requirements

A User Acceptance Test (UAT) was conducted on this integrated health service post (Posyandu) application. The purpose of the UAT was

to ensure the application met user needs and to assess the application's ease of use, functionality, and benefits.

Table 6. User Acceptance Test

No	UAT Scenario	Test Steps	Expected Result	Status
1	Login & Authentication	User logs in with valid account	The system successfully verifies credentials and displays the main dashboard.	Pass
2	Performance Dashboard	User opens dashboard menu	The dashboard loads and displays performanc e charts without delay.	Pass
3	GIS Mapping	User opens map menu and selects a Posyandu point	The map displays correctly and shows detailed information of the selected point.	Pass
4	Data Input	User fills cadre/toddler nutrition form	Data is validated and stored in the database without errors.	Pass
5	Edit & Update Data	User updates existing data	The previous record is updated and changes are reflected immediately.	Pass
6	Delete Data	User deletes a record	The selected record is removed from the system and no longer appears in queries.	Pass
7	Generate Report	User selects month/year and exports report	The report is generated accurately in PDF/Excel format and ready for download.	Pass
8	Analysis & Graph	User opens analysis menu	The system displays analytical tables and charts clearly and correctly.	Pass
9	Usability	Cadre operates the system with minimalguidance	Users can easily navigate menus and complete tasks without external assistance.	Pass
10	Stakeholder Satisfaction	Health office uses system to monitor Posyandu	Data supports decision-making and stakeholders confirm improved transparency.	Pass

Source : (Research Results, 2025)

The UAT results showed that all tested scenarios ran as expected. The application was accepted by users because it facilitated recording and reporting by Posyandu cadres, provided data transparency to stakeholders, and provided rapid analysis to support public health policies.

CONCLUSION

This study successfully validated the functionality of a GIS-based Posyandu performance mapping application using the Blackbox Testing method with the Equivalence Partitioning technique. The results confirm that all functional units ranging from spatial coordinate processing to automatic classification of Posyandu performance operated in accordance with user requirement specifications. Methodologically, this study contributes a structured and replicable functional testing framework for grassroots-level health GIS applications, ensuring the consistency between spatial data and health performance attributes. Theoretically, the integration of geographic information systems with Posyandu performance indicators extends the public health informatics literature by reinforcing the role of spatial data visualization as a strategic decision-support tool for health program planning and monitoring.

The developed application is designed primarily as a strategic monitoring tool for Public Health Centers and district or city-level health offices. Rather than supporting daily field operations conducted by cadres, the system facilitates the monitoring of local health program coverage (PWS) and assists decision-makers in identifying low-performing Posyandu areas that require prioritized intervention. Despite these contributions, this study has several limitations. First, the system currently relies on manual data input, which increases the risk of human error and data inconsistency. Second, system performance under high concurrent usage was not evaluated, as load and stress testing were beyond the scope of this study. Third, the application is limited to a web-based platform and requires a stable internet connection, which may constrain its usability in areas with limited connectivity. Future research and development should address these limitations by integrating predictive analytics to forecast Posyandu performance trends, enabling proactive

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health interventions. In addition, the development of a mobile application would support real-time data entry by cadres in the field, while the integration of Internet of Things (IoT)-based sensors—such as digital weighing scales—could automate data capture and enhance the accuracy of real-time health monitoring. Further studies may also incorporate longitudinal and large-scale system evaluations to assess usability, scalability, and long-term adoption.

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