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ARISOF: Analytics-Based Rural Inventory and Supplies Ordering with AI Trend Analysis for Enhancing Health Services

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Abstract
The efficient management of medical inventory and supplies remains a critical challenge in rural health facilities due to manual processes, limited resources, and the absence of data-driven decision support. This study aimed to design and developed AISOF (Analytics-Based Inventory and Supplies Ordering with Forecasting) to enhance the efficiency, accuracy, and responsiveness of inventory management in rural health services. The system development followed the Input–Process–Output (IPO) model and an Agile methodology, incorporating iterative user feedback from pharmacists, physicians, staff, and administrators. AISOF integrates data analytics to monitor inventory levels, analyze consumption patterns, and generate demand forecasts to support timely and informed procurement decisions. The system was developed using a web-based architecture with modern front-end and back-end technologies to ensure accessibility, reliability, and scalability across devices. The implementation of AISOF addresses limitations of existing manual inventory practices by improving stock visibility, reducing the risk of stockouts and overstocking, and strengthening operational planning in rural healthcare settings. The study demonstrates that analytics-based inventory systems with forecasting capabilities can significantly support evidence-based management and contribute to improved service delivery in rural health facilities.

Keywords: Analytics-Based Inventory, Rural Health Services, Demand Forecasting, Health Supply Chain Management, Decision Support Systems

Introduction

Access to essential medicines is a cornerstone of primary health care and a critical component of universal health coverage promoted by the World Health Organization (WHO, 2010). In rural and resource-constrained settings, primary care facilities frequently experience stockouts, delayed replenishment, and limited visibility of medicine availability, which disrupt continuity of treatment and erode patient trust in health services (WHO, 2015). These challenges are particularly evident in Rural Health Units (RHUs) in the Philippines, where manual, logbook-based inventory systems remain widely used for tracking pharmaceutical supplies. Manual processes are prone to inaccuracies, delayed reporting, and reactive procurement, leading to prolonged patient waiting times and preventable shortages of essential medicines.

Empirical evidence indicates that weak stock visibility and fragmented information flow are major contributors to medicine stockouts in low- and middle-income countries (USAID | DELIVER Project, 2011; WHO, 2011). Digital logistics systems, particularly electronic Logistics Management Information Systems (eLMIS), have been shown to improve stock availability, reporting timeliness, and replenishment efficiency (MEASURE Evaluation, 2016). Reports from global health organizations such as the Global Fund and Gavi highlight that real-time inventory tracking supports faster ordering decisions and reduces the frequency and duration of stockouts (Global Fund, 2018; Gavi, 2019). However, the successful implementation of digital systems in rural health facilities remains constrained by weak information and communication technology (ICT) infrastructure, intermittent internet connectivity, power instability, and limited human-resource capacity (WHO, 2016).

Beyond infrastructure, the effectiveness of digital health systems is strongly influenced by usability, user acceptance, and organizational readiness. Health information systems that are poorly aligned with user workflows or that demand high technical proficiency are at risk of underutilization and eventual abandonment (Davis, 1989 [21]; Venkatesh *et al*., 2003). Prior studies on digital health adoption emphasize the importance of user-centered design, continuous training, and institutional ownership to ensure sustainability of information systems in healthcare settings (WHO, 2019). These considerations are particularly relevant in RHUs, where healthcare workers manage high patient volumes alongside limited administrative support, making ease of use, system reliability, and workflow compatibility critical for routine operations.

Recent advances in data analytics further enhance the potential of digital inventory systems by converting routine transaction data into actionable insights, such as automated reorder alerts, consumption trends, and demand forecasting (Choi, Wallace, & Wang, 2018). Analytics-driven decision support enables a shift from reactive stock management toward proactive, evidence-based planning. However, the value of analytics depends on data quality, system reliability, and users' capacity to interpret and act on generated insights (Raghupathi & Raghupathi, 2014). Integrating analytics into inventory systems therefore requires both technical rigor and alignment with operational realities in rural healthcare environments.

In response to these challenges, the Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services (AISOF) system was conceptualized to automate medicine inventory monitoring and supply ordering in RHUs through real-time tracking and data analytics. The system was developed using the Agile Development Model, which supports iterative refinement based on continuous feedback from RHU end-users, including pharmacists, medical technologists, and administrative staff (Beck *et al.*, 2001) [15]. This development approach emphasizes adaptability, user involvement, and incremental improvement—critical features for building systems that are both technically robust and operationally feasible in low-resource healthcare environments.

To ensure comprehensive quality evaluation, AISOF is assessed using the ISO/IEC 25010 software quality model, which defines eight core quality characteristics: functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability (ISO/IEC, 2011) [37]. This framework enables holistic assessment of both technical performance and user-centered attributes, ensuring that the system not only functions correctly but is also usable, secure, and sustainable within real-world RHU operations.

This study is anchored on the Input–Process–Output (IPO) Model, which illustrates how the AISOF system is conceptualized, developed, evaluated, and validated. The IPO model provides a systematic representation of how defined inputs are transformed through structured processes to produce measurable outputs. The input component consists of the AISOF system modules (inventory management, supplies ordering, forecasting, and centralized database), the respondent groups (IT experts and RHU end-users), and the evaluation standards based on ISO/IEC 25010. The process component is structured around the Agile Development Model, which guides iterative cycles of requirements definition, system design, development, UI/UX enhancement, user acceptance testing, and deployment. Continuous consultations with RHU staff and IT experts inform system refinement, ensuring responsiveness to operational realities. The output integrates IT experts' technical evaluations, end-users' quality ratings, and RHU staff acceptability assessments, resulting in a validated AISOF system that enhances stock visibility, supports data-driven decision-making, and reduces stockouts, overstocking, and manual recording errors.

This study therefore aims to develop and evaluate an analytics-driven inventory and supply ordering system for Rural Health Units using AISOF as a case implementation. Specifically, it seeks to determine the extent to which AISOF meets ISO/IEC 25010 quality standards and supports improved stock visibility, decision support, and service efficiency in rural healthcare settings. By strengthening pharmaceutical inventory management at the primary-care level, this study contributes to ongoing efforts to improve healthcare delivery and medicine availability in underserved rural communities in the Philippines.

Statement of the Problem

This study seeks to determine the effectiveness of AISOF in improving medicine inventory management and decision support in Rural Health Units through Agile-based system development and ISO/IEC 25010–guided quality evaluation. Specifically, this study aims to answer the following questions:

1. How may the AISOF (Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services) be developed based on the phases of the Agile development model in terms of:
   1.1 defining requirements;
   1.2 system design;
   1.3 system development;
   1.4 UI/UX enhancement;
   1.5 user acceptance and testing (UAT); and
   1.6 deployment?
2. How may IT experts evaluate the developed AISOF system based on the ISO/IEC 25010 software quality criteria in terms of:
   2.1 functional suitability;
   2.2 performance efficiency;
   2.3 compatibility;
   2.4 usability;
   2.5 reliability;
   2.6 security;
   2.7 maintainability; and
   2.8 portability?
3. How may end-users evaluate the developed AISOF system based on selected ISO/IEC 25010 quality criteria in terms of:
   3.1 functional suitability;
   3.2 performance efficiency; and
   3.3 usability?
4. How may end-users evaluate the acceptability of the developed AISOF system in terms of perceived usefulness, ease of use, and readiness for adoption in Rural Health Units?

Research Methodology

This study adopted a developmental–evaluative research design grounded in the Agile Software Development Model and the ISO/IEC 25010 Software Quality Model. The design was selected to support both the systematic development of the Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services (AISOF) system and its empirical evaluation in a real-world rural healthcare context. The developmental phase focused on iterative system creation and refinement, while the evaluative phase assessed system quality, usability, and acceptability using standardized quality criteria and user feedback.

The study was conducted at the Rural Health Unit (RHU) of General Tinio. The site was purposively selected because it reflects typical operational conditions of rural healthcare facilities, including manual inventory practices, variable medicine demand, limited ICT resources, and staffing constraints. These conditions provided an appropriate environment for evaluating the feasibility and performance of an analytics-driven inventory and forecasting system in routine RHU operations.

System Development Procedure

AISOF was developed using the Agile Development Model through iterative sprints encompassing requirements definition, system design, development, UI/UX enhancement, user acceptance testing (UAT), and deployment. Continuous consultations with RHU personnel were conducted throughout development to ensure alignment with actual workflows in medicine inventory management, procurement, and reporting. User feedback guided incremental refinements to system features, interface layout, and reporting functions, enabling progressive improvement of system usability and operational fit within the RHU context.

Forecasting and Analytics Module

AISOF incorporated a forecasting and trend analysis module to support evidence-based supply planning. The module employed a time-series–based machine learning approach using Holt–Winters Exponential Smoothing with automated parameter optimization to model historical medicine consumption patterns, including level, trend, and seasonality. Forecast accuracy was assessed using Mean Absolute Percentage Error (MAPE) to evaluate predictive reliability. This method was selected due to the recurring and seasonal nature of medicine utilization patterns in rural primary healthcare facilities.

Participants and Sampling

Participants comprised two groups: RHU end-users and Information Technology (IT) experts. RHU end-users included healthcare and administrative personnel directly involved in inventory management and service delivery, such as the Municipal Health Officer, pharmacist, physician, dentist, nurses, midwives, medical technologists, radiologic technologists, and clerical staff. IT experts had at least two years of professional experience in system development or evaluation and familiarity with software quality standards. Purposive sampling was applied to ensure that participants possessed relevant operational and technical expertise. Inclusion criteria required current involvement in RHU operations or software evaluation, while exclusion criteria applied to individuals not engaged in inventory-related functions or lacking experience in system quality assessment.

Instruments

Data were collected using ISO/IEC 25010–aligned evaluation instruments developed for IT experts and RHU end-users. The IT expert instrument assessed functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability. The end-user instrument measured functional suitability, performance efficiency, and usability. A separate researcher-developed acceptability questionnaire assessed perceived usefulness, ease of use, satisfaction, and readiness for adoption. All instruments used a four-point Likert scale. Content validity was established through expert review by a panel comprising the research adviser, English critic, statistician, ICT specialists, and a system developer. Reliability testing through a pilot study yielded a Cronbach's alpha coefficient of 0.857, indicating good internal consistency of the acceptability instrument.

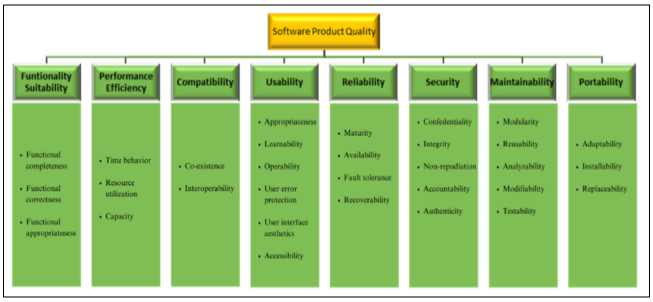

Fig 1: Presents the quality model, which served as the foundation of the product quality evaluation system based on ISO/IEC 25010 Standards that stakeholders assessed

Data Collection

Data collection commenced following approval from the RHU administration of General Tinio, Nueva Ecija. During the requirements analysis phase, RHU personnel participated in needs assessment and workflow mapping to identify functional gaps and system requirements. Upon completion of system development, UAT was conducted. Both IT experts and RHU end-users evaluated AISOF using the ISO/IEC 25010–based instruments and the acceptability questionnaire. Completed questionnaires were retrieved, encoded, and prepared for statistical analysis.

Data Analysis

Descriptive statistical techniques were applied to analyze the evaluation data. Weighted means were computed for each ISO/IEC 25010 quality characteristic and for system acceptability indicators. Mean scores were interpreted using predefined scoring ranges, with an acceptance threshold of 2.50 indicating satisfactory performance. The Agile development process was documented narratively to describe system evolution across iterative cycles. Quantitative results were summarized using corresponding verbal interpretations to facilitate assessment of technical quality, usability, and operational acceptability.

Table 1: Scoring Guide for ISO/IEC 25010

Range	Verbal Interpretation
3.25 – 4.00	Highly Functional/ Highly Efficient/ Highly Compatible/ Highly Usable/ Highly Reliable/ Highly Secured/ Highly Maintainable/ Highly Portable
2.50 – 3.24	Functional/ Efficient/ Compatible/ Usable/ Reliable/ Secured/ Maintainable/ Portable
1.75 – 2.49	Needs Improvement
1.00 – 1.74	Poor

Table 2: Scoring Guide for Level of Effectiveness of AISOF

Interpretation	Descriptor
3.25 – 4.00	Highly Effective
2.50 – 3.24	Effective
1.75 – 2.49	Less Effective
1.00 – 1.74	Not Effective

Ethical Considerations

Ethical approval was obtained from the RHU administration prior to study implementation. Written informed consent was secured from all participants. Participation was voluntary, and confidentiality was assured. The study complied with the Data Privacy Act of 2012 (Republic Act 10173) and relevant Department of Health data protection guidelines. AISOF processed only anonymized and aggregated operational data required for system testing and analysis. No personally identifiable patient information was accessed or stored. Data were protected through role-based access control, secure authentication, and encrypted storage. All research data were retained only for the period required by institutional policy and disposed of using secure data destruction procedures. The study did not disrupt RHU operations or compromise patient care.

Results and Discussion

Part 1: Development of the AISOF: Analytic -Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services

The researcher used the Agile Model for the system's development. In this model, system development was engaged in an iterative process of re-evaluating the goals as necessary to move the project forward. The Agile Model consisted of six (6) phases: define requirements, system design, development, UI/UX enhancement, user acceptance testing, and deployment.

1.1 Defining the Requirement Phase

The requirements definition for AISOF followed the Input–Process–Output (IPO) model and an Agile development approach. In the Input phase, user requirements were gathered from pharmacists, doctors, staff, and administrators to address challenges in inventory and supplies ordering in rural health facilities. Relevant forms and inventory data were collected, and appropriate analytics-based technologies were selected to align with the system's objectives. A wireframe was developed to guide iterative development across Agile sprints, enabling continuous refinement of system features.

The system integrates data analytics to monitor inventory levels, analyze consumption trends, and generate demand forecasts, supporting data-driven decision-making and improving efficiency, accuracy, and responsiveness compared with manual processes.

The requirements also defined the necessary hardware and software resources. Front-end access is supported through PCs, laptops, tablets, and smartphones with minimum performance specifications, while the back end uses web hosting with Apache as the web server and MySQL as the database. The software stack includes web browsers across major operating systems, Visual Studio Code for development, HTML, CSS/Tailwind, Laravel Blade, JavaScript for the front end, and PHP with the Laravel framework for the back end, with GitHub for version control.

The structured requirements-gathering process established a solid foundation for developing an analytics-based inventory and supplies ordering system with forecasting to enhance rural health services through modern, user-centered, and reliable technologies.

Gantt Chart of the Study

The researcher used the Gantt chart for the implementation of the AISOF: Analytic -Based Inventory and Supplies Ordering with Forecasting For Enhancing Rural Health Services System. It visually represented the timeline of each project phase, including preparation, development, internal testing, pilot testing, evaluation, orientation, deployment, and monitoring. The chart highlighted the sequential flow and overlapping of activities, consistent with the iterative nature of the Agile methodology. This graphical presentation enabled effective monitoring of task durations and transitions between phases. It served as a visual complement to the detailed implementation plan provided in Table 18, ensuring clarity and alignment in the project's scheduling and execution.

