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KidGuard: A Digital Immunization Hub for Rural Health Units

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Abstract: Immunization remains one of the most cost-effective public health interventions, yet gaps in coverage persist due to systemic inefficiencies in record-keeping, communication, and monitoring. In rural health units (RHUs) in the Philippines, reliance on paper-based immunization registries hinders timely reporting and contributes to missed vaccinations. This study describes the design, development, and evaluation of KidGuard, a digital vaccination and information hub tailored for the Peñaranda RHU in Nueva Ecija. Guided by the Design and Development Research (DDR) framework and implemented through Agile Systems Development Life Cycle (SDLC), KidGuard was built with core features including electronic child vaccination records, automated SMS reminders, and simplified reporting tools. System evaluation was conducted among RHU staff and parents using an ISO/IEC 25010-based instrument. Results indicate substantial improvements compared to the manual system, with highest gains in report generation speed (+3.5), transferability of records (+3.2), and communication of schedules (+2.6). Overall, KidGuard scored within the Agree to Strongly Agree range across all eight quality dimensions, with functionality (4.7) and usability (4.6) receiving the highest ratings. The findings affirm that a localized digital immunization hub can address persistent challenges in rural health service delivery. By enhancing efficiency, reliability, and communication, KidGuard not only strengthens the RHU's immunization program but also aligns with national efforts such as DigiVacc and global agendas like Immunization Agenda 2030. Future work should explore interoperability with national health platforms and expansion into broader maternal and child health tracking.

Keywords: *Immunization; Digital Health; Kidguard; Rural Health Unit; Design And Development Research; Agile SDLC.*

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I. INTRODUCTION

Childhood immunization remains one of the most cost-effective public health interventions, yet coverage gains stagnated and even regressed globally during and after the COVID-19 pandemic. In 2024, the World Health Organization (WHO) estimated that 14.3 million children were "zero-dose"—having missed even a first vaccination—while global DTP3 coverage sat at 85%, still below pre-pandemic performance [1]. In response, global partners launched The Big Catch-Up in 2023 to restore routine services and close immunity gaps, positioning recovery under the Immunization Agenda 2030 (IA2030) [2,3].

These global trends are mirrored locally. The Philippines has long operated an Expanded/Essential Programme on Immunization (EPI) [4], yet coverage has fluctuated for decades and dipped sharply in the 2010s–2020s due to service disruptions and demand-side hesitancy [5]. A recent UNICEF Philippines update notes a dramatic reduction in zero-dose children—from about 1,000,000 (2020–2021) to ~163,000 (2023)—following intensified catch-up activities such as Chikiting Ligtas and provincial campaigns, though risks of outbreaks (e.g., measles, pertussis) remain [4,6]. Sustaining these gains requires strengthening last-mile delivery and data systems that ensure timely, complete, and continuous vaccination across LGUs.

Digital transformation has emerged as a key lever to address information fragmentation, delayed reporting, and missed follow-ups. On 30 July 2025, the Department of Health (DOH), with UNICEF and the Government of Japan, launched DigiVacc, a suite of applications designed to replace paper-based child immunization records and support automated SMS reminders, offline recording, and near real-time monitoring [6]. This aligns with broader DOH strategies (e.g., Reach Every Purok, PIRIs) and global calls to modernize immunization information systems under IA2030. Evidence from LMICs

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indicates that SMS reminders and electronic immunization registries (EIRs) can improve schedule adherence and administrative efficiency [7,8].

Against this backdrop, this study designs and develops a streamlined, RHU-anchored KidGuard Vaccination & Information Hub for Peñaranda, Nueva Ecija, integrating appointment reminders, digital child registers, and RHU-level dashboards. The objectives are to (1) reduce missed opportunities and delays through automated caregiver nudges; (2) improve data completeness, timeliness, and transferability across barangay health stations and the RHU; and (3) evaluate software quality in use and product quality using ISO/IEC 25010 characteristics relevant to public-sector health information systems. Beyond a working prototype, the study contributes a municipality-level blueprint aligned with national (DigiVacc) directions and international guidance (IA2030), with pragmatic recommendations for scale-up to comparable rural settings.

