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Optimization of Posyandu Data Collection using Web Information System and Plan Do Check Act Model

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***Abstract*— This study aims to optimize Posyandu data management through a Web-Based Information System (WBIS) integrated with the Plan-Do-Check-Act (PDCA) cycle to improve the efficiency and sustainability of Maternal and Child Health (MCH) services. The research employed a Research and Development (R&D) methodology using the 4D model (Define, Design, Develop, Disseminate) combined with a socio-technical approach. The system was implemented and evaluated based on user requirements. Data were collected from 25 Posyandu volunteers and 3 community health center (Puskesmas) officers through observations, interviews, and structured questionnaires. The system was developed using a clientserver architecture with a relational database and was subsequently evaluated through functional testing and user acceptance testing. Empirical results indicate that the system significantly improved data management performance by reducing the average time required for data entry and report preparation by 76.4%, from 145 minutes using manual recording methods to 34.2 minutes using the digital system. Functional testing using the Black-Box Testing method achieved a 100% success rate across all major system modules. Evaluation using the System Usability Scale (SUS) yielded an average score of 81.5, placing the system in the "Excellent" usability category with a Grade A rating. The integration of the PDCA cycle supports continuous improvement processes in planning, data recording, evaluation, and the implementation of health interventions. This study produces a scalable and data-driven framework that has proven effective in reducing administrative workload, eliminating data redundancy, and providing strong quantitative validation for the digital transformation of community-based healthcare governance.**

***Index Terms*— Information System; Plan Do Check Act Model; Posyandu; System Usability Scale; Maternal and Child Health**

I. INTRODUCTION

Integrated Health Service Posts (Posyandu) serve as the frontline of community-based healthcare services in Indonesia, particularly in supporting the health of mothers, infants, toddlers, and older adults. Posyandu also plays a strategic role in stunting prevention efforts, which remain one of the major public health challenges at the national level [1].

In line with the ongoing digital transformation [2] in the healthcare sector [3], the implementation of web-based information systems offers a strategic solution for improving the efficiency and accuracy of health data recording and management [4]. Globally, various electronic health (e-health) programs [5] have been developed to provide real-time data that support faster and more informed decision-making processes. From a socio-technical perspective, the development of a Posyandu Information System [6] should balance both technical and social considerations. From the technical standpoint [7], the system should provide functionalities such as participant registration, maternal and child health record management, nutritional status monitoring, and automated reporting [8]. From the social perspective [9], successful implementation depends heavily on the digital literacy of Posyandu volunteers [10], support from healthcare professionals, and active community participation [11]. To ensure system quality and sustainability, the Plan-Do-Check-Act (PDCA) cycle provides a relevant framework for implementation [12]. PDCA facilitates continuous evaluation and improvement processes, ranging from needs assessment and implementation to data accuracy monitoring and corrective actions [13], including feature enhancement and retraining of Posyandu volunteers. Previous studies on community health [14] information systems have generally treated software engineering and quality assurance as separate domains. Most implementations have focused primarily on technical system development [15] without establishing structured operational feedback mechanisms. Consequently, the long-term sustainability of system usage often declines when volunteers encounter data-related issues or operational challenges [16]. Conversely, PDCA frameworks in healthcare settings are frequently applied to manual administrative processes without digital support tools [17].

This study seeks to bridge this gap by directly integrating the PDCA cycle into both the software architecture and operational workflow of a Web-Based

Information System (WBIS). Through this integration, the Posyandu Information System functions [18] not only as a data management tool but also as a socio-technical system that supports continuous service quality improvement. Furthermore, the system contributes to achieving national targets for stunting reduction through data-driven healthcare governance and sustainable community health service management [19].

Based on the problems identified, this study is formulated around the following research questions:

1. To what extent does the manual data management architecture currently implemented at Posyandu Nagari Pagaruyung contribute to operational inefficiencies and inaccuracies in data analysis?
2. What software engineering requirements and specifications are necessary to develop a responsive, multi-user, web-based Posyandu Information System that is suitable for users with limited digital literacy?
3. How can the PDCA quality management framework be systematically integrated into the data flow and business processes of the information system?
4. To what extent does the developed system improve data entry efficiency, operational accuracy, and user acceptance among Posyandu volunteers?

Based on these research questions, the objectives of this study are: (1) to analyze the existing manual practices of Posyandu data management; (2) to design a web-based Posyandu Information System; (3) to integrate the PDCA methodology into the developed system; and (4) to develop and quantitatively evaluate the system in order to improve efficiency, accuracy, and the quality of maternal and child healthcare services.