Table 1: Gantt Chart for the month of May 2025

	May 2025			
Activities	**Week 1**	**Week 2**	**Week 3**	**Week 4**
1. Planning the System				
1.1 Brain Storming				
1.2 Data Gathering				
1.3 Title Proposal				
2. System Analysis				
2.1 Interview				
2.2 Analyzing Function and Research				
2.3 Documentation				
3.System Design				
3.1 Designing the System				
4.System Development				
4.1 Programming				
4.1.1 Log in system				
4.1.2 System's database				
4.1.3 Queuing system				
4.1.4 Queuing history				
4.2 Debugging				
5.System Implementation				
5.1 Functional Testing				
5.2 Maintenance				
5.2.1 User Roles				
5.2.3 System Manuals				

Table 2: Gantt Chart for the month of June 2025

	June 2025			
Activities	**Week 1**	**Week 2**	**Week 3**	**Week 4**
1. Planning the System				
1.1 Brain Storming				
1.2 Data Gathering				
1.3 Title Proposal				
2. System Analysis				
2.1 Interview				
2.2 Analyzing Function and Research				
2.3 Documentation				
3.System Design				
3.1 Designing the System				
4.System Development				
4.1 Programming				
4.1.1 Log in system				
4.1.2 System's database				
4.1.3 Queuing system				
4.1.4 Queuing history				
4.2 Debugging				
5.System Implementation				
5.1 Functional Testing				
5.2 Maintenance				
5.2.1 User Roles				
5.2.3 System Manuals				

Table 3: Gantt Chart for the month of July 2025

	July 2025			
Activities	**Week 1**	**Week 2**	**Week 3**	**Week 4**
1. Planning the System				
1.1 Brain Storming				
1.2 Data Gathering				
1.3 Title Proposal				
2. System Analysis				
2.1 Interview				
2.2 Analyzing Function and Research				
2.3 Documentation				
3.System Design				
3.1 Designing the System				
4.System Development				
4.1 Programming				
4.1.1 Log in system				
4.1.2 System's database				
4.1.3 Queuing system				
4.1.4 Queuing history				
4.2 Debugging				
5.System Implementation				
5.1 Functional Testing				
5.2 Maintenance				
5.2.1 User Roles				
5.2.3 System Manuals				

Table 4: Gantt Chart for the month of August 2025

	August 2025			
Activities	**Week 1**	**Week 2**	**Week 3**	**Week 4**
1. Planning the System				
1.1 Brain Storming				
1.2 Data Gathering				
1.3 Title Proposal				
2. System Analysis				
2.1 Interview				
2.2 Analyzing Function and Research				
2.3 Documentation				
3.System Design				
3.1 Designing the System				
4.System Development				
4.1 Programming				

4.1.1 Log in system				
4.1.2 System's database				
4.1.3 Queuing system				
4.1.4 Queuing history				
4.2 Debugging				
5.System Implementation				
5.1 Functional Testing				
5.2 Maintenance				
5.2.1 User Roles				
5.2.3 System Manuals				

Table 5: Gantt Chart for the month of September 2025

	September 2025			
Activities	**Week 1**	**Week 2**	**Week 3**	**Week 4**
1. Planning the System				
1.1 Brain Storming				
1.2 Data Gathering				
1.3 Title Proposal				
2. System Analysis				
2.1 Interview				
2.2 Analyzing Function and Research				
2.3 Documentation				
3.System Design				
3.1 Designing the System				
4.System Development				
4.1 Programming				
4.1.1 Log in system				
4.1.2 System's database				
4.1.3 Queuing system				
4.1.4 Queuing history				
4.2 Debugging				
5.System Implementation				
5.1 Functional Testing				
5.2 Maintenance				
5.2.1 User Roles				
5.2.3 System Manuals				

Table 6: Gantt Chart for the month of October 2025

	October 2025			
Activities	**Week 1**	**Week 2**	**Week 3**	**Week 4**
1. Planning the System				
1.1 Brain Storming				
1.2 Data Gathering				
1.3 Title Proposal				
2. System Analysis				
2.1 Interview				
2.2 Analyzing Function and Research				
2.3 Documentation				
3.System Design				
3.1 Designing the System				
4.System Development				
4.1 Programming				
4.1.1 Log in system				
4.1.2 System's database				
4.1.3 Queuing system				
4.1.4 Queuing history				
4.2 Debugging				
5.System Implementation				
5.1 Functional Testing				
5.2 Maintenance				
5.2.1 User Roles				
5.2.3 System Manuals				

Table 7: Gantt Chart for the month of November 2025

	November 2025			
Activities	**Week 1**	**Week 2**	**Week 3**	**Week 4**
1. Planning the System				

1.1 Brain Storming				
1.2 Data Gathering				
1.3 Title Proposal				
2. System Analysis				
2.1 Interview				
2.2 Analyzing Function and Research				
2.3 Documentation				
3.System Design				
3.1 Designing the System				
4.System Development				
4.1 Programming				
4.1.1 Log in system				
4.1.2 System's database				
4.1.3 Queuing system				
4.1.4 Queuing history				
4.2 Debugging				
5.System Implementation				
5.1 Functional Testing				
5.2 Maintenance				
5.2.1 User Roles				
5.2.3 System Manuals				

Table 8: Gantt Chart for the month of December 2025

	December 2026			
Activities	**Week 1**	**Week 2**	**Week 3**	**Week 4**
1. Planning the System				
1.1 Brain Storming				
1.2 Data Gathering				
1.3 Title Proposal				
2. System Analysis				
2.1 Interview				
2.2 Analyzing Function and Research				
2.3 Documentation				
3.System Design				
3.1 Designing the System				
4.System Development				
4.1 Programming				
4.1.1 Log in system				
4.1.2 System's database				
4.1.3 Queuing system				
4.1.4 Queuing history				
4.2 Debugging				
5.System Implementation				
5.1 Functional Testing				
5.2 Maintenance				
5.2.1 User Roles				

1.2 System Design

The system design was established based on the set requirements. The following illustrations were created as results of the analysis:

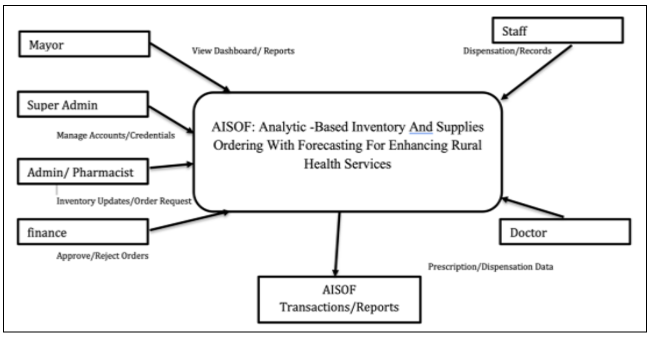

Fig 2: Context Diagram of AISOF

Data Flow Diagram

The Data Flow Diagram showed how data moved through the system. It illustrated the flow of information between external entities, such as users or other systems, internal processes, and data storage areas to produce the desired output.

Figure 2 presents context diagram of AISOF: Analytic - Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services System as a single unified process interacting with multiple external entities. These entities include the Mayor, Super Admin, Admin (Pharmacist), Finance, Staff, and Doctor, each of whom exchanges specific data with the system based on their roles and responsibilities. The system receives inputs such as login credentials, inventory updates, order requests, approval decisions, and dispensation records, while producing outputs including dashboards, reports, inventory status updates, order details, and forecasting insights. This diagram provides a high-level overview of the system boundary and illustrates how the proposed solution supports decision-making, inventory control, and service delivery in rural health facilities.

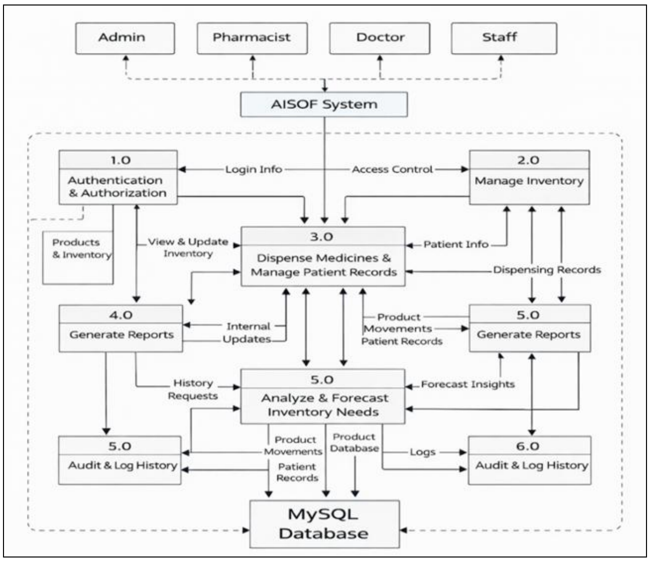

Fig 3: Data Flow Diagram of AISOF

Figure 3 presents the Data Flow Diagram of AISOF: Analytic -Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services System.

The AISOF (Analytics-Based Inventory and Supplies Ordering with Forecasting) system streamlines rural health inventory management through interconnected processes linked to a centralized database. Users access the system via secure authentication and role-based authorization, ensuring data security and accountability. The inventory management module handles product registration, stock monitoring, and expiration tracking, while the supplies ordering process manages approvals and updates to prevent stockouts and overstocking. Patient records and dispensing processes record medicine distribution, linking usage data to inventory levels. The analytics and forecasting component uses historical and real-time data to generate predictive insights for procurement and operational planning. Reporting, dashboards, and audit logs provide transparency, monitoring, and actionable summaries. AISOF integrates these processes to support data-driven decision-making, improve stock availability, and enhance efficiency in rural healthcare delivery.

Entity Relationship Diagram

The entity relationship diagram represents the data structure for your AISOF: Analytic -Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services System at General Tinio Nueva Ecija.

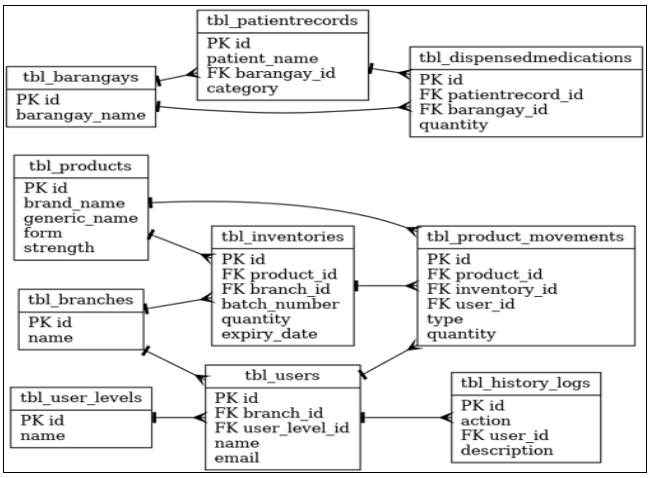

Fig 4: Entity Relationship Diagram of AISOF

Figure 4 The Entity–Relationship Diagram (ERD) defines the logical database structure of the proposed system and specifies the relationships among entities using Crow's Foot notation. This model establishes primary and foreign key constraints that enforce referential integrity, support normalization, and ensure consistency across transactional and master data.

The database structure of the system is designed around well-defined one-to-many relationships to support role-based access, inventory management, and patient care tracking. The relationship between tbl_user_levels and tbl_users is one-to-many, allowing each user level to be associated with multiple users. This enables role-based access control, where system privileges are assigned according to predefined roles, and each user is restricted to a single role to prevent privilege ambiguity. Similarly, tbl_branches relates to tbl_users in a one-to-many configuration, allowing multiple users to be assigned to a single branch. This ensures that operations are branch-specific and user activities are logically tied to their respective locations.

Inventory management is supported through the one-to-many relationships between tbl_products and tbl_inventories, as a single product may have multiple inventory records due to variations in batch numbers, expiration dates, or storage locations. Each inventory record references one product, ensuring accurate stock representation. In addition, tbl_branches maintain a one-to-many relationship with tbl_inventories, allowing branch-level inventory tracking, preventing data overlap, and supporting decentralized stock management. Transaction tracking is implemented through the relationships between tbl_products, tbl_inventories, and tbl_product_movements, where multiple movement logs can be generated per product and inventory record, capturing stock-in and stock-out events. Each inventory transaction is linked to a user through a one-to-many relationship with tbl_users, enhancing accountability and auditability.

Patient data is organized using one-to-many relationships between tbl_barangays and tbl_patient_records, allowing multiple patient records to be associated with a single barangay for geographic classification and location-based analysis. Similarly, tbl_patient_records and tbl_dispensed_medications form a one-to-many relationship, reflecting that patients may receive multiple medications over time, while tbl_barangays and tbl_dispensed_medications enable aggregation of medication distribution by location. Finally, tbl_users is linked to tbl_history_logs in a one-to-many relationship, ensuring that all significant system actions are recorded for monitoring, auditing, and security purposes. This relational structure underpins system integrity, accountability, and effective data-driven decision-making.

Data Dictionary

The data dictionary was developed to define and document the structure of the system's relational database. Each table outlined the specific attributes relevant to a particular entity, detailing their data types, functional descriptions, key designations (Primary Key or Foreign Key), and their associated reference tables. The data fields were systematically organized by reference table to emphasize entity-level relationships and facilitate easier understanding of the underlying schema. This structured approach supported data integrity, normalization, and consistency within the system's overall architecture. The data and descriptions for each table were as follows:

Table 9: Database Table Structure for tbl products

Field Name	Data Type (Size)	Field Description	Key	Reference Table
id	BIGINT(20)	Unique identifier of each product record	PK	tbl_products
brand_name	VARCHAR(255)	Brand name of the medicine	—	tbl_products
generic_name	VARCHAR(255)	Generic name of the medicine	—	tbl_products
form	VARCHAR(255)	Dosage form of the medicine	—	tbl_products
strength	VARCHAR(255)	Strength or concentration of the medicine	—	tbl_products
is_archived	TINYINT(1)	Indicates whether the product is archived	—	tbl_products
created_at	TIMESTAMP	Date and time the record was created	—	tbl_products
updated_at	TIMESTAMP	Date and time the record was last updated	—	tbl_products

Table 10: Database Table Structure for tbl_inventories

Field Name	Data Type (Size)	Field Description	Key	Reference Table
id	BIGINT(20)	Unique identifier for each inventory record	PK	tbl_inventories
product_id	BIGINT(20)	Identifies the product in inventory	FK	tbl_products
branch_id	BIGINT(20)	Identifies the branch where inventory is located	FK	tbl_branches
batch_number	VARCHAR(255)	Batch number of the medicine	—	tbl_inventories
quantity	INT(11)	Available quantity of the product	—	tbl_inventories
expiry_date	DATE	Expiration date of the medicine batch	—	tbl_inventories
is_archived	TINYINT(1)	Indicates whether the inventory record is archived	—	tbl_inventories
created_at	TIMESTAMP	Date and time the record was created	—	tbl_inventories
updated_at	TIMESTAMP	Date and time the record was last updated	—	tbl_inventories

Table 13: Database Table Structure for tbl_product_movements

Field Name	Data Type (Size)	Field Description	Key	Reference Table
id	BIGINT(20)	Unique identifier for each product movement	PK	tbl_product_movements
product_id	BIGINT(20)	Identifies the product involved	FK	tbl_products
inventory_id	BIGINT(20)	Identifies the affected inventory	FK	tbl_inventories
user_id	BIGINT(20)	Identifies the user who performed the action	FK	tbl_users
type	ENUM('IN','OUT')	Type of stock movement	—	tbl_product_movements
quantity	INT(11)	Quantity moved	—	tbl_product_movements
quantity_before	INT(11)	Quantity before movement	—	tbl_product_movements
quantity_after	INT(11)	Quantity after movement	—	tbl_product_movements
description	VARCHAR(255)	Reason for stock movement	—	tbl_product_movements
created_at	TIMESTAMP	Date and time recorded	—	tbl_product_movements
updated_at	TIMESTAMP	Date and time updated	—	tbl_product_movements

Table 11: Database Table Structure for tbl_users

Field Name	Data Type (Size)	Field Description	Key	Reference Table
id	BIGINT(20)	Unique identifier for each user	PK	tbl_users
branch_id	BIGINT(20)	Branch where the user is assigned	FK	tbl_branches
user_level_id	BIGINT(20)	Access level of the user	FK	tbl_user_levels
name	VARCHAR(255)	Full name of the user	—	tbl_users
email	VARCHAR(255)	Email address of the user	—	tbl_users
password	VARCHAR(255)	Encrypted password	—	tbl_users
last_login_at	TIMESTAMP	Last login date and time	—	tbl_users
last_login_ip	VARCHAR(255)	IP address used in last login	—	tbl_users
created_at	TIMESTAMP	Account creation date	—	tbl_users
updated_at	TIMESTAMP	Last update date	—	tbl_users