II. REVIEW OF RELATED LITERATURE

Childhood immunization is consistently recognized as one of the most effective public health interventions, preventing 4–5 million deaths annually worldwide [1]. Despite this, global coverage has experienced stagnation and setbacks, particularly during the COVID-19 pandemic, where routine immunization services were disrupted, leaving millions of children unprotected (WHO/UNICEF, 2023). In response, the global Immunization Agenda 2030 (IA2030) and the Big Catch-Up campaign were launched to accelerate recovery and achieve universal coverage by emphasizing stronger data systems, local leadership, and digital innovation [2,3].

In the Philippines, challenges in sustaining immunization coverage are well-documented. Corpuz (2024) highlighted persistent delays in timeliness and regional disparities, leading to gaps that increase the risk of outbreaks of measles, pertussis, and other vaccine-preventable diseases [5]. UNICEF Philippines (2024) reported that the country successfully reduced the number of zero-dose children from approximately one million in 2021 to 163,000 in 2023, largely due to catch-up campaigns such as Chi kiting Ligtas [4]. However, the same report stressed that maintaining these gains requires resilient, technology-driven systems at the local level.

One major barrier has been the reliance on manual, paper-based records. Studies across low- and middle-income countries have shown that paper registries are prone to errors, delays, and inefficiencies in generating reports [8]. In the Philippines, similar challenges are seen in rural health units (RHUs), where fragmented reporting slows down monitoring and hinders timely communication with parents [6]. These systemic weaknesses underline the urgency of digital transformation in health service delivery.

Digital health solutions have shown promising results in enhancing immunization outcomes. Evidence from systematic reviews and randomized controlled trials demonstrates that SMS reminders significantly increase vaccination adherence [7,9]. Electronic immunization registries (EIRs), when properly implemented, improve coverage tracking, reduce missed doses, and enhance data accuracy [8]. In Vietnam, the introduction of an EIR strengthened national immunization monitoring by reducing duplicate records and enabling near real-time data exchange [10]. These findings align with the Philippines' 2025 launch of DigiVacc, a digital platform replacing manual vaccination cards and supporting text reminders for parents [6].

Beyond immunization, the evaluation of digital health systems has increasingly relied on international quality standards. The ISO/IEC 25010 framework is widely used to assess software product quality and quality in use, covering attributes such as functionality, reliability, usability, efficiency, maintainability, and portability [11]. Local studies in the Philippines have also adapted this model to evaluate health information systems, demonstrating its applicability in resource-limited hospital settings, where similar frameworks can be applied at the RHU level. [12]. Furthermore, Agile software development methods have gained traction in healthcare projects for their iterative, user-centered approach, allowing systems to evolve through continuous feedback [13].

Together, this body of literature highlights three crucial insights. First, immunization gaps remain a pressing concern in both global and Philippine contexts, requiring innovations that strengthen last-mile delivery. Second, digital interventions—particularly SMS reminders and EIRs—have demonstrated measurable benefits in improving coverage and efficiency. Third, frameworks such as ISO/IEC 25010 and Agile SDLC provide structured approaches to designing and evaluating systems that meet healthcare workers' needs while aligning with national digital health strategies. These insights provide the foundation for the design and development of Kid Guard, a localized vaccination and information hub for the Peñaranda RHU.

III. METHODOLOGY

- *Research Design*

This study employed a Design and Development Research (DDR) framework, which emphasizes the systematic creation and evaluation of educational and technological innovations [14]. DDR is particularly suitable in developing localized digital health solutions, as it accommodates iterative feedback from users and contextual adaptation. Complementing DDR, the Agile Systems Development Life Cycle (SDLC) methodology was used, allowing the system to be developed in incremental sprints, with continuous feedback from health workers ensuring relevance and usability [13].