From a theoretical perspective, this study is grounded in the concept of Posyandu as a primary healthcare service that emphasizes community participation [20], information systems theory [21] which highlights the integration of people, hardware, software, data, and networks to generate accurate and meaningful information [22], the advantages of web-based systems in providing accessibility, flexibility, and real-time data presentation [23], and the application of the PDCA cycle as a continuous quality improvement approach. Previous studies have demonstrated that the digitalization of Posyandu services can improve data accuracy [24], support maternal and child health monitoring [25], and strengthen system sustainability through socio-technical approaches [26]. Nevertheless, the integration of the PDCA cycle into Posyandu Information Systems [27] remains relatively underexplored. Therefore, this study offers a novel contribution through the development of a web-based Posyandu Information System [28] that comprehensively integrates the PDCA cycle [29] to support more effective, efficient, and sustainable community health data management [30].

I. METHODOLOGY

This study employed a systematic Research and Development (R&D) framework by implementing the 4D Development Model (Define, Design, Develop, and Disseminate), integrated with a socio-technical quality management approach. This methodology was selected to develop an information system that not only fulfills users' technical requirements but also considers social, organizational, and sustainability aspects within the Posyandu environment. The research was conducted at Posyandu Nagari Pagaruyung, Tanjung Emas District, Tanah Datar Regency, West Sumatra Province, Indonesia. The study site was selected because health data recording and management processes were still predominantly performed manually, creating a need for transformation toward a more effective and efficient digital system.

The research participants consisted of 28 key stakeholders, including 25 active Posyandu volunteers distributed across several Posyandu units in Nagari Pagaruyung and 3 healthcare administration officers from the Community Health Center (Puskesmas) responsible for managing and reporting public health data. Respondents were selected using purposive sampling based on specific criteria, namely Posyandu volunteers with at least one year of field experience and active responsibility for manual health data recording processes. Meanwhile, the Puskesmas officers were selected because of their direct involvement in the verification, monitoring, and reporting of health data generated by Posyandu activities.

Through the active involvement of these stakeholders, this study aims to develop a web-based Posyandu Information System that aligns with user needs, is easy to use, and supports continuous improvement in maternal and child healthcare services through the implementation of the PDCA cycle. The integration of technical system development with socio-technical quality management principles is expected to enhance system adoption, operational effectiveness, and the long-term sustainability of digital healthcare services at the community level.

The system engineering and evaluation activities in this study were aligned with the four iterative phases of the PDCA cycle as follows:

1. Plan (Define and Design)

During the planning phase, field observations and time motion studies were conducted to map the workflow of Posyandu data recording processes, which were still performed manually. In addition, a user requirements analysis was carried out to identify existing problems and system needs. The findings from this analysis were subsequently used to formulate system requirements specifications, design the system model using Unified Modeling Language (UML), and develop a normalized relational database schema that served as the foundation for system development.

2. Do (Develop)

During the implementation phase, a web-based Posyandu Information System was developed using a client–server architecture with PHP, JavaScript, and MySQL technologies. The system was designed to support integrated health data recording and management processes. Furthermore, an automated data validation mechanism was implemented to prevent data duplication, input errors, and the loss of critical data attributes during data entry activities.

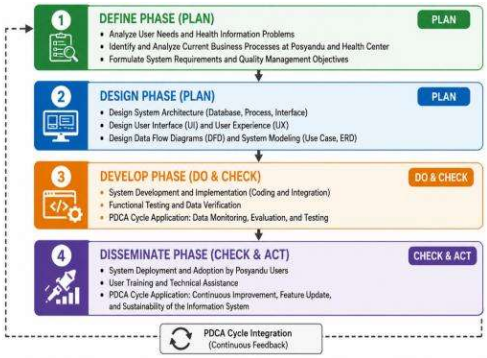

Fig. 1. PDCA Cycle

3. Check (Evaluate)

The evaluation phase involved comprehensive technical testing and user assessment. Technical validation was conducted using the Black-Box Testing method to ensure that all system functions operated according to specifications, including verification of input parameters, output results, and system boundary conditions. Subsequently, user acceptance and system usability were evaluated using the standardized and psychometrically validated System Usability Scale (SUS) instrument. The SUS questionnaire was administered to all 28 respondents, consisting of Posyandu volunteers and Puskesmas healthcare officers.

4. Act (Optimize)

The action phase focused on system optimization and refinement based on evaluation outcomes. Various findings identified during testing, including system bugs, user interface friction points, and requirements for additional features such as nutritional status threshold notifications for children under five were utilized as the basis for system improvement through code refactoring and functional enhancement. This phase ensured that the system could continuously evolve and adapt to users' needs in a sustainable manner. To ensure data validity during the initial stage of the study, source and methodological triangulation techniques were employed. Validation was performed by comparing information obtained from in-depth interviews with Posyandu volunteers and healthcare officers against data recorded in manual Posyandu registration books. This approach was intended to ensure the consistency, accuracy, and credibility of the data used throughout the analysis and system development processes.