Table 12: Database Table Structure for tbl_patient records

Field Name	Data Type (Size)	Field Description	Key	Reference Table
id	BIGINT(20)	Unique identifier for patient record	PK	tbl_patient records
patient_name	VARCHAR(255)	Name of the patient	—	tbl_patient records
barangay_id	BIGINT(20)	Barangay of residence	FK	tbl_barangays
purok	VARCHAR(255)	Purok or zone	—	tbl_patient records
category	ENUM('Adult','Child','Senior')	Patient classification	—	tbl_patient records
date_dispensed	DATE	Date medication was dispensed	—	tbl_patient records
branch_id	BIGINT(20)	Branch providing service	FK	tbl_branches
created_at	TIMESTAMP	Record creation date	—	tbl_patient records
updated_at	TIMESTAMP	Record update date	—	tbl_patient records

Table 13: Database Table Structure for tbl_dispensedmedications

Field Name	Data Type (Size)	Field Description	Key	Reference Table
id	BIGINT(20)	Unique identifier for dispensed medication	PK	tbl_dispensed medications
patientrecord_id	BIGINT(20)	Associated patient record	FK	tbl_patient records
barangay_id	BIGINT(20)	Barangay of the patient	FK	tbl_ barangays
batch_number	VARCHAR(255)	Batch number of medicine	—	Tbl dispensed medications
generic_name	VARCHAR(255)	Generic name	—	tbl_dispensed medications
brand_name	VARCHAR(255)	Brand name	—	tbl_dispensed medications
strength	VARCHAR(255)	Strength of medicine	—	tbl_dispensed medications
form	VARCHAR(255)	Dosage form	—	tbl_dispensed medications
quantity	INT(11)	Quantity dispensed	—	tbl_dispensed medications
created_at	TIMESTAMP	Date created	—	tbl_dispensed medications
updated_at	TIMESTAMP	Date updated	—	tbl_dispensed medications

Use-Case Diagram

The use-case diagram defines interactions between the users and the system. Figure 9 presents the use-case diagram for the AISOF: Analytic -Based Inventory and Supplies Ordering with Forecasting For Enhancing Rural Health Services

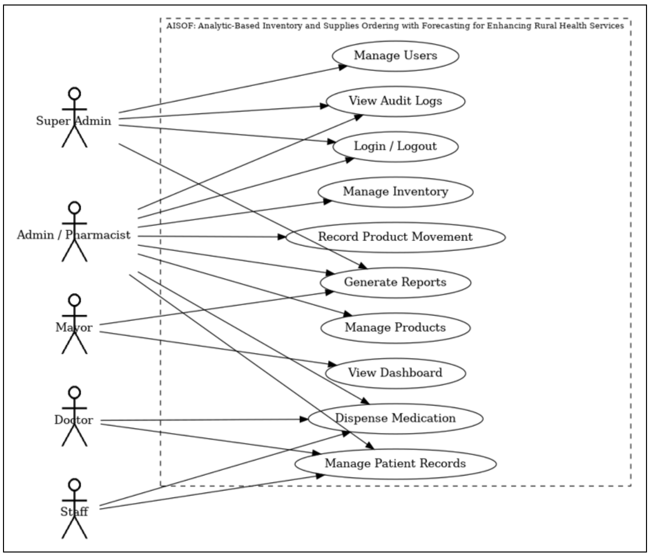

Fig 5: Use-Case Diagram of AISOF

The Use Case Diagram of AISOF (Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services) illustrates the functional interactions between system users and the core processes of the system, organized according to defined user roles. The diagram identifies the system actors and specifies the scope of functionalities accessible to each actor, thereby providing a clear representation of the system's operational flow.

All system interactions begin with the Login/Logout use case, which serves as the entry point for all users. Actors, including the Super Admin, Admin/Pharmacist, Doctor, Staff, and Mayor, must undergo authentication before accessing any system function, ensuring authorized access and establishing user identity.

Upon authentication, the Super Admin has access to administrative use cases such as Manage Users, Generate Reports, and View Audit Logs, enabling user account management, system activity monitoring, and maintenance of overall security and control. The Admin/Pharmacist performs primary operational functions, including Manage Products, Manage Inventory, and Record Product Movement, which support product maintenance, stock adjustments, and transaction recording. Additionally, the Admin/Pharmacist can Dispense Medication, Manage Patient Records, and Generate Reports, integrating inventory operations with patient-related transactions and reporting requirements.

The Doctor and Staff actors are limited to patient-focused functions, accessing Manage Patient Records and Dispense Medication to record patient information and dispense medicines according to prescriptions and available stock. Meanwhile, the Mayor has a monitoring role, accessing View Dashboard and Generate Reports to observe system performance, inventory status, and healthcare service data without modifying records.

Overall, the Use Case Diagram emphasizes that all system interactions are initiated through user authentication and governed by role-based access control. This design ensures data security, maintains data integrity, and supports efficient, controlled operation of AISOF, aligning with its objectives of optimizing inventory management, supporting clinical workflows, and enabling data-driven decision-making in rural health services.

System Architecture

The AISOF: Analytic -Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services System is designed using a structured web-based system architecture that supports efficient inventory management, data-driven forecasting, and informed decision-making in rural healthcare environments. The architecture defines the organization of system components and explains how user roles, application services, analytic modules, and database storage interact to deliver accurate inventory monitoring, predictive supply planning, and reliable health service support.

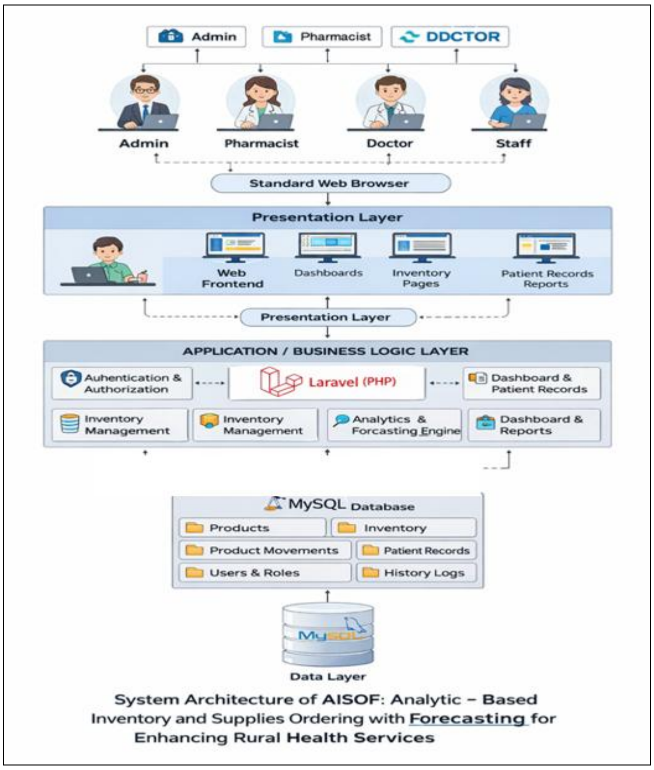

Fig 6: System Architecture of AISOF

The AISOF (Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services) system employs a multi-tier web-based architecture designed to support modularity, scalability, and data integrity. The architecture is structured into distinct layers that separate user interaction, application processing, and data management.

The client layer consists of authorized system users, including the Admin, Pharmacist, Doctor, and Staff, who access the system through a standard web browser. User access is governed by role-based authorization to ensure secure and controlled system operations.

The presentation layer is implemented using Laravel Blade templates and Tailwind CSS, providing a responsive and dynamic user interface. This layer is responsible for rendering dashboards, inventory views, patient records, and reports, as well as capturing and validating user inputs before transmission to the backend.

The application or business logic layer is developed using the Laravel PHP framework. This layer processes client requests, enforces business rules, and coordinates system workflows. Core functional modules include authentication and authorization, inventory management, product movement tracking, patient record and dispensing management, analytics and forecasting, report generation, and audit logging. The forecasting component utilizes historical inventory and dispensing data to support predictive analysis and informed decision-making.

The data layer utilizes a MySQL relational database to provide persistent data storage. The database schema is designed based on the Entity Relationship Diagram (ERD) and includes entities such as products, inventories, product movements, patient records, users, barangays, and history logs. This layer ensures data consistency, referential integrity, and efficient data retrieval.

The AISOF system architecture aligns with the Data Flow Diagram (DFD) and ERD by implementing defined processes within the application layer and maintaining structured data storage in the database layer. This architectural approach supports reliable transaction processing, auditability, and analytic-driven inventory management, thereby enhancing the efficiency of rural health service operations.

1.3 Development Phase of AISOF: Analytic-Based Inventory and Forecasting System for Rural Health Services

The system development followed a structured and iterative approach that integrated frontend interface design, backend application logic, artificial intelligence services, and relational database management to support intelligent system interaction, accessibility, and data-driven functionality. Guided by the Agile Development Model, the development process emphasized incremental implementation, continuous testing, and iterative refinement to ensure that the system met functional, usability, performance, and security requirements.

During the development stage, the researcher prioritized modularity, scalability, and maintainability. The system was developed as a web-based application composed of four main layers, namely the frontend, backend, AI integration, and database. Each layer was developed and refined across multiple sprint cycles to ensure seamless integration and consistent system behavior.

Frontend development focused on creating responsive, clean, and user-friendly interfaces using HTML and Tailwind CSS. Tailwind CSS utility classes were applied to ensure layout consistency, responsiveness, and accessibility across different devices and screen sizes. The frontend emphasized clarity, readability, and ease of navigation, with carefully structured forms, dashboards, and content displays to improve overall user experience. User inputs were validated at the client level to reduce errors and enhance interaction efficiency.

Backend development was implemented using the Laravel framework, which served as the core application engine responsible for managing system logic and server-side operations. The backend handled request routing, authentication and authorization, role-based access control, form processing, data validation, and system workflows. Laravel's MVC architecture enabled separation of concerns, while middleware and controllers ensured secure communication between the frontend, the database, and external services. Backend processes also handled error management, logging, and response formatting to maintain system reliability.

Artificial intelligence functionality was integrated through the Gemini API, which provided intelligent processing capabilities within the system. The backend facilitated secure communication with the Gemini API by sending structured prompts and processing generated responses. AI-generated outputs were validated and formatted before being delivered to the frontend, ensuring relevance, consistency, and responsible system behavior. This integration strengthened the system's ability to generate trend-based forecasts and demand predictions from historical inventory and issuance data.

Database development utilized MySQL as the relational database management system. The database schema was designed based on the system's data requirements and logical structure established during the design phase. MySQL was used to store user accounts, system records, transaction logs, and application-generated data. Relationships between tables were enforced using primary and foreign keys to maintain data integrity and consistency. Laravel's Eloquent ORM was employed to manage database operations efficiently and securely.

Beyond technical implementation, the forecasting results generated by ARISOF played a direct role in supporting RHU-level decision-making. The system translated historical medicine usage data into predictive demand trends, which were displayed through dashboards and analytical summaries. These outputs enabled RHU personnel to anticipate periods of high or low medicine consumption, identify fast-moving and slow-moving items, and determine optimal reorder points. As a result, inventory planning became more proactive rather than reactive, reducing the risks of stockouts, overstocking, and emergency procurement.

In terms of supply ordering, the forecasts supported evidence-based decisions by providing projected quantity requirements for upcoming periods. This allowed RHU staff to align purchase requests with actual demand patterns, prioritize essential medicines, and improve budget utilization. The forecasting outputs thus functioned not only as technical predictions but as practical decision-support tools that enhanced operational efficiency and service readiness at the RHU level.

Throughout the development phase, continuous integration and testing were conducted to ensure compatibility between system components. Functional testing, integration testing, and validation checks were performed after each sprint to identify issues and apply refinements. This iterative process ensured that the system evolved progressively while maintaining stability, performance, and scalability.

Coding environment

The image shows a software development environment using Visual Studio Code (VS Code) in dark mode, where the source code of a web-based inventory management system is being edited.

On the left panel, the VS Code Explorer displays the project directory structure. The main project folder appears to be "GeneralTinioIMS", which follows a typical Laravel framework layout. Visible directories include app, bootstrap, config, database, node_modules, public, and resources. Inside the resources/views/admin directory are several Blade template files such as dashboard.blade.php, inventory.blade.php, product_movements.blade.php, patientrecords.blade.php, and manageaccount.blade.php, indicating that the system supports multiple administrative modules.

The center panel shows the open file inventory.blade.php, which is a Laravel Blade view used for the Inventory Management module. The code consists mainly of HTML, Blade directives, and Tailwind CSS utility classes. Several @include statements are present, indicating the modular structure of the system where reusable components such as modals are loaded dynamically. These include modals for viewing products, viewing archived products, adding new products, adding stock, editing products, editing stock, and transferring stock.

Further down the code, a "Transfer Stock" modal is defined. This section includes a modal container with backdrop styling, a header with a close button, and a form that submits data using the POST method to a Laravel route (admin.inventory.transferstock). The form uses CSRF protection and contains input fields for inventory-related data, demonstrating secure handling of stock transfer operations between health units or branches.

On the right side, a vertical minimap of the file is visible, providing an overview of the entire code structure and allowing quick navigation. The bottom status bar shows active tools and extensions such as Prettier, Go Live, and Gemini Code Assist, suggesting that the developer is using formatting and live preview tools to improve development efficiency.

The image depicts the backend view-layer development of the AISOF inventory system, highlighting a well-structured, modular, and secure implementation of inventory-related functionalities within a Laravel-based web application.

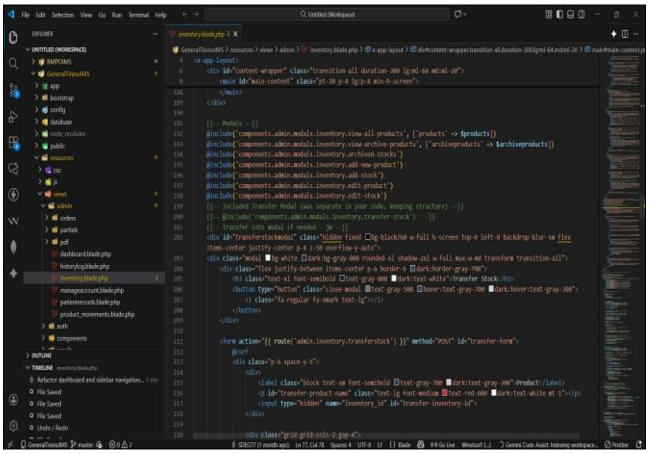

Fig 7: Coding Environment of the System

The following figures showed the actual outputs of the AISOF: Analytic -Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services System.

The Agile Development Model, which emphasizes incremental deployment, continual feedback, and iterative improvement, was used to construct the Analytic-Based Inventory and Supply Optimization Framework (AISOF). Data-driven inventory management, predictive forecasting, and resource allocation are AISOF's main goals to improve rural health service delivery.

1. Agile Dev

Sprint-based cycles allowed AISOF's development team to establish core functionalities, test them in real life, and adjust them based on rural health clinic user input. These Agile approaches are key:

- Inventory tracking and forecasting analytics were built first. Dashboards, alerts, and reporting tools dominated succeeding sprints.
- Sprint reviews improved usability, workflows, and data visualization using rural health staff feedback.

- Agile allows for feature reprioritization based on operational constraints such seasonal supply changes or emergency response needs.

2. System architecture, layers

Scalability, maintainability, and seamless integration of analytics and forecasting were achieved by designing AISOF as a web-based, modular, three-tier system.

1. The Frontend Layer (Presentation Layer) gives users dashboards, alerts, and reports.
Easy to use for non-technical workers.
Interactively displays stock levels, expected demand, and notifications.

2. The backend (application layer) manages inventories, forecasting, and analytics.
Supports real-time stock replenishment and resource allocation decisions.
Provides versatility for future upgrades like machine learning prediction models.

3. Database Layer: Centralized storage for inventory, transaction, and supplier data, including security, redundancy, and trend analysis.
Integrates audits and strategic planning reporting tools.

Module 3: Analysis and Forecasting.
Our analytics-driven forecasting engine turns historical and real-time inventory data into actionable insights.

- Predicts pharmaceutical and supply demand using moving averages and trend analysis.
- Risk Management: Identifies stockouts or overstocks to minimize waste and sustain service delivery.