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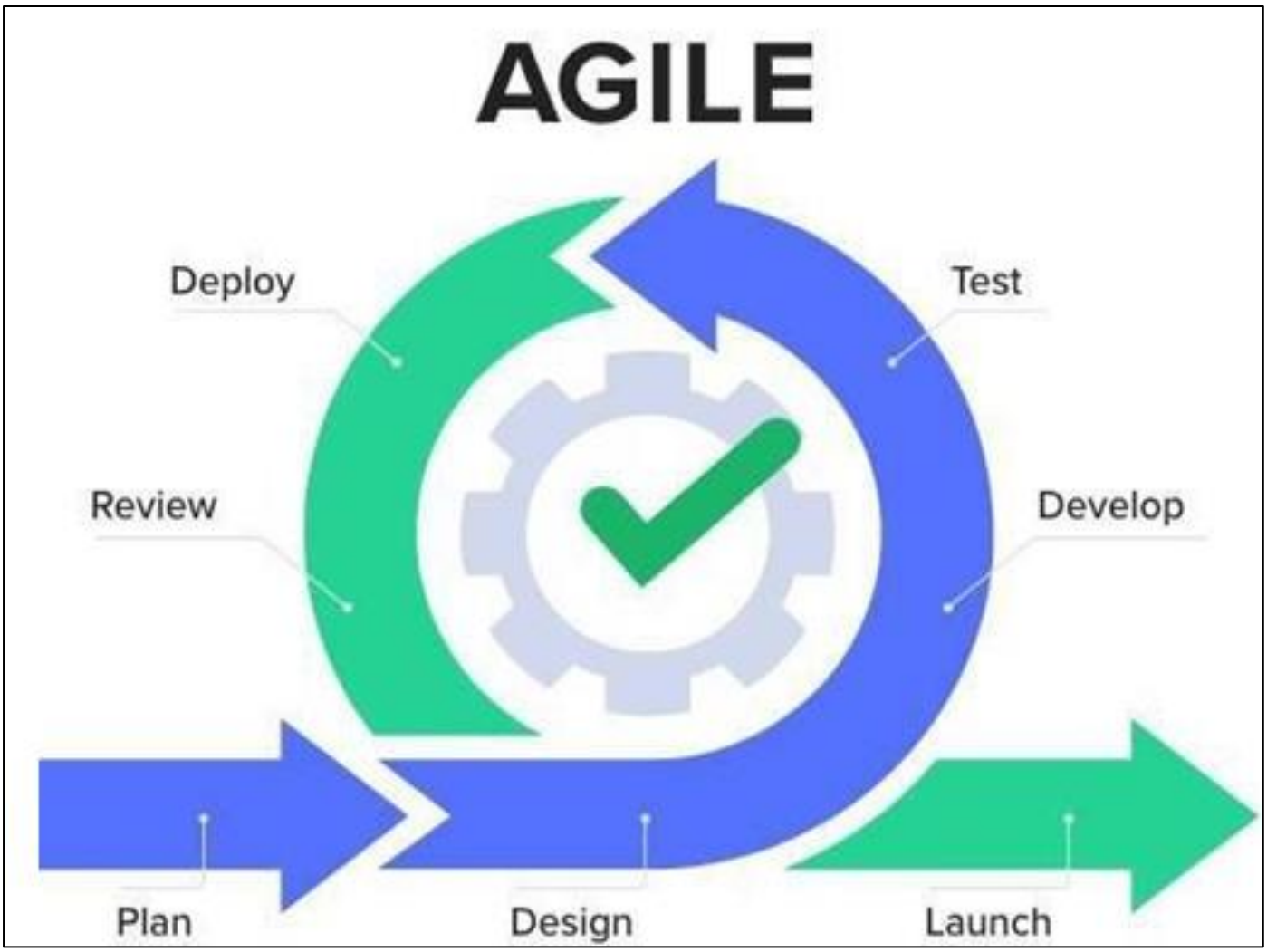

Fig 1 Agile Systems Development Life Cycle (SDLC).

The system was evaluated using the ISO/IEC 25010:2011 framework for software quality, which covers both product quality and quality in use. For this study, eight key quality characteristics were prioritized: functionality, usability, reliability, efficiency, maintainability, portability, security, and compatibility [11].

- *Research Locale*

This The study was conducted at the Peñaranda Rural Health Unit (RHU) in Nueva Ecija, Philippines. The RHU serves approximately 32,300 residents across 10 barangays [15], with vaccination services being a core part of maternal and child health programs. Prior to the introduction of KidGuard, the RHU relied on paper-based vaccination cards and manual tally sheets for monitoring, which posed challenges in timeliness, completeness, and transferability of data