II. RESULT AND FINDINGS

A. Evaluation of the Initial Conditions Prior to System Implementation

Posyandu in Nagari Pagaruyung serves as a community-based healthcare facility that provides services for pregnant women, breastfeeding mothers, children under five years of age, and older adults (elderly populations). Observations of the existing manual workflow (baseline workflow) using a time–motion study revealed several significant operational challenges. Posyandu volunteers were still recording body weight, height, immunization status, and other health-related information manually across multiple registration books and separate reporting forms.

The process of preparing monthly reports for submission to the Community Health Center (Puskesmas) was particularly time-consuming because volunteers were required to collect, verify, and consolidate data from various manual records. Measurement results indicated that preparing a single monthly report required an average of 145 minutes for each Posyandu unit. Most of this time was spent reviewing data entries, correcting recording errors, eliminating duplicate information, and calculating nutritional status indicators using paper-based reference tables.

These conditions resulted in low operational efficiency, a high risk of data inaccuracies, and delays in the submission of health reports to the Puskesmas. Furthermore, the reliance on manual record-keeping limited the ability of healthcare workers to access timely and accurate information for monitoring maternal and child health conditions and supporting evidence-based decision-making.

B. System Engineering Architecture and Interface Specifications

The developed Web-Based Posyandu Information System (WBIS) was designed with a responsive user interface, enabling access through both desktop computers and smartphones using standard web browsers. To meet international publication standards and user requirements, the software architecture and interface configurations were developed according to established software engineering principles and usability standards. The system consists of several core modules that support Posyandu service operations, including: Participant Registration Module, Maternal and Child Health Examination Module, Reporting and Data Analytics Module, and Child Growth and Development Monitoring Module.

These modules were designed to support integrated health data management processes, ranging from data collection and storage to automated reporting and analytical information generation. Through this integrated architecture, health data can be processed more efficiently, consistently, and accurately, thereby reducing administrative workload and improving the availability of real-time information for healthcare decision-making.

The responsive interface design also ensures accessibility for users with varying levels of digital literacy. User interaction workflows were simplified through intuitive navigation structures, standardized data entry forms, and automated validation features. As a result, Posyandu volunteers can perform data recording and reporting tasks more effectively while minimizing the likelihood of input errors and data inconsistencies.

The overall system architecture follows a client server model, where users interact with the application through web browsers, while data processing and storage are managed centrally within a relational database management system. This architecture facilitates data integration, improves data security, and supports scalability for future implementation across multiple Posyandu units and healthcare facilities.

TABLE I. WEB-BASED INFORMATION SYSTEM DESIGN AND PDCA CYCLE MAPPING

Component	Technical Specifications and Architecture	Relationship with PDCA and Analytical Significance
System Design	Blueprint constructed based on database normalization and responsive web architecture.	Plan: Establishing the operational framework of the system based on identified user requirements.
System Architecture	Client: Responsive HTML5/JavaScript for PC and mobile. Server: PHP as core logic. Database: Relational MySQL.	Do: Executing real-time data transactions, managing user sessions, and maintaining data storage integrity.
Process Design	Plan: Service target setting. Do: Field data entry. Check: Automated reporting/evaluation. Act: Continuous health intervention monitoring.	Continuous Cycle: Ensuring that entered data is processed immediately into evaluative information and health action recommendations.
User Interface	Specialized panels for Registration, Health Examination, Analytics, and Growth Monitoring.	Do & Check: Reducing manual recording burden for health workers and facilitating real-time data monitoring.
Database Design	Primary tables including tbl_mother, tbl_child, tbl_examination, and tbl_monthly_report.	Do: Ensuring relational data integrity via foreign keys, preventing data duplication, and maintaining information consistency.
Conceptual Blueprint	Use Case Diagrams, Entity Relationship Diagrams (ERD), and System Process Flow Diagrams.	Plan: Providing technical clarity regarding user access rights and system execution flows.

Table I explains the structural architecture of the developed system. Unlike conceptual approaches that view PDCA merely as a quality management framework, this research integrates the PDCA cycle directly into the database structure and system workflow. For example, when health workers input examination data into the tbl_examination table during the **Do** stage, the system automatically triggers an analytical engine to recalculate growth indicators and nutritional status, update child development charts, and generate evaluation reports for the **Check** stage. Subsequently, these analytical findings are used to update the health monitoring dashboard, which serves as the foundation for nutrition interventions and health follow-ups during the **Act** stage.