Decision Support: Helps rural health administrators maximize procurement and distribution.
The module seamlessly integrates with the backend processing layer to provide real-time forecasts and warnings.

4. Continuous quality assurance and testing.
All system components were carefully evaluated during each Agile sprint to ensure reliability, usability, and performance.

- Functionally tested inventory tracking, forecasts, and alarms.
- User-tested dashboard clarity, alert levels, and reporting tools.
- Evaluate system performance to efficiently process massive datasets for real-time forecasting.

Recurrent testing and refining confirmed that AISOF satisfied ISO/IEC 25010:2011 software quality requirements for functional appropriateness, performance efficiency, usability, and dependability.

5. Agile Principles in Action
AISOF's development clearly demonstrated the benefits of using Agile methodology. By implementing basic functionalities early, health units were able to start tracking inventories and forecasting needs even while new modules were still being developed. This early deployment allowed users to see immediate value from the system and ensured

that essential features were available from the start. Continuous user feedback was then used to improve system usability and relevance, making AISOF more responsive to the real needs of health workers.

The system's modular architecture also played a key role in its success. Because the components were designed to work independently yet integrate smoothly, adding advanced analytics, accounting for seasonal demand changes, and generating detailed reports became straightforward. This flexibility allowed AISOF to grow over time without disrupting existing operations, ensuring that enhancements could be introduced efficiently as requirements evolved.

AISOF's Agile-driven development has had a significant impact on rural health services. Rural clinics can now manage their inventories more effectively and avoid stockouts by using data to guide procurement and allocation. Timely alerts, dashboards, and forecasts improve operational efficiency and support faster, better-informed decisions. Most importantly, the system enables health units to meet changing healthcare needs without costly and time-consuming system redesigns.

Overall, the AISOF development phase produced a durable, extendable, and user-friendly solution by combining Agile practices, modular system architecture, and analytics-driven forecasting. Through iterative development, continuous testing, and active user feedback, AISOF continues to enhance service delivery, optimize inventory management, and strengthen data-driven decision-making in rural health units.

1.4 UI/UX Enhancement of AISOF: Analytic-Based Inventory and Forecasting System

AISOF's UI and UX design enable rural health workers to interact with the system quickly and confidently. The interface allows them to easily read inventory levels, understand forecasting data, and make informed decisions for daily operations. By prioritizing simplicity and clarity, the system reduces the learning curve and supports efficient use even in busy or low-resource health settings.

Through Agile methodology, AISOF's UI/UX was continuously refined using user-centered design, regular feedback, and incremental development. Health workers were actively involved in testing and evaluating the interface, ensuring that features matched their real workflows and needs. Each iteration improved usability, accessibility, and relevance, making the system more intuitive and practical over time.

The UI was designed around the actual tasks of rural health workers, such as checking stock levels, recording usage, and viewing alerts. Menus, buttons, and dashboards were organized to minimize steps and reduce errors, allowing users to complete tasks quickly and accurately. The design emphasizes clarity, consistency, and ease of navigation.

AISOF presents data in a clear and understandable way through simple labels, visual cues, and easy-to-read dashboards. Inventory status, trends, and forecasts are displayed using charts and summaries that help users grasp information at a glance. This improves understanding, supports better judgment, and strengthens confidence in making data-driven decisions.

Fig 8: AISOF system flow

People that administer rural health units, handle supplies, or work in healthcare use AISOF most. The user layout was simple because many people aren't tech-savvy. Users were asked and observed to identify data access, interpretation, and system navigation issues during Agile sprint reviews.

A role-based design restricts users to job-related information. Administrators have full stock records, forecasting dashboards, and analytics summaries. Supply management can track stock, receive notifications, and order. However, health care workers may view accessible medications and supplies. Work-related information simplifies thinking.

Simple dashboards with color-coded notifications and dynamic visual features help users easily assess stock, shortages, and inventory needs. Stressed include low stock, expiring items, and expected demand. Line graphs, bar charts, and trend indicators clarify forecasting and analytics data. This simplifies pattern recognition and demand prediction. Ads with colors and graphics emphasize urgency. Text sizes, color contrast, and interface responsiveness were optimized for rural health center computers and apps. Clear labels for actions and buttons and simpler navigation make things easier and require less training.

Checking stock, making predictions, and sending reports is faster with AISOF's interactive design. Agile sprints focused on process planning to match system navigation with rural health unit tasks. Scarcity, expiration, and stock notifications are real-time. Interactive features let users drill down from dashboard summaries to granular inventory data to make smarter decisions. Form checking and clear warnings reduce data entering errors. Undo and repair tools allow error correction without halting work.

UI/UX modifications were constant during Agile system development. Health professionals revised dashboard and interface prototypes' layout, color schemes, language, and navigation flow during sprints. Tracking commodities was the primary development priority, followed by visualizations, warnings, and dashboards for ease of use. Agile adaptability let it swiftly respond to seasonal demand

and new data needs without rebuilding the system. This maintained the UI modern and user-focused.

Overall, AISOF's UI/UX enhancements improved rural healthcare. Workers learn critical information fast and with little training, reducing cognitive burden. Stock shortages and overstocks can be addressed swiftly using interactive interfaces and real-time alerts. Rural health clinics can easily apply the strategy, and data-driven forecasting and analytics simplify planning and purchasing. Iterative testing, feedback integration, and feature enhancement make AISOF a simple, usable, and effective inventory management and remote healthcare service provider. People that run rural health units, handle supplies, and work in healthcare use AISOF. The UI was simplified to make it accessible to many. Users were interviewed and observed during Agile sprint reviews to identify data access, interpretation, and system movement issues.

A role-based interface shows users just relevant information. Administrators get detailed stock reports, prediction dashboards, and analytics summaries. Health staff merely need to check drug and supply availability. However, supply managers may monitor inventories, receive warnings, and process orders. In role-based differentiation, job-specific information simplifies thinking.

Simple dashboards with color-coded notifications and moving visuals show users how much stock they have, how much they need, and how much demand there is for things. Low stock, expired items, and expected demand are shown graphically. Forecasting and analytics data is shown in line graphs, bar charts, and trend indications to help comprehend historical trends and predicted demand. Warnings employ images and colors to emphasize importance. Word sizes, color contrast, and responsiveness of rural health center PCs and tablets were changed. Clear button labels and navigation menus make things easier to operate and require less training.

AISOF's interactive screen simplifies stock checks, projections, and reports. Workflow mapping aligned system navigation with rural health unit tasks during agile sprints. Live updates reveal supply levels, expiration dates, and shortages. Users may easily analyze and make decisions by drilling down from dashboard summaries to complete inventory reports utilizing interactive components. Clear warning messages and form checks reduce data entry errors. Undo and correction features allow users to remedy mistakes without pausing.

Agile system development included UI/UX adjustments. Health professionals revised dashboard and interface prototypes during sprints, changing layout, color, language, and navigation. Inventory tracking features were created for speed before images, alarms, and panels were envisaged. Agility allowed for quick adaptation to seasonal demand and new reporting demands without rebuilding the system. This focused the user experience on their needs.

AISOF UI/UX enhancements have improved rural healthcare. Workers can quickly access vital information with minimum training to lessen mental stress. Interactive screens and real-time warnings help manage supply shortages and overstocks. Rural health centers adopt the system because it is simple and uses data-driven forecasting and analytics to plan operations and procure supplies. Iterative testing, frequent feedback integration, and modest feature improvement make AISOF easy to use, effective, and beneficial for rural inventory management and healthcare.

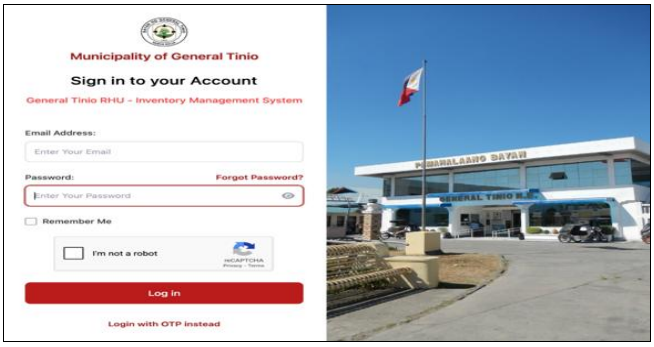

Fig 9: Opening Screen

Figure 9 presents the opening screen interface of the AISOF: Analytic -Based Inventory and Supplies Ordering With Forecasting for Enhancing Rural Health Services system, a web application designed for n Rural Health Unit of General Tinio Municipality. It show case web page screen that represent the initial visuals displayed when the application is launched.

The image shows the login interface of a web-based information system used by the Municipality of General Tinio.

On the left side, the screen presents a clean and formal login panel. At the top is the official seal of the municipality, followed by the heading “Municipality of General Tinio” and the prompt “Sign in to your Account.” Below this is the system title “General Tinio RHU – Inventory Management System,” indicating that the platform is intended for managing inventory at the Rural Health Unit.

The login form requires the user to enter an email address and password, with a visible “Forgot Password?” option for account recovery. Additional security and usability features are included, such as a “Remember Me” checkbox, a reCAPTCHA verification (“I’m not a robot”), and an option to log in using OTP instead, highlighting the system’s emphasis on secure access. A prominent red “Log in” button is placed at the bottom of the form, making the primary action clear and accessible.

On the right side, the interface displays a large background image of the General Tinio Municipal Hall. The building is shown under a clear blue sky, with the Philippine flag raised in front, reinforcing the official and government-affiliated nature of the system. The architectural image provides visual context and establishes credibility by linking the digital system to its physical institutional setting.

The image depicts a professional, secure, and government-branded login page designed to authenticate authorized users before granting access to an inventory management system for public health operations.

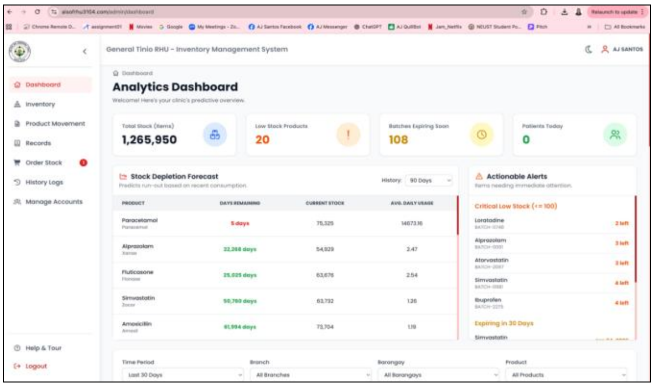

Fig 10: Dashboard of AISOF

Figure 10. The image presents the Analytics Dashboard page of the General Tinio RHU – Inventory Management System, which serves as the central monitoring interface for inventory status, usage trends, and predictive insights.

At the top section, the dashboard displays the system title and the logged-in user's account, indicating authenticated access. This reinforces that the page is intended for authorized personnel only. The page heading "Analytics Dashboard" highlights that the system provides data-driven and predictive information rather than simple record viewing.

On the left-hand side, a vertical navigation panel is shown. This menu provides access to the major system modules, including Dashboard, Inventory, Product Movement, Records, Order Stock, History Logs, and Manage Accounts. The structured layout allows users to quickly navigate between operational and administrative functions.

The main content area begins with summary metric cards that provide a high-level overview of the system's current state. These include:

- Total Stock (Items), which reflects the overall quantity of available supplies;
- Low Stock Products, indicating items that have reached a critical threshold;
- Batches Expiring Soon, highlighting inventory at risk of expiration.
- Patients Today, showing daily service activity. These indicators allow users to assess system status at a glance.

Below the summary cards is the Stock Depletion Forecast section. This component presents a predictive analysis based on recent consumption patterns. The table lists products along with days remaining, current stock, and average daily usage, enabling users to anticipate shortages and plan replenishment in advance. A selectable history range (e.g., 90 days) allows flexible analysis based on different time frames.

On the right side, the Actionable Alerts panel emphasizes items that require immediate attention. This includes critical low stock items and products nearing expiration, with batch numbers and remaining quantities clearly displayed. This feature supports proactive decision-making by drawing attention to high-risk inventory conditions.

At the lower portion of the dashboard, filtering options are provided for time period, branch, barangay, and product. These controls allow users to customize the data displayed on the dashboard, supporting more focused analysis based on location or specific inventory items.

The dashboard page functions as a decision-support interface, combining real-time inventory data, predictive analytics, and alert mechanisms. It enables administrators and health personnel to monitor stock levels, anticipate future needs, and respond promptly to potential supply issues, thereby supporting efficient inventory management and improved healthcare service delivery.

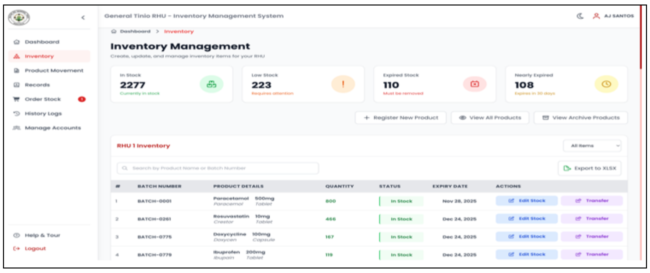

Fig 11: Inventory Management page

Figure 11 showcases the Inventory Management page of the General Tinio RHU Inventory Management System, which is a core functional module of AISOF. This page is designed to allow authorized users to monitor, manage, and update medicine and supply inventories within the Rural Health Unit.

At the top of the page, the system header displays the system name and the currently logged-in user, confirming secure access. A breadcrumb navigation (Dashboard > Inventory) is provided to indicate the user's current location within the system and to support easy navigation.

On the left-hand side, a vertical navigation menu is visible, listing the main system modules such as Dashboard, Inventory, Product Movement, Records, Order Stock, History Logs, and Manage Accounts. The Inventory module is highlighted, indicating that it is the active page. This menu structure enables efficient movement between different system functionalities.

The main content area begins with the page title "Inventory Management", accompanied by a brief description indicating that the page is used to create, update, and manage inventory items for the Rural Health Unit. Below this are summary indicator cards that provide a quick overview of inventory status. These include:

- In Stock, showing the total number of items currently available;
- Low Stock, indicating items that require attention due to low quantity;
- Expired Stock, representing items that must be removed from circulation;
- Nearly Expired, identifying items that will expire within a defined period.

These indicators allow users to immediately assess the condition of the inventory.

Below the summary section are action buttons such as Register New Product, View All Products, and View Archive Products, which allow users to add new inventory items, view the complete product list, or access archived records. These functions support inventory maintenance and record organization.

The lower portion of the page displays the RHU Inventory table, which contains detailed information for each inventory item. The table includes fields such as batch number, product details, quantity, status, expiry date, and available actions. The status labels (e.g., *In Stock*) provide visual indicators of item availability, while action buttons such as Edit Stock and Transfer allow authorized users to update quantities or move stock between locations.

Additional tools such as a search bar (for product name or batch number), a filter option (e.g., all items), and an Export to XLSX button enhance usability by allowing users to quickly locate records and generate reports for documentation or analysis.

This Inventory Management page functions as a centralized interface for controlling medicine and supply stocks. It supports accurate tracking of quantities, monitoring of expiration dates, and timely decision-making, thereby contributing to efficient inventory control and improved healthcare service delivery at the Rural Health Unit.

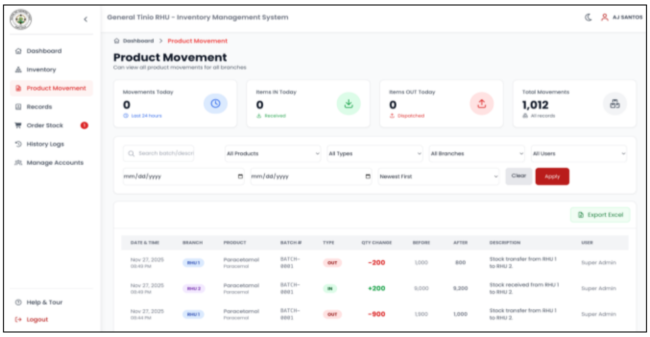

Fig 12: Product Movement page

The image presents the Product Movement page of the General Tinio RHU – Inventory Management System, which is a key module used to monitor and record inventory transactions across different Rural Health Units (RHUs).