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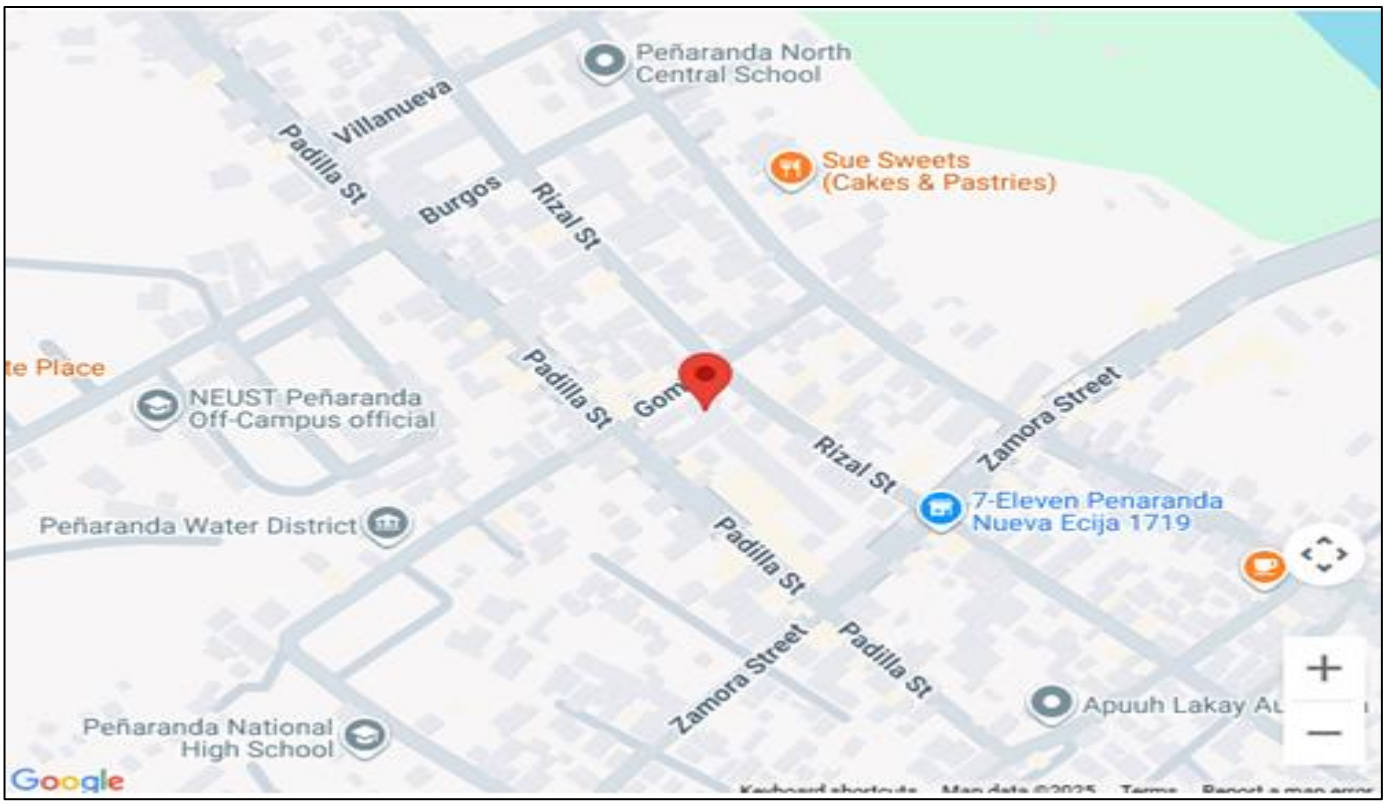

Fig 2 Research Locale (Google Map)

Fig 3 Peñaranda Rural Health Unit (RHU)

➢ *Participants*

Respondents for the system evaluation consisted of RHU staff and selected parents of vaccinated children. Health workers were purposively chosen based on their direct involvement in immunization services, while parents were selected to provide user feedback on the reminder and information features of the system.

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Table 1 Profile of Respondents

Category	Number (n)	Percentage (%)
RHU Staff (nurses, midwives, admin)	10	16.67
Parents/Guardians	50	83.33
Total	**60**	**100**

➢ *Development Process*

- *Following The Agile SDLC, Development Was Organized into Four Sprints*:

✓ *Sprint 1*

▪ *Requirements Analysis*

Interviews with RHU staff identified key needs: automated reminders, centralized child vaccination records, and simplified reporting tools.