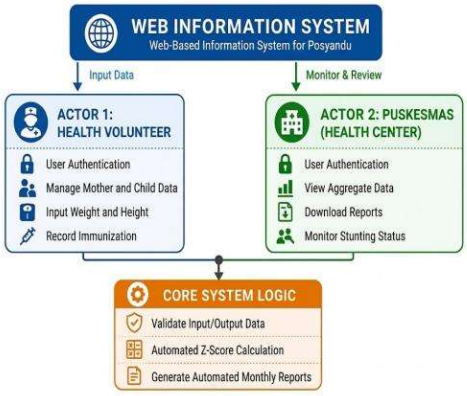

Fig. 2. Web Information System

Figure 2 presents the Use Case structure mapping of the developed web-based Posyandu Information System. The system design strictly implements a separation of duties and access rights to maintain data security, integrity, and consistency. Posyandu volunteers are granted access rights to record and manage health examination data at the Posyandu level, including entering mother and child data, measuring weight and height, and recording immunizations. Meanwhile, Puskesmas (Public Health Center) officers hold access rights at the managerial level to view, monitor, and analyze data accumulated from various Posyandus in an integrated manner. Through this mechanism, reporting processes that were previously manual and time-consuming are eliminated, allowing health information to be available more quickly, accurately, and in real-time to support decision-making and public health condition monitoring, including the early detection of stunting risks.

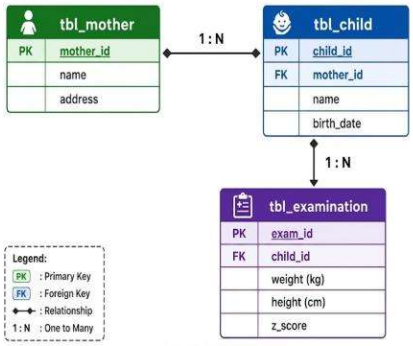

Fig. 3. Relational Database

Figure 3 illustrates the normalized relational database schema. By implementing unique primary keys in the tbl_mother and tbl_child tables and establishing a one-to-many relationship between them, the database architecture effectively reduces and eliminates data redundancy. This structure also prevents duplicate child registrations a common issue in manual, register-based recording systems thereby enhancing the consistency, integrity, and accuracy of the health data stored within the system.

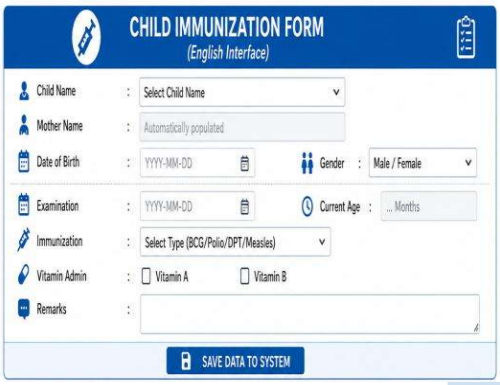

Fig. 4. Child Immunization Form

Fig. 5. Maternal Weighting Form

Figures 4 and 5 present the system's input interface, which has been customized for operational use in the field. To support implementation in environments with varying levels of digital literacy, the system's forms are equipped with inline input validation mechanisms using HTML5 technology. In the Child Immunization Form (Figure 4), the system automatically rejects data storage if any mandatory vaccine fields remain empty. This mechanism helps ensure the completeness of immunization data and reduces recording errors. Meanwhile, the Pregnant Mother Examination Form (Figure 5) is equipped with real-time boundary verification logic that operates automatically as the user inputs data. For example, if a user inputs a gestational age outside the permitted range of 1–42 weeks, the system immediately displays a visual warning, allowing errors to be detected and corrected during the data entry process. These validation features play a crucial role in improving data quality, minimizing input errors, and supporting more accurate and timely health decision-making.

C. Quantitative System Evaluation and Experimental Validation

To meet the requirements for measurable empirical verification, the developed system was evaluated using three key indicators: Functional Feature Testing, Operational Velocity Evaluation, and Psychometric Usability Testing. These three approaches were employed to assess the reliability of system functions, improvements in operational efficiency, and the level of user acceptance of the developed information system.