At the top section, the page header displays the system name and the authenticated user, indicating secure system access. A breadcrumb trail (Dashboard > Product Movement) is shown to help users identify their current location within the system and to support efficient navigation.

On the left-hand side, a vertical navigation panel lists the primary system modules, including Dashboard, Inventory, Product Movement, Records, Order Stock, History Logs, and Manage Accounts. The Product Movement module is highlighted, signifying that it is the active page. This menu structure enables users to seamlessly move between operational and administrative functions.

The main content area begins with the page title "Product Movement", accompanied by a brief description indicating that the page allows viewing of all product movements across branches. Below this are summary indicator cards that provide an overview of transaction activity. These include Movements Today, Items IN Today, Items OUT Today, and Total Movements. These indicators give users an immediate snapshot of inventory flow within a selected time period.

Beneath the summary cards is a comprehensive filter and search section, which allows users to refine displayed records. Filtering options include product name, movement type (IN or OUT), branch, user, date range, and sorting order. The presence of Clear and Apply buttons enables controlled data querying, supporting detailed analysis and review of inventory transactions.

The lower portion of the page displays a Product Movement table, which provides detailed transaction records. Each entry includes the date and time, branch, product name, batch number, movement type, quantity change, stock levels before and after the transaction, transaction description, and the user responsible for the action. Color-coded indicators (e.g., green for IN and red for OUT) visually distinguish incoming and outgoing stock movements, improving readability and interpretation.

An Export Excel function is provided, allowing users to generate reports for documentation, auditing, or further analysis. This feature supports transparency and accountability by enabling the extraction of transaction data for external review.

Product Movement page functions as a transaction monitoring and audit interface, ensuring that all inventory changes are systematically recorded and traceable. By providing detailed logs, filtering capabilities, and export options, the module supports accurate inventory tracking, accountability of user actions, and effective decision-making in managing healthcare supplies across RHUs.

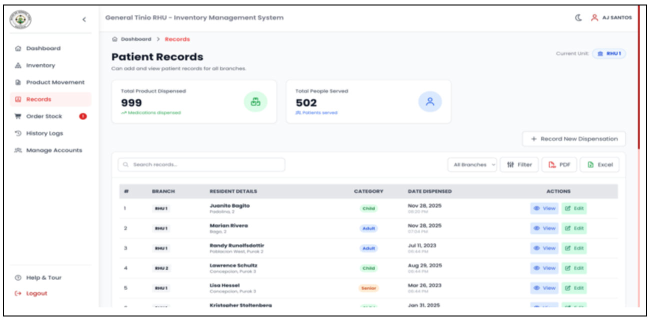

Fig 13: Patient Records page

Figure 13 shows the Patient Records page of the General Tinio RHU – Inventory Management System, which serves as the module for managing and monitoring patient-related medication dispensing records across Rural Health Units.

At the top section, the page header displays the system name and the currently logged-in user, indicating that access is restricted to authorized personnel. A breadcrumb navigation (Dashboard > Records) is provided to show the user's current location within the system. The page title "Patient Records" is accompanied by a brief description stating that the module allows the addition and viewing of patient records for all branches, clarifying its functional purpose.

The left-hand navigation panel lists the main system modules, including Dashboard, Inventory, Product Movement, Records, Order Stock, History Logs, and Manage Accounts. The Records module is highlighted, signifying that it is the active section. This layout supports efficient navigation between system functions.

Within the main content area, summary cards are displayed to provide an overview of patient-related activities. These include Total Product Dispensed, which reflects the number of medications released, and Total People Served, indicating

the number of patients assisted within the selected scope. These indicators allow users to quickly assess service volume and system utilization.
Below the summary section is a set of action and filtering controls. These include a search bar for locating specific records, branch selection, filtering options, and export buttons for PDF and Excel formats. A Record New Dispensation button is also provided, enabling authorized users to add new patient dispensation records into the system. These tools support efficient record management, reporting, and documentation.
The lower portion of the page presents a Patient Records table, which contains detailed information for each recorded dispensation. The table includes fields such as branch, resident details, patient category (e.g., Child, Adult, Senior), date dispensed, and available actions. Action buttons such as View and Edit allow users to review record details or update information as needed, subject to access privileges.
Patient Records page functions as a centralized repository for patient dispensation data, linking inventory usage with healthcare service delivery. By providing summarized indicators, detailed records, and export capabilities, the module supports accurate documentation, accountability, and informed decision-making in the management of rural health services.

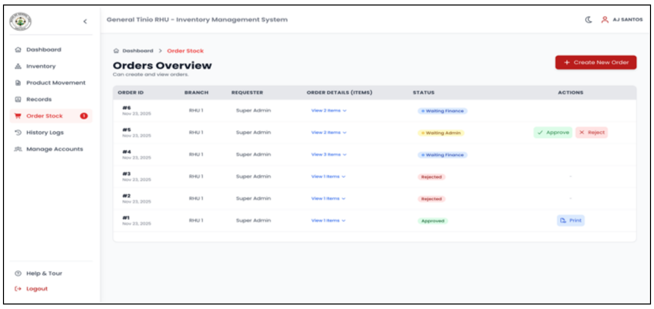

Fig 14: Orders Overview page

The image displays the Orders Overview page of the General Tinio RHU – Inventory Management System, which serves as the module for managing and monitoring stock replenishment requests within the Rural Health Unit.
At the top of the interface, the system header shows the system name and the authenticated user, confirming that access is limited to authorized personnel. A breadcrumb navigation (Dashboard > Order Stock) is provided to indicate the user's current location within the system and to support ease of navigation. The page title "Orders Overview" is accompanied by a brief description stating that the module allows users to create and view orders, clearly defining its purpose.
The left-hand navigation panel lists the major system modules, including Dashboard, Inventory, Product Movement, Records, Order Stock, History Logs, and Manage Accounts. The Order Stock module is highlighted, indicating that it is the active page. This consistent layout supports intuitive movement between different system functions.
Within the main content area, a table is presented that summarizes all stock orders submitted by the RHU. The table includes key information such as Order ID, Branch, Requester, Order Details (Items), Status, and Actions. Each order is assigned a unique identifier and is associated with a specific branch and requesting user, ensuring traceability and accountability.
The Status column reflects the current stage of each order in the approval workflow, such as *Waiting Admin*, *Waiting Finance*, *Approved*, or *Rejected*. This status-based flow illustrates the system's built-in approval mechanism, which supports controlled and transparent decision-making. Depending on the order status and user role, corresponding action buttons such as Approve, Reject, or Print are made available. These actions enable authorized personnel to process orders, enforce approval rules, or generate official documentation.
A Create New Order button is prominently displayed at the top-right corner of the page, allowing authorized users to initiate new stock requests. This feature supports timely replenishment of medical supplies and ensures continuity of healthcare services.
The Orders Overview page functions as a centralized order management and approval interface, providing visibility into stock requests, approval status, and order history. By integrating structured workflows, status monitoring, and role-based actions, the module supports efficient inventory replenishment, accountability, and effective supply management within the Rural Health Unit.

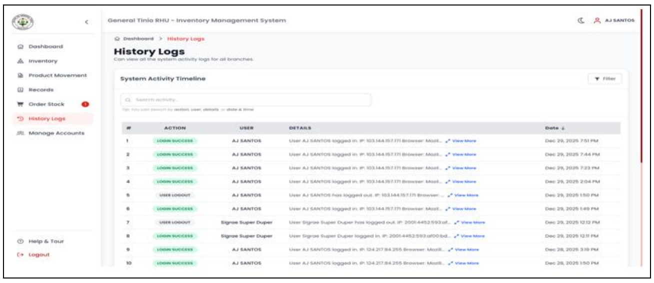

Fig 15: History Logs page

The image shows the History Logs page of the General Tinio RHU – Inventory Management System, which functions as the system's audit and monitoring module for tracking user activities across all branches.
At the top section, the system header displays the system name and the currently authenticated user, confirming secure access. A breadcrumb navigation (Dashboard > History Logs) is provided to indicate the user's current position within the system and to facilitate navigation. The page title "History Logs", together with the subtitle stating that all system activity logs can be viewed for all branches, clearly defines the purpose of the module.
On the left-hand navigation panel, the main system modules are listed, including Dashboard, Inventory, Product Movement, Records, Order Stock, History Logs, and Manage Accounts. The History Logs module is highlighted, indicating that it is the active page. This consistent menu structure allows users to efficiently access different functional areas of the system.
The main content area features the System Activity Timeline, which provides a chronological record of system events. A search bar is included to allow users to locate specific activities using keywords such as action type, user name, details, or date and time. A filter option is also available to refine the displayed logs, supporting efficient review and analysis of system activities.
Below this section is a detailed activity log table, which records each system event. The table includes columns for

action, user, details, and date and time. Common actions displayed include Login Success and User Logout, each clearly labeled and visually distinguished. The details column provides contextual information such as IP address and browser used during the activity, enhancing traceability and security monitoring. A View More option is available for each entry, allowing users to access additional log details when necessary.

The History Logs page serves as a comprehensive audit trail for the system. By systematically recording user actions and access events, the module supports transparency, accountability, and security. It enables administrators to monitor system usage, investigate anomalies, and ensure compliance with operational and data governance requirements within the Rural Health Unit.

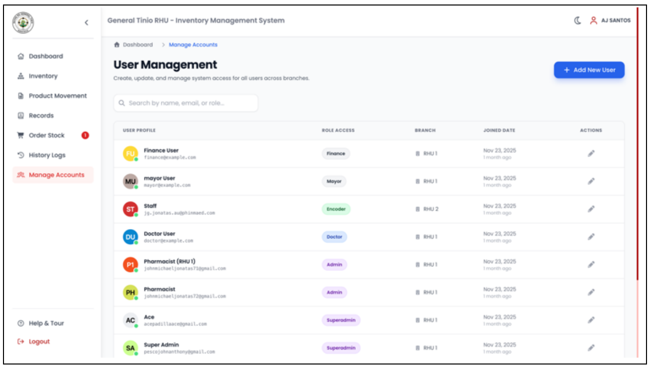

Fig 16: Orders Overview page

The image illustrates the User Management page of the General Tinio RHU – Inventory Management System, which is responsible for administering system access and managing user accounts across different branches.

At the top of the page, the system header displays the system name along with the currently logged-in user, confirming that access to this module is restricted to authorized personnel. A breadcrumb navigation (Dashboard > Manage Accounts) is provided to indicate the user's current location within the system. The page title "User Management" is accompanied by a short description stating that the module allows the creation, updating, and management of system access for users across branches.

On the left-hand side, a vertical navigation menu lists the primary system modules, including Dashboard, Inventory, Product Movement, Records, Order Stock, History Logs, and Manage Accounts. The Manage Accounts module is highlighted, signifying that it is the active section. This consistent layout supports ease of navigation throughout the system.

The main content area features a searchable table of registered system users. A search bar at the top allows administrators to locate users by name, email address, or role, enabling efficient account management. An Add New User button is prominently displayed, allowing authorized administrators to create new user accounts when necessary.

The user list table presents detailed information for each account, including user profile, role access, assigned branch, date joined, and available actions. Role labels such as *Finance*, *Mayor*, *Encoder*, *Doctor*, *Admin*, and *Super Admin* clearly indicate each user's level of access and responsibilities within the system. This role-based structure ensures that system functions are accessed only by appropriate users, supporting security and operational control.

Action icons provided in each row allow administrators to edit user details, such as role assignment or branch association, as needed. The inclusion of branch information further supports multi-branch management by clearly identifying the operational unit to which each user belongs.

User Management page functions as a centralized access control module of the system. By enabling role-based user administration, controlled account creation, and account maintenance, this module supports system security, accountability, and efficient management of user access within the Rural Health Unit inventory management system.

1.5 User Acceptance and Testing of AISOF: Analytic-Based Inventory and Forecasting System

The Analytic-Based Inventory and Supply Optimization Framework (AISOF) helps rural health clinics manage inventory, predict, and make data-driven decisions. User acceptance and system stability were crucial to development. AISOF employed Agile for iterative testing and assessment to ensure the system's functionality, usability, and performance met end-user needs.

1. Agile-Based Testing

AISOF's quality assurance and user acceptance methods used Agile development principles including continuous testing and feedback integration. Inventory tracking, forecasting, alert systems, and dashboards were tested after each sprint. Administrators, supply managers, and healthcare professionals provided sprint evaluations and real-time feedback to improve workflows, alert mechanisms, and interface design. Iterative refinement worked sprint feedback into succeeding development cycles to meet operational needs rather than initial specifications.

To ensure reliability and efficacy, several system tests were performed. Functional testing verified real-time inventory updates, forecasting computations, and alarm production, ensuring data processing and system outputs met operational requirements. Dashboard style, data display, and process navigation were tested for usability. Health professionals reviewed stock level monitoring, forecast report interpretation, and alert reactions to improve navigation and data display. Performance tests showed that the system could handle real-time analytics, forecasting, multiple concurrent users, and large inventory databases. Security testing verified access controls and role-based constraints for critical health and inventory data.

User acceptance testing (UAT) ensured the system met rural health professionals' functional and operational demands. Health professionals examined the system for supply replenishment planning and seasonal demand projections. Structured questionnaires, direct observation, and interviews examined user happiness, perceived utility, and simplicity. In subsequent Agile sprint cycles, feedback-driven refinement fixed navigation and notification issues. UAT results demonstrated high user satisfaction with dashboards and analytics tools, improved stock management and forecasting accuracy, and positive feedback on real-time notifications and decision-support recommendations.

Agile principles encouraged user interaction and modification, which improved system acceptability. Sprint evaluations increased user engagement and revealed usability concerns quickly. Incremental delivery provided key system capabilities early, giving customers instant benefits while gathering feedback before full implementation. Reporting formats and inventory operations could be changed when operational needs changed due to the system's versatility.

Rural health specialists liked AISOF because to intensive testing and user interaction. The system was easy, relevant, and reliable, encouraging daily use. Accurate projections and timely notifications helped inventory planning, resource allocation, and decision-making. Continuous Agile improvement makes the system flexible for future healthcare needs. Agile-based testing and user acceptance improved AISOF's technical quality and usability, enabling analytic-based inventory management and forecasting to improve rural health service delivery.

1.6 Deployment Phase of AISOF: Analytic-Based Inventory and Forecasting System

Fig 17: User Acceptance and Testing of AISOF: Analytic-Based Inventory and Forecasting System

The AISOF system is deployed from development and testing to rural health centers. This step is critical because it ensures the system is fully functional, accessible, and optimized for health professional workflow. Flexibility, incremental deployment, and continual improvement are maintained by agile concepts.

1. Agile-led deployment

Rollout gradually

AISOF was gradually implemented. The Analytic-Based Inventory and Supplies Ordering with Forecasting (AISOF) system was developed to meet ISO/IEC 25010 software quality standards for performance efficiency, dependability, and usability. These quality traits guided the system's deployment strategy, assessment, and improvement efforts to ensure rural health unit operational efficacy.

Efficiency of Performance

The system's web-based architecture and phased deployment improved performance. Installers monitored real-time inventory changes, forecasting computation speed, dashboard refresh rates, and system response time. Agile sprint cycles optimized analytics production, alert triggering, and report rendering. The development team fixed network connectivity and data volume performance issues through pilot deployments before a full-scale deployment. Although many users and rural health units used AISOF, it nevertheless offered timely inventory analytics and forecasting reports.

Dependability

Secure cloud hosting with redundancy, centralized access control, and data backup ensured system reliability. Pilot testing in a few rural health facilities revealed system failures, workflow disruptions, and data synchronization issues in real-world settings. Before deployment, these issues were resolved to reduce downtime and ensure system reliability. Continuous monitoring throughout and after deployment ensured system availability, data accuracy, and alarm production. Agile enabled rapid defect repair and adaptive modifications based on real-world operational feedback, improving reliability.

Usability

Usability was prioritized during launch to accommodate non-technical users like healthcare workers, supply managers, and rural health administrators. The system interfaces' seamless integration with workflows allows real-time data entry and retrieval without disrupting operations. Comprehensive user training using manuals, quick reference aids, and hands-on workshops increased learnability and usability. Based on survey, interview, and direct observation input, dashboard layout, alert display, navigation structure, and reporting functions were improved. These improvements allowed users to prepare reports, respond to warnings, and analyze inventory data without much cognitive effort or training.