✓ *Sprint 2*

▪ *System Design*

Low-fidelity prototypes and database schema were designed. Data flow diagrams were used to map relationships between parents, RHU staff, and system modules

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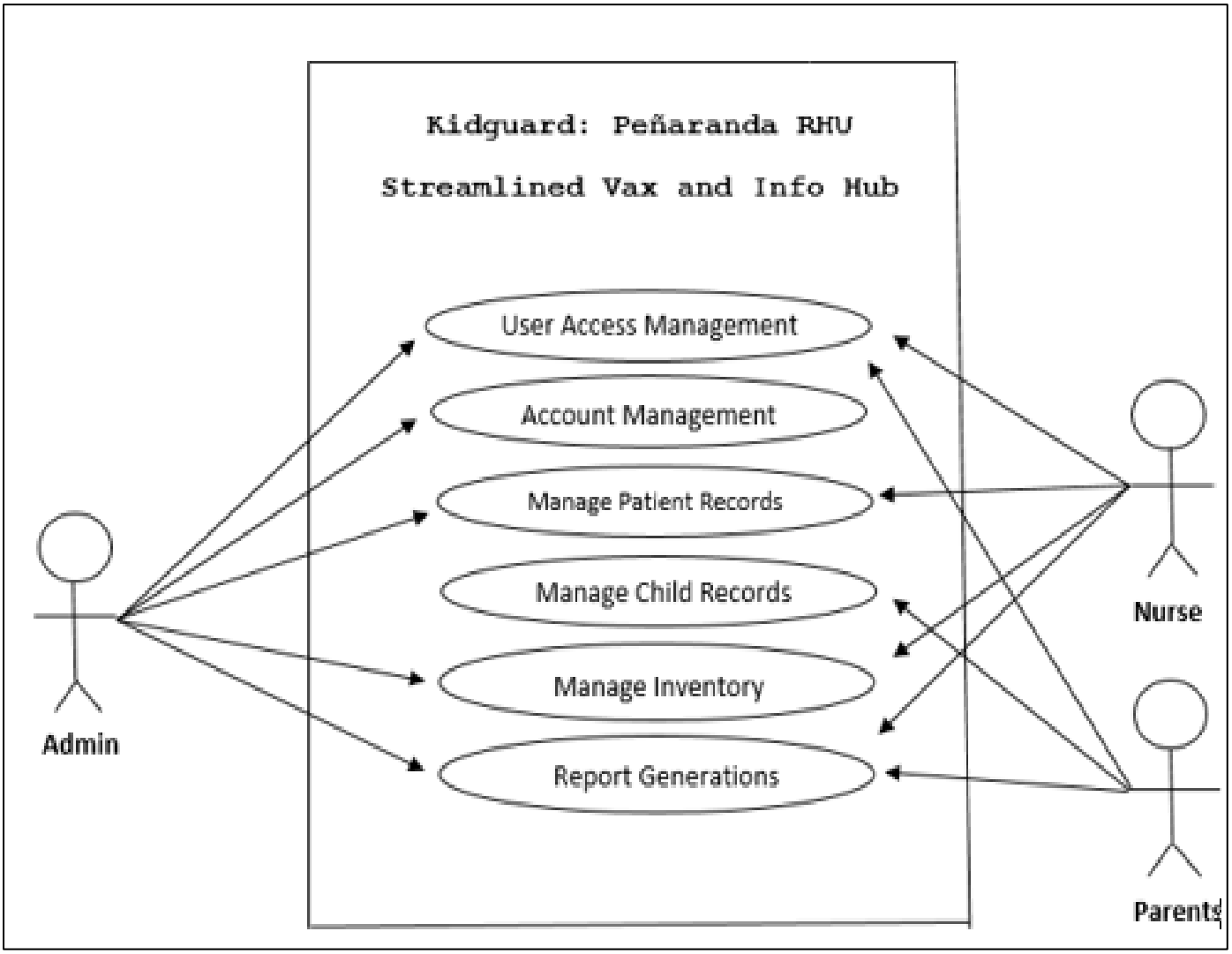

Fig 4 Use-Case Diagram of KidGuard.