TABLE II. QUANTITATIVE BLACK-BOX FUNCTIONAL TESTING MATRIX

Tested Module	Input Scenario Provided	Expected System Output	Actual System Result	Success Rate
Authentication	Valid username and correct encrypted password	System grants access and directs user to role-specific dashboard	As-expected	100%
Authentication	Invalid username or incorrect password	System denies access and displays an authentication error message	As-expected	100%
Registration	New child data linked to an existing mother_id	System creates new data in tbl_child with correct foreign key relationship	As-expected	100%
Data Validation	Input of same child name with identical date of birth	System rejects data storage and displays a duplication warning	As-expected	100%
Calculation Engine	Child age = 12 months, weight = 10 kg, height = 75 cm	System automatically calculates Z-Score and determines nutritional status	As-expected (Normal Status)	100%
Report Panel	Request for "Integrated Monthly Summary" report	System compiles data from tbl_examination and exports report in PDF or Excel	As-expected	100%

The results in Table II indicate that the system achieved a functional success rate of 100% across all six core modules tested using Black-Box Testing methods. The testing was conducted using various input scenarios and boundary conditions (boundary testing) to ensure that every system function operates according to the established specifications.

The success of these tests indicates that the mechanisms for authentication, data registration, input validation, nutritional status calculation, and automated report generation perform consistently without any functional failures. Consequently, it can be concluded that the developed software logic possesses a high degree of reliability and is suitable for use in

real-world operational conditions within the Posyandu environment. Furthermore, the 100% success rate across all modules demonstrates that the integration between the user interface, application logic, and the database is optimal, enabling the accurate, efficient, and sustainable management of health data.

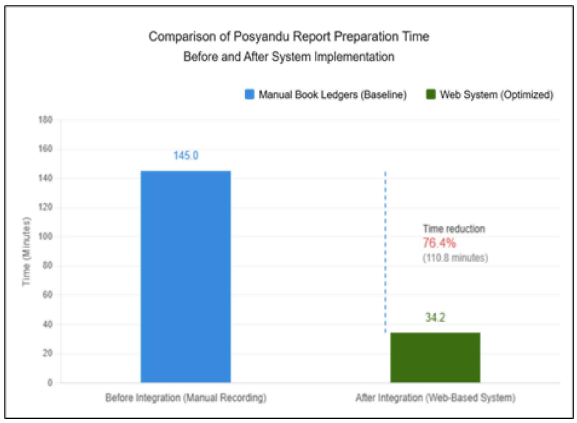

Fig. 6. Report Preparation Time Comparison Manual vs Web-Based System

A time-motion tracking evaluation was conducted to measure the operational efficiency of the developed system. The measurement involved comparing the use of the web-based information system with the manual recording method using Posyandu administration books. The observed activities included participant registration, data recording for 50 toddler visits, nutritional status calculation, and the preparation of monthly reports.

The evaluation results show that the manual process requires an average of 145.0 minutes to complete one reporting cycle. Conversely, using the web-based Posyandu Information System, the same workload can be completed in just 34.2 minutes. These findings indicate a 76.4% reduction in administrative time, representing a highly significant increase in operational efficiency. This time reduction allows Posyandu volunteers to decrease repetitive administrative burdens and allocate more time to direct community health services, such as monitoring child growth and development, health education, and providing assistance to mothers and toddlers. Beyond increasing the productivity of volunteers, the digitalization of the recording process contributes to improved data accuracy, faster reporting, and overall enhancement of health service quality.

User acceptance was measured using the standardized System Usability Scale (SUS) instrument, administered to all 28 active participants comprising 25 Posyandu cadres and 3 Puskesmas health officers. The evaluation results show that the system achieved a mean SUS score of 81.5. Based on SUS psychometric interpretation standards, this score places the web-based Posyandu Information System in the "Excellent" category with a Grade A rating. This indicates that the system has a high level of usability and is very well accepted by its users. The high score also suggests that the system's interface, features, and workflows are easy to understand and operate including for Posyandu cadres with limited technical experience and digital literacy.

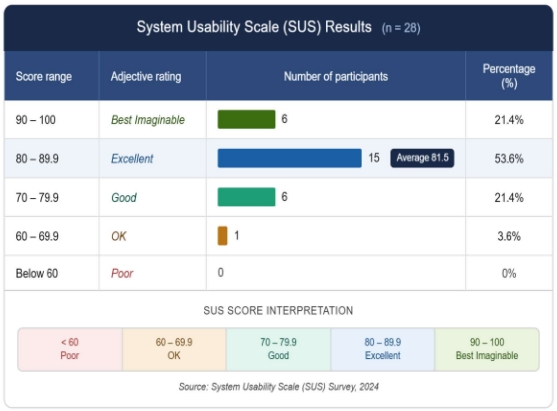

Fig. 7. System Usability Scale

These findings reinforce that the developed system not only meets functional requirements but also delivers a positive user experience, thereby supporting the sustainability of its implementation in the digital management of Posyandu data. The high level of user acceptance is an important indicator that the system can be effectively adopted to improve the quality of maternal and child health data recording, reporting, and management within the Posyandu setting.