Continuous quality improvement with agile deployment

ISO/IEC 25010-compliant agile principles improved quality after deployment. Methodical user input analysis enhanced alert accuracy, visualization clarity, performance, and dependability through regular system improvements. Due to its versatility, the system can accommodate several rural health units, various forecasting models, and seasonal demand variations without a major redesign.

Overall Impact on Rural Health Services

AISOF achieved high user acceptance and operational integration in rural health facilities by focusing on performance efficiency, dependability, and usability. Predictive forecasting and real-time inventory tracking improved purchase planning, reduced stockouts and overstocking, and ensured medicine delivery. The deployment approach aligned with ISO/IEC 25010 increased analytically based decision-making in rural healthcare delivery by making the system technically sound, useful, reliable, and user-centered.

Fig 18: Deployment Phase of AISOF

Part 2: IT Experts' Evaluation of the AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services

The following tables present the technical qualities of the developed AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services, based on ISO 25010 Software Product Quality Standards, assessed by the IT Experts.

2.1 Functional Suitability

Table 17 presents the IT experts' evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in terms of functional suitability. Functional suitability refers to the degree to which a system provides functions that meet stated and implied needs under specified conditions.

Table 14*:* IT Experts' Evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in Terms of Functional Suitability

S. No	Functional Suitability	Mean	Verbal Description
1	Functional completeness. Set of functions covers all the specified tasks and user objectives.	4.00	Highly Functional
2	Functional correctness. Provides the correct results with the needed degree of precision.	4.00	Highly Functional
3	Functional appropriateness. The functions facilitate the accomplishment of specified tasks and objectives.	4.00	Highly Functional
	Overall Mean	4.00	Highly Functional

As reflected in the table, all indicators under functional suitability obtained a mean score of 4.00, which is verbally described as Highly Functional. Statistically, a mean value of 4.00 indicates a consistently high level of agreement among the IT experts regarding the system's functional performance.

Specifically, Functional completeness, which evaluates whether the system's set of functions covers all specified tasks and user objectives, yielded a mean of 4.00. This statistically signifies that AISOF adequately provides all essential functionalities required for inventory monitoring, medicine movement analysis, ordering processes, and reporting activities within the Rural Health Unit.

Likewise, Functional correctness, which measures the accuracy and precision of system outputs, also obtained a mean of 4.00. From a statistical standpoint, this result suggests that the system reliably produces correct outputs with minimal variance, indicating dependable system computations and accurate data processing.

Similarly, Functional appropriateness, which assesses how effectively system functions facilitate the accomplishment of specified tasks and objectives, recorded a mean of 4.00. This result statistically implies that the system functions are well-aligned with user operational requirements and effectively support task completion.

AISOF achieved an overall mean of 4.00, verbally interpreted as Highly Functional. Statistically, this overall mean indicates that the system has fully met both stated and implied functional requirements, with a high level of consistency in expert evaluations. The results further imply that no significant functional deficiencies were identified during the assessment, confirming the system's strong functional suitability.

Functional suitability, as defined in ISO/IEC 25010 (2011), ensures that a system delivers complete, correct, and appropriate functions to meet user needs. Studies show that aligning system functions with organizational goals and user workflows significantly improves system effectiveness and satisfaction (Puspaningrum *et al.*, 2017 [67]; Kholifah *et al.*, 2023). Research in web and mobile systems further confirms that functional completeness and correctness enhance service quality, user trust, and system acceptance, making functional suitability a critical quality attribute in evaluating systems such as AISOF (Pratama *et al.*, 2020; Ariningsih *et al.*, 2024 [12]).

Chukwu *et al.* (2020) [20] and Ndong *et al.* (2020) [46] show that digital forecasting tools support functional suitability by delivering accurate and timely data for inventory planning. Improved data analysis enables more precise demand forecasting, reducing overstocking and shortages. This supports AISOF's analytics function by enabling proactive decision-making and minimizing reliance on manual estimates.

2.2 Performance Efficiency

Table 18 presents the IT experts' evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in terms of performance efficiency. Performance efficiency refers to the system's ability to deliver appropriate performance relative to the amount of resources used under stated conditions.

Table 15: IT Experts' Evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in Terms of Performance Efficiency

S. No	Performance Efficiency	Mean	Verbal Description
1	Time behavior. The response and processing time and throughput rate of the system meet the requirements when it functions.	4.00	Highly Efficient
2	Resource utilization. The amount and type of resources used by the system meet the requirements when it functions.	3.80	Highly Efficient
3	Capacity. The maximum parameter limits of the AISOF developed meet requirements.	4.00	Highly Efficient
	Overall Mean	3.93	Highly Efficient

As shown in the table, all indicators under performance efficiency obtained mean scores ranging from 3.80 to 4.00, which are verbally described as Highly Efficient. Statistically, these mean values indicate a high level of agreement among IT experts regarding the system's efficient performance during operation.

Specifically, Time behavior, which measures the system's response time, processing time, and throughput rate, obtained a mean score of 4.00. This statistically indicates that AISOF responds promptly and processes data efficiently when performing tasks such as inventory updates, analytics computation, report generation, and medicine movement tracking, meeting the required performance standards.

The indicator Resource utilization, which evaluates whether the system uses an appropriate amount and type of computing resources during operation, recorded a mean score of 3.80, verbally interpreted as Highly Efficient. From a statistical perspective, this result suggests that AISOF efficiently utilizes system resources such as processing power, memory, and network bandwidth. Although slightly lower than the other indicators, the mean score still reflects a high level of efficiency and indicates that resource usage remains within acceptable operational limits.

Furthermore, Capacity, which assesses whether the system can handle maximum parameter limits such as data volume, number of users, and transaction load, obtained a mean score of 4.00. Statistically, this result signifies that AISOF is capable of accommodating the required workload without performance degradation, supporting concurrent users and large volumes of inventory and transaction data.

The AISOF achieved an overall mean of 3.93, verbally described as Highly Efficient. Statistically, this overall mean indicates that the system consistently demonstrates strong performance efficiency across all evaluated indicators. The results imply that AISOF operates effectively under expected conditions, with sufficient speed, optimal resource utilization, and adequate capacity to support inventory management and analytics functions within the Rural Health Unit. Performance efficiency, as defined in ISO/IEC 25010 (2011), refers to a system's ability to perform its functions within acceptable time and resource limits, measured through time behavior, resource utilization, and capacity. Research consistently highlights its importance in determining system quality and user satisfaction. Behl and Behl (2017) [16] emphasized that response time and processing speed are critical to scalability and reliability in enterprise systems. Similarly, Pratama, Putra, and Wijaya (2020) found that optimized response time and balanced resource utilization improve stability and user satisfaction in web-based information systems. In academic contexts, Kurniawan *et al.* (2021) identified time behavior as the most influential factor affecting system acceptance. More recently, Arifin, Nugroho, and Santoso (2023) demonstrated that efficient resource utilization and capacity planning enhance scalability and cost efficiency in cloud-based systems. Collectively, these studies underscore the vital role of performance efficiency in ensuring responsive, reliable, and scalable information systems.

2.3 Compatibility

Table 19 presents the IT experts' evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in terms of compatibility. Compatibility refers to the degree to which the system can operate effectively within a shared environment and interact with other system components or platforms without conflict.

Table 16: IT Experts' Evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in Terms of Compatibility

S. No	Compatibility	Mean	Verbal Description
1	Co-existence. The system can efficiently perform its functions while sharing common environment and resources with other products. It has no detrimental impact on any other product.	4.00	Highly Compatible
2	Inter-operability. Two or more system components can exchange information and use the information that has been exchanged.	3.80	Highly Compatible
	Overall Mean	3.90	Highly Compatible

As shown in the table, the indicators under compatibility obtained mean scores ranging from 3.80 to 4.00, which are verbally described as Highly Compatible. Statistically, these mean values indicate a high level of agreement among the IT experts regarding the system's ability to function properly within its operational environment and to interact with other system components.

Specifically, Co-existence, which evaluates the system's ability to efficiently perform its functions while sharing common environments and computing resources with other applications, obtained a mean score of 4.00. This statistically indicates that AISOF can operate reliably alongside other systems without causing performance degradation or interference, demonstrating stable system behavior within a shared infrastructure.

Meanwhile, Inter-operability, which measures the capability of system components to exchange information and effectively use the data exchanged, recorded a mean score of 3.80, verbally interpreted as Highly Compatible. From a statistical standpoint, this result suggests that AISOF supports effective data interaction among its internal components, such as inventory management, analytics processing, reporting modules, and database services.

Although slightly lower than the co-existence indicator, the score still reflects strong interoperability and reliable information exchange within the system.

AISOF achieved an overall mean of 3.90, verbally described as Highly Compatible. Statistically, this overall mean indicates that the system demonstrates a high degree of compatibility in terms of both co-existence and interoperability. The results imply that AISOF can function effectively within a shared operational environment and maintain seamless interaction among its components, supporting stable and integrated system performance in the Rural Health Unit setting.

Compatibility, as defined in ISO/IEC 25010 (2011), refers to a system's ability to exchange information and operate effectively within a shared environment through interoperability and co-existence. Research shows that well-designed interfaces and standardized data exchange mechanisms improve interoperability, reduce maintenance costs, and support system scalability (Pressman & Maxim, 2020; Rochimah *et al*., 2018) [59, 69]. Studies in web-based and cloud systems further demonstrate that strong compatibility enhances system reliability, service continuity, and user satisfaction, supporting its importance in integrated information systems such as AISOF (Pratama *et al*., 2020; Arifin *et al*., 2023).

2.4 Usability

Table 20 presents the IT experts' evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in terms of usability. Usability refers to the degree to which the system can be used by specified users to achieve specified goals with effectiveness, efficiency, satisfaction, and minimal risk in a defined context of use.

Table 17: IT Experts' Evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in Terms of Usability

S. No	Usability	Mean	Verbal Description
1	Appropriateness and recognizability. Users can recognize whether the system is appropriate for their needs.	4.00	Highly Usable
2	Learnability. The system can be used by specified users to achieve specified goals of learning: to use the system with effectiveness, efficiency, freedom from risk and satisfaction in a specified context of use.	4.00	Highly Usable
3	Operability. The system has attributes that make it easy to operate and control.	4.00	Highly Usable
4	User error protection. The system protects users against making errors.	4.00	Highly Usable
5	User interface aesthetics. The user interface of the system enables pleasing and satisfying interaction for the user.	4.00	Highly Usable
6	Accessibility. The system can be used by people with the widest range of characteristics and capabilities to achieve a specified goal in a specified context of use.	3.20	Usable
	Overall Mean	3.87	Highly Usable

As shown in the table, the indicators under usability obtained mean scores ranging from 3.20 to 4.00, with verbal descriptions of Usable to Highly Usable. Statistically, these results indicate a generally high level of agreement among IT experts regarding the system's usability, with minor variation across specific usability attributes.

Specifically, Appropriateness and recognizability, which assesses whether users can easily recognize that the system is suitable for their operational needs, obtained a mean score of 4.00, verbally described as Highly Usable. This statistically indicates that AISOF is clearly aligned with the intended functions of inventory management, medicine movement analysis, and reporting within the Rural Health Unit.

Similarly, Learnability recorded a mean score of 4.00, indicating that users can easily learn how to use the system effectively and efficiently. From a statistical perspective, this result suggests that AISOF allows new users to quickly understand system functions, navigate modules, and perform required tasks with minimal training.

The indicator Operability, which measures how easily users can operate and control the system, also obtained a mean score of 4.00. This statistically implies that AISOF provides intuitive controls and system behavior that support smooth and efficient user interaction during routine operations. Likewise, User error protection received a mean score of 4.00, indicating that the system effectively minimizes user errors through validation mechanisms, confirmations, and controlled inputs. Statistically, this reflects a high level of system support in preventing incorrect operations and data inconsistencies. User interface aesthetics, which evaluates the visual appeal and satisfaction provided by the system interface, also achieved a mean score of 4.00. This result statistically suggests that the design, layout, and visual elements of AISOF contribute positively to user satisfaction and interaction quality.

In contrast, Accessibility obtained a lower mean score of 3.20, verbally described as Usable. Statistically, this result indicates that while the system is generally accessible to users, there is room for improvement in supporting a wider range of user characteristics and capabilities, such as enhanced visual accessibility features or alternative interaction options.

Overall, AISOF achieved an overall mean of 3.87, verbally interpreted as Highly Usable. Statistically, this overall mean indicates that the system demonstrates strong usability characteristics, with most indicators showing consistently high evaluations. The results suggest that AISOF is user-friendly, easy to learn, and efficient to operate, while also highlighting accessibility as a potential area for future enhancement.

Usability, as defined in ISO/IEC 25010 (2011), concerns how effectively, efficiently, and satisfactorily users achieve their goals through system interaction. Studies consistently show that high usability particularly in learnability, operability, and interface design significantly improves user satisfaction, retention, and system effectiveness (Almarabeh & Qabajah, 2020; Ramadani & Mahdiana, 2024 [68]). Research also indicates that usability issues, such as unclear navigation and poor interface clarity, reduce task efficiency and increase redesign costs, underscoring the need to prioritize usability early in system development (Kurniawan *et al*., 2021; Kholifah *et al*., 2023).

2.5 Reliability

Table 21 presents the IT experts' evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in terms of reliability. Reliability refers to the degree to which the system consistently performs specified functions under stated conditions for a specified period of time.

Table 18: IT Experts' Evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in Terms of Reliability

S. No	Reliability	Mean	Verbal Description
1	Maturity. The system meets needs for reliability under normal operation.	3.80	Highly Reliable
2	Availability. It is operational and accessible when required for use.	4.00	Highly Reliable
3	Fault tolerance. It operates as intended despite the presence of hardware or software faults.	4.00	Highly Reliable
4	Recoverability. In the event of an interruption or a failure, the system can recover the data directly affected and re-establish the desired state of the system.	4.00	Highly Reliable
	Overall Mean	3.95	Highly Reliable

As shown in the table, the indicators under reliability obtained mean scores ranging from 3.80 to 4.00, all of which are verbally described as Highly Reliable. Statistically, these mean values indicate a high level of agreement among IT experts regarding the system's dependable and stable operation.

Specifically, Maturity, which measures the system's ability to meet reliability requirements during normal operation, obtained a mean score of 3.80. Statistically, this result suggests that AISOF operates consistently and reliably during routine use, with minimal occurrence of errors or unexpected behavior. Although slightly lower than the other indicators, the mean still reflects a high level of reliability under normal operating conditions.

The indicator Availability, which evaluates whether the system is operational and accessible when required for use, recorded a mean score of 4.00. This statistically indicates that AISOF maintains consistent uptime and can be accessed reliably by authorized users during operational hours, supporting uninterrupted inventory and healthcare service activities.

Similarly, Fault tolerance obtained a mean score of 4.00, indicating that the system continues to operate as intended even in the presence of minor hardware or software issues. From a statistical perspective, this result suggests that AISOF demonstrates resilience against system faults, allowing ongoing operations without significant disruption.

In addition, Recoverability, which assesses the system's capability to restore affected data and return to a stable state following a failure or interruption, also achieved a mean score of 4.00. Statistically, this indicates that AISOF is capable of effectively recovering from unexpected interruptions, thereby reducing the risk of data loss and ensuring continuity of operations. AISOF obtained an overall mean of 3.95, verbally interpreted as Highly Reliable. Statistically, this overall mean reflects a consistently high evaluation across all reliability indicators, confirming that the system demonstrates dependable performance, resilience, and stability. These results suggest that AISOF is capable of supporting continuous and reliable inventory management and analytics operations within the Rural area.

Reliability, as defined in ISO/IEC 25010 (2011), is a system's ability to consistently perform functions over time, evaluated through maturity, availability, and fault tolerance. Studies show that high availability, effective error handling, and robust recovery mechanisms enhance user satisfaction, trust, and acceptance across web, academic, mobile, and cloud-based systems (Pratama *et al*., 2020; Kurniawan *et al*., 2021; Arifin *et al*., 2023; Almarabeh & Qabajah, 2020). These findings confirm reliability as a critical quality attribute for system stability and long-term adoption.