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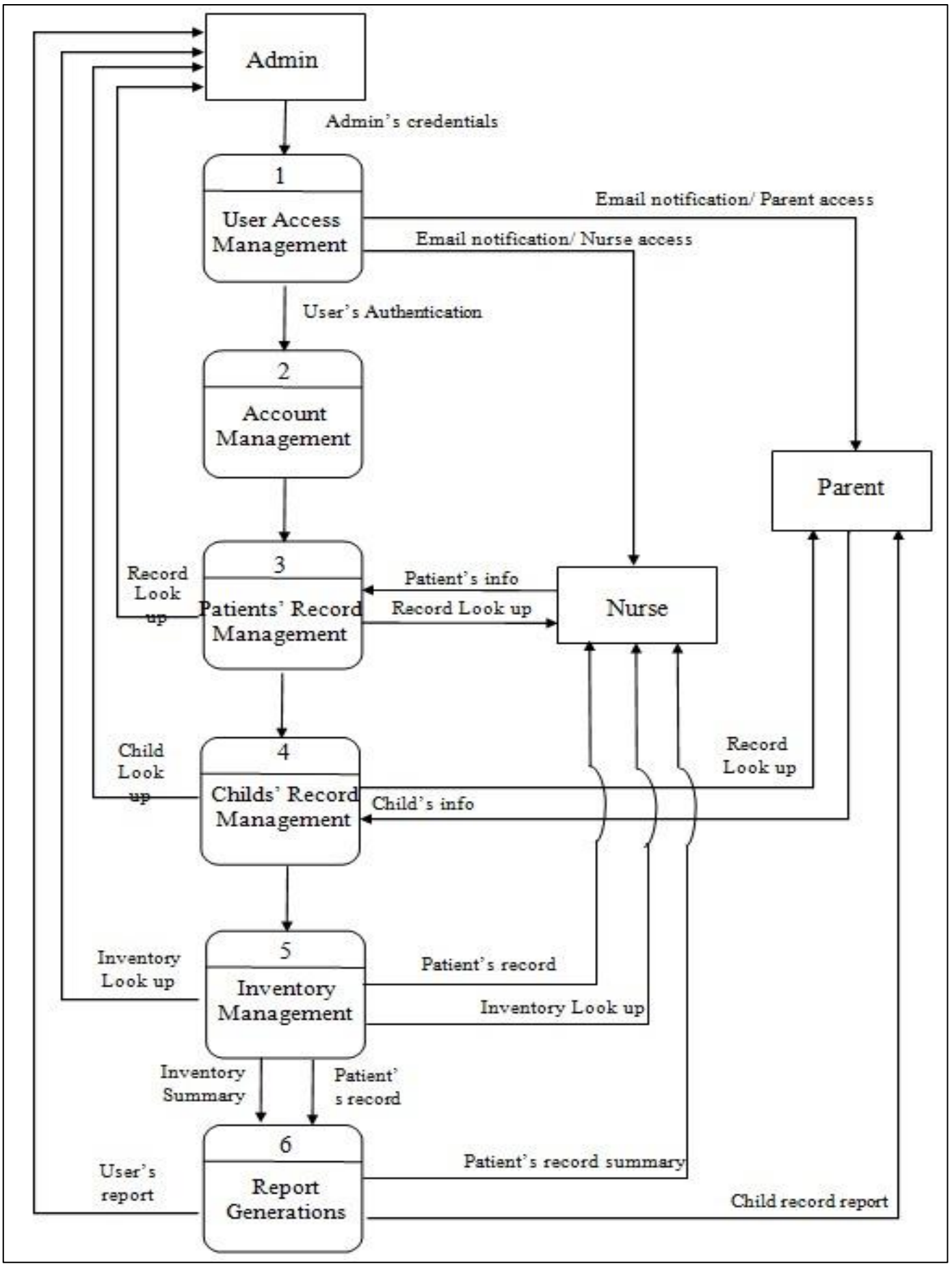

Fig 5 Data Flow Diagram of KidGuard.

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✓ *Sprint 3*

- *System Development*

Core Modules (Registration, Scheduling, Reminders, and Reporting) were programmed using a PHP-MySQL stack. SMS integration was tested using an open-source gateway.

Fig 6 KidGuard's Landing Page.