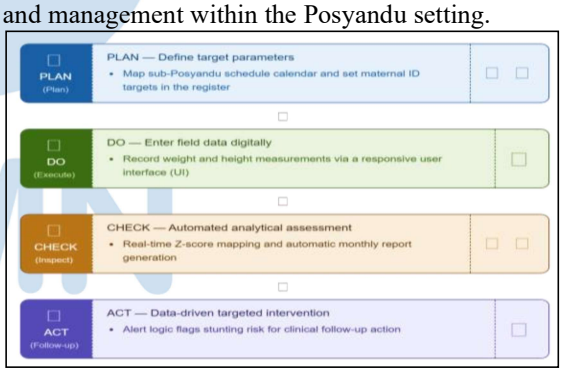

Fig. 8. Synthesis of PDCA

Figure 8 demonstrates the implementation and integration of the PDCA cycle into the web-based Posyandu Information System. Unlike conventional approaches that view PDCA merely as a theoretical quality management concept, this research implements PDCA as an operational workflow loop integrated directly with business processes and health data management within the system. **Plan** → At this stage, the system is used to manage Posyandu activity schedules, determine service targets, and identify community groups requiring special attention, such as pregnant women, toddlers, and children at risk of nutritional issues. This process helps ensure that baseline data coverage is obtained in a complete and structured manner. **Do** → The system supports real-time health data entry through a responsive web-based

interface. Digital recording replaces the manual method of using register books, allowing child growth and development data to be recorded directly as services occur. This mechanism increases recording speed while reducing the risk of errors and data loss. **Check** → Once data is entered, the system automatically processes and analyzes health data based on growth standards established by the World Health Organization (WHO). Calculations of nutritional status indicators and Z-scores are performed automatically, replacing manual analysis which was previously time-consuming and prone to error with rapid, accurate, and consistent reporting and evaluation. **Act** → At this stage, the system dashboard automatically flags children identified as being at risk of undernutrition, malnutrition, or stunting. This information generates a list of intervention targets that Posyandu volunteers and Puskesmas officers can use to provide targeted nutritional support and guidance. The intervention results are then used as input for planning subsequent activities, thus forming a continuous quality improvement cycle that completes the PDCA process. The integration of the PDCA cycle into the Posyandu Information System demonstrates that the developed system functions not only as a medium for health data recording but also as a data-driven decision support system capable of continuously improving the quality of maternal and child health services.

TABLE III. COMPREHENSIVE MATRIX OF SYSTEM RESULT, EMPIRICAL FINDINGS, AND SOSCIO-TECHNICAL IMPLICATIONS

Evaluated Domain	Key System Outputs	Objective Empirical Findings	Socio-Technical Strategic Implications
System Engineering	Responsive web-based information system prototype with a normalized MySQL database.	Feature execution success rate reached 100% based on the Black-Box Testing functional validation matrix.	Demonstrates that implementing a sound database structure and robust validation mechanisms can maintain health data integrity, even in resource-constrained technological environments.
Operational Efficiency	Automated growth chart generation and recapitulasi reports.	A 76.4% reduction in processing time, decreasing from an average of 145.0 minutes to 34.2 minutes.	Reduces the administrative burden on Posyandu volunteers, allowing them to focus more on direct health services and community support rather than repetitive administrative tasks.
User Acceptance	Simple, user-friendly interface with clear navigation and accessible language.	Achieved an average System Usability Scale (SUS) score of 81.5, categorized as "Excellent" with a Grade A rating.	Proves that applying user-centered design principles can overcome digital literacy barriers and increase technology adoption among Posyandu volunteers and health workers.
PDCA Integration	Closed-loop system connecting data entry directly to nutritional status and stunting risk notifications.	Collected health data can be immediately processed into clinical indicators to automatically detect and monitor stunting risks.	Establishes a sustainable, data-driven public health management framework that supports continuous service quality improvement through the PDCA cycle.

Table III summarizes the overall research findings obtained from the development, implementation, and evaluation processes of the web-based Posyandu Information System. The results demonstrate that combining a systematic Research and Development (R&D) methodology with the implementation of the PDCA framework provides benefits that extend far beyond simple digitalization of data recording. The developed system not only improves the efficiency and accuracy of health data management but also establishes an evaluation and continuous improvement mechanism integrated directly into the Posyandu's operational processes. Empirically, this research proves that work environments with relatively low levels of digital literacy can successfully transform toward data-driven health governance when supported by software that is user-tailored, intuitive, and equipped with structured quality control mechanisms. These findings emphasize the importance of integrating technological, human, and organizational process aspects to support the successful digital transformation of community health services.