Studies by Yadav (2015) [83], the Global Fund (2023) [28], Gavi (2020) [27], and Vledder *et al*. (2019) [81] show that real-time digital inventory systems strengthen reliability, particularly availability and fault tolerance, by reducing stockouts and ensuring continuous access to essential medicines. Accurate, real-time stock visibility minimizes replenishment delays and supply failures, as evidenced by eLMIS-supported systems that significantly lowered stockout frequency and duration (Vledder *et al*., 2019) [81]. These findings indicate that AISOF can enhance RHU service reliability by maintaining medicine availability and supporting timely recovery from supply disruptions.

2.6 Security

Table 22 presents the IT experts' evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in terms of security. Security refers to the degree to which the system protects information and data so that unauthorized persons or systems cannot access, modify, or misuse them.

Table 22: IT Experts' Evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in Terms of Security

S. No	Security	Mean	Verbal Description
1	Confidentiality. The system ensures that data are accessible only to those authorized to have access.	3.80	Highly Secured
2	Integrity. It prevents unauthorized access to, or modification of, computer programs or data.	4.00	Highly Secured
3	Non-repudiation. Its actions or events can be proven to have taken place, so that the events or actions cannot be repudiated later.	4.00	Highly Secured
4	Accountability. Actions of the entity can be traced uniquely to the entity.	4.00	Highly Secured
5	Authenticity. It can prove that the identity of a subject or resource is the one claimed.	3.80	Highly Secured
	Overall Mean	3.92	Highly Secured

As shown in the table, the security indicators obtained mean scores ranging from 3.80 to 4.00, all of which are verbally described as Highly Secured. Statistically, these mean values indicate a high level of agreement among the IT experts regarding the effectiveness of the system's security mechanisms.

Specifically, Confidentiality, which assesses whether data are accessible only to authorized users, obtained a mean score of 3.80. Statistically, this result suggests that AISOF adequately restricts access to sensitive inventory, patient, and system data through authentication and role-based access control mechanisms. Although slightly lower than other indicators, the score still reflects a high level of data confidentiality.

The indicator Integrity, which evaluates the system's ability to prevent unauthorized access to or modification of programs and data, recorded a mean score of 4.00. This statistically indicates that AISOF effectively safeguards data accuracy and consistency, ensuring that system records such as inventory levels, transaction logs, and analytics results are protected from unauthorized alteration.

Similarly, Non-repudiation obtained a mean score of 4.00, indicating that system actions and events can be reliably traced and verified. From a statistical perspective, this result suggests that AISOF maintains sufficient records and logs to ensure that transactions and user actions cannot be denied after they occur.

The indicator Accountability, which measures the ability to uniquely trace actions to specific users, also achieved a mean score of 4.00. Statistically, this reflects that AISOF effectively records user activities, thereby supporting audit trails and reinforcing responsibility and transparency within system operations.

Finally, Authenticity, which evaluates whether the system can verify the identity of users and resources, obtained a mean score of 3.80. Statistically, this result implies that AISOF reliably authenticates users through secure login mechanisms, although there remains potential for further enhancement in identity verification features.

AISOF achieved an overall mean of 3.92, verbally interpreted as Highly Secured. Statistically, this overall mean indicates that the system demonstrates strong security characteristics across all evaluated indicators. The findings suggest that AISOF effectively protects sensitive data, ensures traceability of user actions, and maintains secure access controls, making it suitable for deployment in a healthcare inventory management environment.

Security, a core ISO/IEC 25010 (2023) quality characteristic, refers to a system's ability to protect information and control access through confidentiality, integrity, non-repudiation, accountability, and authenticity. Studies show that applying these sub-characteristics enhances data protection, user accountability, and system trustworthiness across web, cloud, and enterprise systems. Case studies demonstrate that ISO/IEC 25010 provides a systematic framework to identify and address security issues, confirming security as essential for system resilience, compliance, and user confidence.

2.7 Maintainability

Table 23 presents the IT experts' evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in terms of maintainability. Maintainability refers to the degree to which the system can be effectively and efficiently modified, analyzed, and improved to correct defects, enhance performance, or adapt to changes in requirements.

Table 19: IT Experts' Evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in Terms of Maintainability

S. No	Maintainability	Mean	Verbal Description
1	Modularity. The system is composed of distinct components such that a change to one component has minimal impact on other components.	4.00	Highly Maintainable
2	Reusability. The asset can be used in more than one system, or in building other assets.	4.00	Highly Maintainable
3	Analyzability. It is possible to assess the impact of the AISOF System on an intended change to one or more of its parts, or to diagnose the system for deficiencies or causes of failures, or to identify parts to be modified.	4.00	Highly Maintainable
4	Modifiability. The system can be effectively and efficiently modified without introducing defects or degrading existing product quality.	4.00	Highly Maintainable
	Overall Mean	4.00	Highly Maintainable

As shown in the table, all maintainability indicators obtained a mean score of 4.00, each verbally described as Highly Maintainable. Statistically, these results indicate unanimous and very high agreement among IT experts regarding the system's ease of maintenance and adaptability.

Specifically, Modularity, which measures whether the system is composed of distinct and independent components, obtained a mean score of 4.00. Statistically, this result suggests that AISOF is well-structured into separate modules, allowing changes or updates in one component to have minimal impact on other parts of the system. This design characteristic supports efficient maintenance and reduces the risk of system-wide issues during updates.

The indicator Reusability, which evaluates whether system assets can be used in other systems or in the development of additional components, also recorded a mean score of 4.00. Statistically, this implies that AISOF components, such as its inventory management logic and analytics modules, are designed in a way that allows them to be reused or extended for future system enhancements or related applications.

Similarly, Analyzability obtained a mean score of 4.00, indicating that the system can be easily assessed to identify deficiencies, determine causes of failures, or evaluate the impact of proposed changes. From a statistical perspective, this reflects that AISOF provides clear system structure, logs, and documentation that facilitate efficient diagnosis and evaluation during maintenance activities. Furthermore, Modifiability, which measures the system's ability to be modified without introducing defects or degrading existing quality, also achieved a mean score of 4.00. Statistically, this suggests that AISOF can be updated or enhanced efficiently while preserving its functional integrity, making it suitable for long-term use and continuous improvement.

AISOF obtained an overall mean of 4.00, verbally interpreted as Highly Maintainable. Statistically, this perfect mean score indicates a very strong consensus among IT experts that the system exhibits excellent maintainability characteristics. These findings confirm that AISOF is well-designed for ongoing maintenance, future enhancements, and scalability, ensuring its long-term sustainability and effectiveness in supporting inventory and supply management operations in rural health service environments. Here's a super-succinct 3–4 sentence version.

Maintainability, per ISO/IEC 25010, refers to how easily software can be modified, encompassing modularity, analyzability, modifiability, reusability, and testability (ISO/IEC, 2011). Studies show that modular, analyzable code and tools mapping maintainability metrics to ISO sub-characteristics improve software evolution and long-term sustainability (Dewi *et al*., 2020 [24]; SEI; TIOBE). These findings confirm maintainability as a key quality attribute for supporting system updates and longevity.

2.8 Portability

Table 24 presents the IT experts' evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in terms of portability. Portability refers to the degree to which the system can be transferred, installed, or adapted to different hardware, software, or operational environments without requiring extensive modification.

Table 20: IT Experts' Evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in Terms of Portability

S. No	Portability	Mean	Verbal Description
1	Adaptability. The system can effectively and efficiently be adapted for different or evolving hardware, software or other operational or usage environments.	3.80	Highly Portable
2	Installability Effectiveness and efficiency with which the system can be successfully installed and/or uninstalled in a specified environment.	4.00	Highly Portable
3	Replaceability. The system can replace another specified software product for the same purpose in the same environment.	3.80	Highly Portable
	Overall Mean	3.87	Highly Portable

As shown in the table, the portability indicators obtained mean scores ranging from 3.80 to 4.00, all of which are verbally described as Highly Portable. Statistically, these mean values indicate a strong level of agreement among IT experts regarding the system's ability to operate effectively across different computing environments.

Specifically, Adaptability, which measures the system's capability to be efficiently adapted to evolving hardware, software, or operational conditions, obtained a mean score of 3.80. Statistically, this result suggests that AISOF can be deployed across various environments with minimal adjustments, although certain configurations may still be required depending on infrastructure constraints such as network availability or server settings.

The indicator Installability, which evaluates the effectiveness and efficiency with which the system can be installed or uninstalled in a specified environment, recorded a mean score of 4.00. From a statistical perspective, this indicates that AISOF can be deployed and configured smoothly, with installation procedures that are straightforward and manageable for system administrators.

Similarly, Replaceability obtained a mean score of 3.80, indicating that AISOF can replace existing inventory and supply management systems within the same operational environment. Statistically, this implies that AISOF is compatible with standard workflows and data structures commonly used in healthcare inventory systems, allowing for system migration with minimal disruption.

AISOF achieved an overall mean of 3.87, verbally interpreted as Highly Portable. Statistically, this overall mean reflects consistent positive evaluations across all portability indicators, confirming that the system can be deployed, adapted, and maintained across different environments. These results demonstrate that AISOF is suitable for implementation in various Rural Health Units and similar healthcare facilities, supporting scalability and wider adoption.

Portability, as defined by ISO/IEC 25010, refers to the degree to which software can be efficiently transferred and operated across different environments, including platforms and operating systems (ISO/IEC, 2023). It comprises adaptability, installability, and replaceability, which determine how easily a system can be deployed and integrated in varied contexts. Empirical studies applying ISO/IEC 25010 show that systems such as the MyITS Mobile application and Shopeepay achieve portability scores ranging from about 78% to 82%, indicating generally good cross-platform performance while revealing areas for improvement. These findings underscore portability as a critical quality attribute in both academic and commercial software systems.

Table 21: Summary of the IT Experts' Evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services

AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services	Overall Mean	Verbal Description
Functional Suitability	4.00	Highly Functional
Performance Efficiency	3.93	Highly Efficient
Compatibility	3.90	Highly Compatible
Usability	3.87	Highly Usable
Reliability	3.95	Highly Reliable
Security	3.92	Highly Secured
Maintainability	4.00	Highly Maintainable
Portability	3.87	Highly Portable
Grand Mean	3.93	Excellent System Quality

Table 25 presents the summary of the IT experts' evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services based on the eight quality characteristics defined in the ISO/IEC 25010 Software Product Quality Model.

As shown in the table, Functional Suitability and Maintainability both obtained the highest overall mean of 4.00, verbally described as Highly Functional and Highly Maintainable, respectively. Statistically, these results indicate a very high level of agreement among IT experts that AISOF fully satisfies user requirements and objectives, and that its system architecture supports efficient maintenance, modification, and long-term sustainability.

Reliability obtained an overall mean of 3.95, while Performance Efficiency and Security recorded overall means of 3.93 and 3.92, respectively. These values are all verbally interpreted as Highly Reliable, Highly Efficient, and Highly Secured. Statistically, these results suggest that AISOF demonstrates stable operation, efficient system response, and strong data protection mechanisms, making it suitable for continuous use in a healthcare inventory management environment.

Meanwhile, Compatibility, Usability, and Portability achieved overall mean scores of 3.90, 3.87, and 3.87, respectively, all verbally described as Highly Compatible, Highly Usable, and Highly Portable. From a statistical standpoint, these findings indicate that AISOF can operate effectively alongside other systems, is easy to use for intended users, and can be deployed across different environments with minimal configuration.

The grand mean of 3.93, verbally interpreted as Excellent System Quality, reflects an overall strong and consistent evaluation across all quality characteristics. Statistically, this grand mean indicates a high degree of consensus among IT experts regarding the system's technical soundness, robustness, and readiness for real-world deployment.

The results confirm that AISOF meets and exceeds established software quality standards under ISO/IEC 25010. The consistently high mean scores across all evaluated criteria demonstrate that the system is functionally complete, efficient, secure, reliable, maintainable, and portable. These findings support the conclusion that AISOF is a technically sound and high-quality system capable of effectively supporting inventory management, supply ordering, and analytic-based forecasting in Rural Health Units.

The grand mean of 3.93, interpreted as Excellent System Quality, indicates strong consensus among IT experts on AISOF's technical soundness and readiness for deployment. These results align with previous studies showing that systems with high functional suitability, reliability, security, maintainability, and portability achieve improved user satisfaction, performance, and long-term sustainability (Dewi *et al*., 2020 [24]; Pratama *et al*., 2020; Arifin *et al*., 2023; SEI; TIOBE). Collectively, these findings confirm that AISOF is a high-quality system capable of supporting inventory management, supply ordering, and data-driven forecasting in Rural Health Units.

Part 3: End-Users' Evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services

The end users' evaluation of AISOF focused on its efficacy, usability, and general acceptability in rural health service inventory and supply management. Real system users were surveyed to determine how well AISOF met operational needs, improved decision-making, and supported normal healthcare chores. The data reveal how well the system works in a rural health unit.

3.1 Functional Suitability

Table 26 presents the end-users' evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in terms of functional suitability, as defined in the ISO/IEC 25010:2011 Software Product Quality Model. According to ISO/IEC 25010:2011, functional suitability refers to the degree to which a software product provides functions that meet stated and implied needs under specified conditions.

Table 26: End-Users' Evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in Terms of Functional Suitability

S. No	Functional Suitability	Mean	Verbal Description
1	Functional completeness. Set of functions covers all the specified tasks and user objectives.	3.96	Highly Functional
2	Functional correctness. Provides the correct results with the needed degree of precision.	3.96	Highly Functional
3	Functional appropriateness. The functions facilitate the accomplishment of specified tasks and objectives.	3.92	Highly Functional
	Overall Mean	3.95	Highly Functional

As shown in the table, all indicators under functional suitability obtained mean scores ranging from 3.92 to 3.96, all of which are verbally described as Highly Functional. Statistically, these mean values indicate a high level of agreement among end users regarding the system's ability to deliver the required functions in accordance with ISO/IEC 25010:2011 standards.

Specifically, Functional completeness, which corresponds to the ISO/IEC 25010:2011 sub-characteristic describing the extent to which all necessary functions are provided, obtained a mean score of 3.96. Statistically, this result indicates that end users perceived AISOF as capable of supporting all essential tasks related to inventory monitoring, medicine movement analysis, supply ordering, and reporting within the Rural Health Unit.

Similarly, Functional correctness, aligned with the ISO/IEC 25010:2011 sub-characteristic concerning the accuracy and precision of system outputs, also recorded a mean score of 3.96. From a statistical perspective, this suggests that end users found AISOF to produce accurate and reliable results, such as correct inventory counts, transaction records, and analytic outputs.

The indicator Functional appropriateness, which reflects the ISO/IEC 25010:2011 sub-characteristic assessing how well system functions facilitate the accomplishment of specified tasks and objectives, obtained a mean score of 3.92. Statistically, this implies that AISOF effectively supports user workflows and operational tasks, although minor enhancements could further improve task efficiency and usability.

Overall, AISOF achieved an overall mean of 3.95, verbally interpreted as Highly Functional. Statistically, this overall mean indicates that the system satisfies the functional suitability requirements outlined in ISO/IEC 25010:2011, as perceived by its end users.

A comparative analysis with the IT experts' evaluation, which yielded an overall mean of 4.00 for functional suitability, shows close alignment between technical assessment and end-user experience. Statistically, the minimal difference between the two groups indicates that AISOF not only complies with the functional suitability criteria of ISO/IEC 25010:2011 from a technical perspective but also demonstrates effective functional performance in real-world operational use at the Rural Health Unit.

The IT experts' mean of 4.00 for functional suitability aligns with end-user evaluations, showing AISOF meets ISO/IEC 25010 criteria and performs effectively in RHU operations. This supports prior findings that functional completeness and appropriateness improve user satisfaction and system effectiveness (Puspaningrum *et al*., 2017 [67]; Kholifah *et al*., 2023).

3.2 Performance Efficiency

Table 27 presents the end-users' evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in terms of performance efficiency, as defined in the ISO/IEC 25010:2011 Software Product Quality Model. According to ISO/IEC 25010:2011, performance efficiency refers to the performance of a system relative to the amount of resources used under stated conditions.