III. DISCUSSION

A. Evaluation of the Initial Conditions Prior to System Implementation

The analysis of the Posyandu in Nagari Pagaruyung prior to the intervention reveals critical structural inefficiencies typical of paper-based community health settings. The baseline workflow, characterized by disjointed administrative tasks, highlights a significant divergence between data generation at the point of care and its consolidation for public health reporting.

The reliance on manual register books creates a "data silo" effect, where health indicators such as anthropometric measurements, immunization statuses, and maternal history remain fragmented across multiple physical documents. The time-motion study reveals that this manual workflow consumes an average of 145 minutes per reporting cycle per Posyandu. Critically, this duration is not spent on patient interaction or health intervention, but rather on non-value-added administrative overhead, including manual data collation, redundant cross-referencing, and paper-based nutritional status calculations (e.g., Z-score determination via reference tables).

From a socio-technical perspective, these baseline conditions impose significant cognitive and operational burdens on health volunteers (kader). The manual nature of these tasks introduces high susceptibility to human error, such as data entry inaccuracies, omissions, and duplicate records, which fundamentally compromise the longitudinal integrity of public health data. Furthermore, the delay between the collection of health metrics at the community level and the downstream aggregation at the Puskesmas level effectively negates the potential for real-time health monitoring. This "latency in reporting" prevents the timely identification of public health risks, such as stunting or malnutrition, thereby illustrating an urgent need for the transition toward digitalized, data-driven governance to enhance both service quality and the efficacy of health interventions.

B. System Engineering and Interface Architecture

The architectural design of the Web-Based Posyandu Information System (WBPIS) represents a strategic shift from monolithic, paper-based workflows toward a decoupled, client server computing model. By leveraging a responsive, browser-based interface, the system effectively mitigates the "digital divide" often observed in rural health environments, ensuring cross-platform accessibility that accommodates the hardware constraints of field-based Posyandu volunteers.

From a systems engineering perspective, the modular architecture comprising specialized units for registration, maternal/child examinations, analytics, and growth monitoring facilitates an integrated data lifecycle. This design ensures that raw data collected at the point of service is immediately ingested into a normalized relational database, thereby ensuring data persistence and referential integrity. By transitioning from fragmented physical ledgers to a centralized digital schema, the system inherently addresses the risks of information entropy, such as data duplication and orphan records, which are prevalent in manual register-based systems.

Furthermore, the integration of automated validation logic and intuitive UI design principles serves as a critical socio-technical intervention. By embedding technical guardrails (e.g., HTML5 validation and real-time error checking) directly into the user interface, the system reduces the cognitive load on the end-user. This approach effectively lowers the barrier to entry for personnel with lower levels of digital literacy, transforming the software from a mere recording tool into an active partner in data quality assurance.

The adoption of a client server architecture provides significant long-term strategic advantages. Centralized data management not only bolsters security protocols through structured access controls but also ensures system scalability. This architecture provides the necessary infrastructure for future interoperability, enabling the potential aggregation of health data across regional healthcare networks, which is an essential prerequisite for evidence-based public health planning and sophisticated predictive health analytics.

The integration of the PDCA cycle into the architectural fabric of the Web-Based Posyandu Information System (WBPIS) represents a departure from traditional, passive data-recording models. By embedding quality management directly into the system logic, the research transforms the WBPIS into an active, data-driven governance tool. Key points of this integration and its technical implications are discussed below:

Operationalization of the PDCA Cycle: Unlike static management frameworks, this system hardcodes the PDCA cycle into the workflow. The **Plan** phase is facilitated through structured architectural blueprints and requirement mapping. The **Do** phase is realized via real-time data transactions using a robust client server architecture. The **Check** phase is automated through an analytical engine that processes growth indicators, while the **Act** phase is supported by a dynamic monitoring dashboard that informs health interventions.

Socio-Technical Access Control: The system enforces a clear separation of duties, aligning user access rights with operational hierarchies. Posyandu volunteers are restricted to transactional data entry, whereas Puskesmas officers possess managerial oversight for integrated data analysis. This design not only ensures data security and integrity but also streamlines organizational reporting, eliminating the time-lag characteristic of manual, paper-based workflows.

Relational Integrity as a Quality Mechanism: The normalization of the database schema (e.g., tbl_mother to tbl_child one-to-many relationships) is a strategic intervention to eliminate redundancy and duplicate registrations. This structural integrity is fundamental to maintaining accurate longitudinal data, which is essential for effective public health monitoring and stunting risk detection.

Mitigating Cognitive and Operational Errors: The implementation of inline input validation and real-time boundary verification using HTML5 technologies acts as a technical guardrail against human error. By rejecting incomplete data or out-of-range inputs (e.g., gestation outside 1–42 weeks) at the point of entry, the system ensures high data quality without placing undue cognitive burden on field volunteers with varying levels of digital literacy.

The synergy between these technical components suggests that digital transformation in community health is most effective when software engineering principles (normalization, responsive architecture, and validation) are explicitly aligned with organizational quality objectives (the PDCA cycle). This integrated approach provides a scalable foundation for

continuous, evidence-based public health management.

C. System Evaluation and Socio-Technical Impact

The experimental validation of the Web-Based Posyandu Information System (WBPIS) confirms that systematic digital transformationwhen underpinned by robust engineering and organizational frameworks serves as a catalyst for improving public health governance. The evaluation outcomes can be summarized through the following key dimensions.

Software Reliability as a Foundational Prerequisite: The 100% success rate in Black-Box functional testing across all six core modules provides empirical assurance of the system's backend logic. This reliability is critical; in community health settings, even minor software failures can lead to significant data integrity risks or user distrust, thereby undermining the viability of digital adoption.

Operational Velocity and the Mitigation of Administrative Burden: The transition from manual registers to the WBPIS yielded a 76.4% reduction in reporting time (from 145.0 to 34.2 minutes). This represents a paradigm shift in the Posyandu volunteer's role: by automating repetitive tasks like Z-score calculations and report collation, the system reclaims time for high-value activities such as maternal health education, growth monitoring, and personalized nutritional intervention.

User-Centric Design as a Catalyst for Adoption: Achieving a SUS score of 81.5 (Grade A, "Excellent") proves that technological sophistication does not require high user technical proficiency. The system's success validates that user-centered design characterized by intuitive navigation and real-time input validation effectively bridges the digital literacy gap, transforming the software from a complex requirement into a facilitating tool for local health cadres.

Closed-Loop Governance via PDCA Integration: The most significant contribution of this research is the operationalization of the PDCA cycle within the system's workflow. By hardcoding "Check" (automated growth analysis) and "Act" (stunting risk flagging) mechanisms into the "Do" (data entry) process, the system facilitates a continuous quality improvement cycle. This transforms the Posyandu from a simple repository of records into a proactive, data-driven decision support environment where health interventions are timely, evidence-based, and targeted toward high-risk groups.

In summary, the research demonstrates that the successful digitalization of community health is a socio-technical endeavor. The alignment of technical robustness (system engineering), operational efficiency (time-motion optimization), and organizational process integration (PDCA) creates a sustainable framework that can enhance the quality of maternal and child health services on a larger scale.

IV. CONCLUSION

This research has successfully developed, validated, and evaluated a Web-Based Posyandu Information System integrated with the PDCA continuous quality improvement model. By achieving the four predefined research objectives, this study demonstrates a significant improvement compared to the manual, register-based recording system previously used at Posyandu. Empirical test results prove that the developed system possesses a high level of reliability, indicated by a 100% success rate in functional testing using the Black-Box Testing method. Furthermore, the system significantly enhances administrative efficiency by reducing the time required for recording and reporting processes by 76.4%, from an average of 145 minutes with the manual method to just 34.2 minutes with the web-based system. User evaluation using the System Usability Scale (SUS) instrument yielded an average score of 81.5, placing the system in the "Excellent" category with a Grade A rating. These results indicate that the system is user-friendly and well-accepted by both Posyandu volunteers and Puskesmas officers, including users with limited digital literacy.

The primary contribution of this research lies in the practical implementation of the PDCA cycle into software architecture and health data management workflows. Unlike approaches that view PDCA merely as a theoretical quality management concept, the developed system integrates this cycle directly into operational processes ranging from service target planning and health data recording to automated growth and nutritional status analysis, as well as stunting risk identification that can be immediately addressed through targeted health interventions. Although system implementation is currently limited to the Posyandu environment in Nagari Pagaruyung, the obtained results demonstrate immense potential for adoption across other Posyandus and public health service networks at regional and national levels. The measurable improvements in efficiency, data accuracy, and decision-making quality provide a strong foundation for the development and expansion of the system on a larger scale.

Consequently, the socio-technical model proposed in this research can serve as an effective framework to support the digital transformation of public health services, particularly in real-time maternal and child health monitoring, the improvement of health data governance, and data-driven stunting prevention efforts. Beyond providing operational benefits for volunteers and health workers, this system contributes to supporting faster, more accurate, and sustainable decision-making in the management of public health programs.

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