Table 22: End-Users' Evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in Terms of Performance Efficiency

S. No	Performance Efficiency	Mean	Verbal Description
1	Time behavior. The response and processing time and throughput rate of the system meet the requirements when it functions.	3.92	Highly Efficient
2	Resource utilization. The amount and type of resources used by the system meet the requirements when it functions.	3.96	Highly Efficient
3	Capacity. The maximum parameter limits of the AISOF developed meet requirements.	3.96	Highly Efficient
	Overall Mean	3.95	Highly Efficient

As shown in the table, the indicators under performance efficiency obtained mean scores ranging from 3.92 to 3.96, all of which are verbally described as Highly Efficient. Statistically, these mean values indicate a high level of agreement among end users regarding the system's efficient performance during actual operational use.

Specifically, Time behavior, which corresponds to the ISO/IEC 25010:2011 sub-characteristic measuring response time, processing time, and throughput rate, obtained a mean score of 3.92. Statistically, this result indicates that end users experienced timely system responses when performing tasks such as inventory updates, viewing analytics, generating reports, and recording medicine movements, with minimal delays during normal operation.

The indicator Resource utilization, aligned with the ISO/IEC 25010:2011 sub-characteristic assessing the efficient use of system resources, recorded a mean score of 3.96. From a statistical perspective, this suggests that AISOF operates efficiently without excessive consumption of computing resources, allowing smooth system use even during routine transactions and data processing activities.

Similarly, Capacity, which reflects the ISO/IEC 25010:2011 sub-characteristic evaluating the system's ability to handle maximum limits such as number of users, transactions, and data volume, also obtained a mean score of 3.96. Statistically, this implies that AISOF can accommodate the operational workload of the Rural Health Unit without noticeable degradation in system performance.

Overall, AISOF achieved an overall mean of 3.95, verbally interpreted as Highly Efficient. Statistically, this overall mean indicates that the system satisfies the performance efficiency requirements specified under ISO/IEC 25010:2011, as perceived by end users during real-world usage.

A comparative analysis with the IT experts' evaluation shows consistent results. While IT experts rated performance efficiency with an overall mean of 3.93, end users reported a slightly higher overall mean of 3.95. Statistically, this close alignment suggests that the system's technical performance efficiency is reflected in actual user experience, confirming that AISOF delivers efficient response times, optimal resource usage, and sufficient capacity in operational healthcare settings.

The present study demonstrated a close alignment between IT experts' ($\bar{x}$ = 3.93) and end users' ($\bar{x}$ = 3.95) evaluations of AISOF's performance efficiency, indicating that the system's technical performance is consistently reflected in actual operational use. This finding is consistent with previous studies which identified performance efficiency as a highly perceptible system quality attribute, often resulting in minimal variation between expert-based and user-based assessments when systems exhibit stable response times and efficient resource utilization (Behkamal *et al.*, 2014) [17]. Similar consistency was observed in healthcare information systems, where optimized system performance led to comparable evaluations from IT professionals and healthcare users (Kaya & Ertürk, 2020) [48]. Studies conducted in resource-constrained settings further reported that systems designed to function efficiently despite infrastructural limitations demonstrated strong agreement between technical evaluation and user experience (Alnanih *et al.*, 2019) [6]. Overall, the present findings support the Information Systems Success Model of DeLone and McLean (2003) [23], confirming that high performance efficiency contributes to positive user experience and reinforces AISOF's suitability for deployment in Rural Health Units.

3.3 Usability

Table 28 presents the end-users' evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in terms of usability, as defined in the ISO/IEC 25010:2011 Software Product Quality Model. According to ISO/IEC 25010:2011, usability refers to the degree to which a system can be used by specified users to achieve specified goals with effectiveness, efficiency, satisfaction, and minimal risk in a defined context of use.

Table 23: End-Users' Evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services in Terms of Usability

S. No	Usability	Mean	Verbal Description
1	Appropriateness and recognizability. Users can recognize whether the system is appropriate for their needs.	3.96	Highly Usable
2	Learnability. The system can be used by specified users to achieve specified goals of learning: to use the system with effectiveness, efficiency, freedom from risk and satisfaction in a specified context of use.	3.96	Highly Usable
3	Operability. The system has attributes that make it easy to operate and control.	3.92	Highly Usable
4	User error protection. The system protects users against making errors.	3.92	Highly Usable
5	User interface aesthetics. The user interface of the system enables pleasing and satisfying interaction for the user.	3.96	Highly Usable
6	Accessibility. The system can be used by people with the widest range of characteristics and capabilities to achieve a specified goal in a specified context of use.	3.96	Highly Usable
	Overall Mean	3.95	Highly Usable

As shown in the table, all usability indicators obtained mean scores ranging from 3.92 to 3.96, all of which are verbally described as Highly Usable. Statistically, these results indicate a high level of agreement among end users regarding the ease of use, clarity, and overall user experience provided by the system.

Specifically, Appropriateness and recognizability, which corresponds to the ISO/IEC 25010:2011 sub-characteristic assessing whether users can easily recognize the system's suitability for their needs, obtained a mean score of 3.96. Statistically, this result suggests that end users clearly perceived AISOF as appropriate for inventory management, medicine tracking, and reporting activities within the Rural Health Unit.

Similarly, Learnability, aligned with the ISO/IEC 25010:2011 sub-characteristic measuring how easily users can learn to use the system effectively and efficiently, also recorded a mean score of 3.96. From a statistical standpoint, this indicates that end users were able to quickly understand system functions and perform required tasks with minimal training and reduced risk of errors.

The indicator Operability, which evaluates the ease with which users can operate and control the system, obtained a mean score of 3.92. Statistically, this implies that AISOF provides intuitive controls and system behavior that support smooth daily operations, although minor refinements could further enhance operational efficiency.

Likewise, User error protection achieved a mean score of 3.92, indicating that the system effectively assists users in preventing or minimizing errors through validations, confirmations, and controlled inputs. Statistically, this reflects a high level of system support in maintaining accurate and consistent data entry.

User interface aesthetics, which assesses the visual appeal and satisfaction derived from system interaction, obtained a mean score of 3.96. This statistically suggests that the system's layout, design, and visual presentation contribute positively to user satisfaction and engagement.

Finally, Accessibility, corresponding to the ISO/IEC 25010:2011 sub-characteristic measuring the system's ability to accommodate users with varying characteristics and capabilities, also recorded a mean score of 3.96. Statistically, this indicates that AISOF is generally accessible to a wide range of end users within the Rural Health Unit, supporting inclusive system use.

AISOF achieved an overall mean of 3.95, verbally interpreted as Highly Usable. Statistically, this overall mean confirms that the system satisfies the usability requirements outlined in ISO/IEC 25010:2011, as perceived by end users during actual system operation.

A comparative analysis with the IT experts' evaluation further supports this finding. While IT experts rated usability with an overall mean of 3.87, end users reported a higher overall mean of 3.95. Statistically, this difference suggests that actual system users experienced a more favorable level of usability during real-world operation, reinforcing that AISOF's interface design and interaction mechanisms are well-suited to its intended users.

The higher usability rating from end users ($\bar{x}$ = 3.95) compared to IT experts ($\bar{x}$ = 3.87) is consistent with previous studies indicating that usability is often rated more favorably by actual users due to direct interaction with the system. Prior research noted that ease of use and interface clarity are best assessed through real-world use, leading to higher user evaluations than expert assessments (Behkamal *et al*., 2014) [17]. Similar findings in healthcare information systems confirm that user-centered design results in more positive usability perceptions among end users (Kaya & Ertürk, 2020) [48].

Table 24: Summary of the End-Users' Evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services

AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services	Overall Mean	Verbal Description
Functional Suitability	3.95	Highly Functional
Performance Efficiency	3.95	Highly Efficient
Usability	3.95	Highly Usable
Grand Mean	3.95	Excellent System Quality

Table 29 presents the summary of the end-users' evaluation of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services based on selected quality characteristics of the ISO/IEC 25010:2011 Software Product Quality Model, namely functional suitability, performance efficiency, and usability.

As shown in the table, Functional Suitability, Performance Efficiency, and Usability each obtained an identical overall mean score of 3.95, all verbally interpreted as Highly Functional, Highly Efficient, and Highly Usable, respectively. Statistically, these equal mean values indicate a consistently high level of agreement among end users across all evaluated quality characteristics, suggesting a balanced and well-performing system from the users' perspective.

The overall evaluation resulted in a grand mean of 3.95, verbally described as Excellent System Quality. Statistically, this grand mean reflects a strong positive perception of AISOF by its end users, indicating that the system meets user expectations in terms of providing complete and appropriate functions, efficient system performance, and ease of use during actual operation.

These results demonstrate that AISOF complies with the relevant quality requirements outlined in ISO/IEC 25010:2011, particularly those most critical from an end-user standpoint. The consistently high mean scores suggest that the system effectively supports daily inventory management, medicine movement tracking, and operational decision-making within the Rural Health Unit.

When compared with the IT experts' evaluation, which yielded a grand mean of 3.93, the end-users' grand mean of 3.95 indicates close alignment between technical assessment and actual user experience. Statistically, this minimal difference implies that AISOF's technical quality is successfully translated into practical usability and operational effectiveness, further validating the system's readiness for real-world deployment.

Overall, the end-users' evaluation confirms that AISOF demonstrates excellent system quality, reinforcing its suitability as a reliable, efficient, and user-centered solution for analytic-based inventory and supply management in rural healthcare settings.

The close alignment between IT experts' and end users' evaluations in the present study is consistent with previous findings showing that minimal variance between technical and user assessments indicates effective translation of system quality into real-world use (DeLone & McLean, 2003; Alnanih *et al*., 2019) [23, 6]. Similar studies on healthcare information systems reported that such alignment reflects system readiness, reliability, and user-centered design in operational settings (Kaya & Ertürk, 2020) [48].

Part 4: End-Users' Evaluation of the Acceptability of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services

The level of effectiveness of the implementation of the developed system was assessed using eight (7) statements that describe the system's overall function. Respondents used a rating scale to evaluate the system.

Table 25: End-Users' Evaluation of the Acceptability of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services

S. No	Acceptability	Mean	Verbal Description
1	AISOF provides accurate and reliable information for inventory and supply management.	3.92	Highly Acceptable
2	The AISOF interface is user-friendly and easy to navigate.	3.96	Highly Acceptable
3	AISOF efficiently provides real-time updates on inventory status and supply levels.	3.92	Highly Acceptable
4	AISOF is accessible and usable by different types of users (RHU Admin and RHU personnel).	3.96	Highly Acceptable
5	AISOF responds quickly to user inputs and processes tasks in a timely manner.	3.88	Highly Acceptable
6	AISOF significantly enhances workflow and operational efficiency in the RHU.	3.96	Highly Acceptable
7	AISOF is stable and does not encounter errors or system crashes.	3.96	Highly Acceptable
	Overall Mean	3.94	Highly Acceptable

Table 30 presents the end-users' evaluation of the acceptability of AISOF: Analytic-Based Inventory and Supplies Ordering with Forecasting for Enhancing Rural Health Services. Acceptability refers to the degree to which the system is perceived by users as useful, satisfactory, and appropriate for supporting their operational tasks in a real-world setting.

As shown in the table, all acceptability indicators obtained mean scores ranging from 3.88 to 3.96, all of which are verbally described as Highly Acceptable. Statistically, these mean values indicate a strong level of agreement among end users regarding the system's overall usefulness, efficiency, and reliability in supporting inventory and supply management operations at the Rural Health Unit.

Specifically, the indicator "AISOF provides accurate and reliable information for inventory and supply management" obtained a mean score of 3.92, suggesting that end users perceive the system's data outputs such as inventory levels, stock movement records, and analytic insights as dependable and trustworthy for decision-making purposes.

The indicator related to user-friendliness and ease of navigation recorded a mean score of 3.96, indicating that the system interface is intuitive and easy to use. Statistically, this result suggests that users can efficiently navigate system modules and perform required tasks with minimal difficulty.

Similarly, real-time updates on inventory status and supply levels achieved a mean score of 3.92, indicating that AISOF effectively supports timely monitoring of inventory conditions. This result highlights the system's capability to provide up-to-date information necessary for proactive inventory management.

The indicator assessing accessibility and usability for different types of users, including RHU administrators and personnel, also obtained a mean score of 3.96. Statistically, this suggests that AISOF accommodates varying user roles and responsibilities through appropriate access controls and interface design.

In terms of system responsiveness, AISOF obtained a mean score of 3.88, which remains within the Highly Acceptable range. Statistically, this indicates that the system responds promptly to user inputs and processes tasks efficiently, although minor improvements could further optimize response times.

Moreover, the indicator "AISOF significantly enhances workflow and operational efficiency in the RHU" recorded a mean score of 3.96, reflecting strong user agreement that the system positively contributes to streamlining inventory processes, reducing manual workload, and improving overall operational efficiency.

Finally, system stability, measured by the absence of frequent errors or system crashes, also achieved a mean score of 3.96, indicating that users perceive AISOF as a stable and dependable system during daily operations.

Overall, AISOF obtained an overall mean of 3.94, verbally interpreted as Highly Acceptable. Statistically, this overall mean reflects a high level of user satisfaction and acceptance of the system. The results confirm that AISOF is well-received by its intended users and is considered effective, reliable, and beneficial in supporting inventory and supply management processes within the Rural Health Unit. Here are specific sources of previous studies you can cite to compare with your present finding on AISOF user satisfaction. According to (Saghaeiannejad-Isfahani *et al.*, 2014) [71] found that users of hospital information systems reported *relatively good satisfaction* in medical-teaching hospitals, supporting that healthcare IT systems can achieve positive acceptance levels. Meanwhile, Herwati *et al.* (2023) showed that users of a hospital management information system (SIMRS) expressed satisfaction overall using the End User Computing Satisfaction (EUCS) method, aligning with your findings of high acceptance. (Herwati, Ayu, & Mustafida, 2023). On the other hand, Meiyana *et al.* (2023) similarly reported significant satisfaction among healthcare providers with hospital management information systems and highlighted the importance of usability factors.

Further, Ferdiana & Pramono demonstrated that multiple system quality aspects (performance, control, service) significantly influence user satisfaction with hospital information systems, consistent with the present study's emphasis on system effectiveness and reliability. (Ferdiana & Pramono, 2024) [26].

Conclusion and Recommendations

Conclusions

1. **AISOF was successfully developed in accordance with the Agile development model**
   The iterative and incremental development process ensured that system requirements were accurately translated into functional components, resulting in a robust and adaptable inventory and supply management system.
2. **AISOF conforms to the ISO/IEC 25010:2011 software quality standards**
   The system demonstrated high levels of functional suitability, performance efficiency, compatibility,

usability, reliability, security, maintainability, and portability, confirming its technical soundness and compliance with internationally recognized software quality criteria.

3. **AISOF exhibits effective system performance in operational use**
   End-user evaluations indicate that the system delivers accurate inventory data, efficient processing, and responsive system behavior, supporting routine inventory monitoring, medicine movement analysis, and supply ordering activities.
4. **AISOF is highly acceptable to its intended users**
   The acceptability results confirm that users perceive the system as user-friendly, reliable, stable, and beneficial in improving workflow efficiency and operational effectiveness within the Rural Health Unit.

Recommendations

Based on the conclusions of the study, the following recommendations are proposed:

1. The **Rural Health Unit (RHU) management** may adopt AISOF for routine inventory and supply management to leverage its robust and adaptable features developed through the Agile model.
2. **The RHU management and IT personnel** may implement and maintain AISOF in daily operations, ensuring continued adherence to ISO/IEC 25010:2011 standards for reliable and high-quality software performance.
3. **The RHU staff and administrators** may utilize AISOF for regular inventory monitoring and supply management to maximize operational efficiency and data accuracy.
4. **The RHU management** may continue to promote and integrate AISOF in daily operations, providing necessary training and support to ensure sustained user satisfaction and optimal workflow efficiency
5. **The Rural Health Unit** may continue to utilize and expand the analytic and forecasting capabilities of AISOF to further optimize inventory management, ensure timely resource availability, and support data-driven decision-making in healthcare service delivery**.**

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