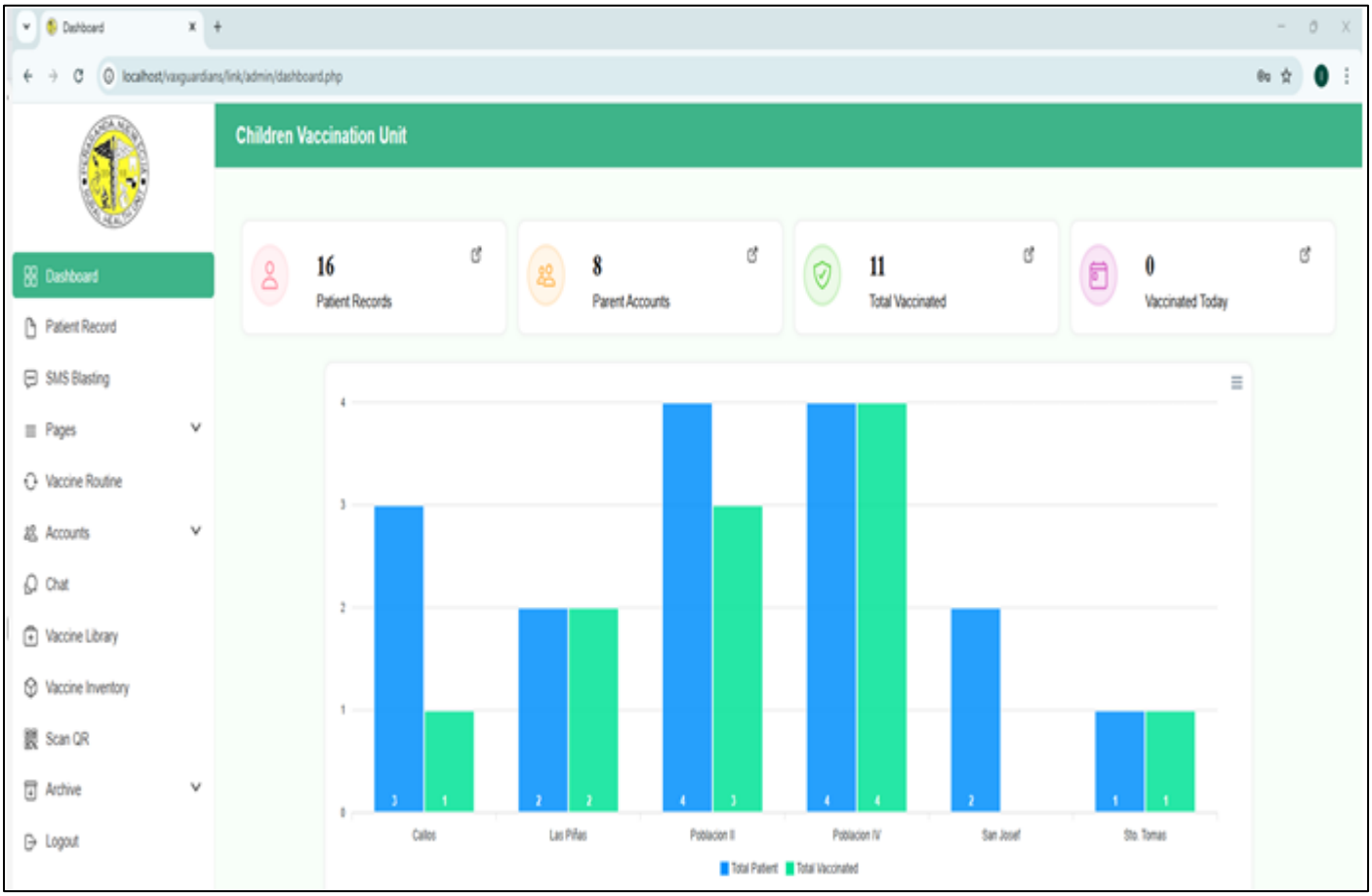

Fig 7 KidGuard's Dashboard.

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✓ *Sprint 4*

▪ *Testing and Refinement*

Alpha testing with RHU staff led to adjustments in the dashboard interface and simplification of parent SMS formats. Beta testing involved 20 parents over a two-week vaccination cycle.

➢ *Evaluation Instruments*

The System quality was assessed through a structured questionnaire based on ISO/IEC 25010, with a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The evaluation covered eight quality dimensions

Table 2 Evaluation Criteria (ISO/IEC 25010 Dimensions)

Quality Dimension	Definition (adapted from ISO/IEC 25010)
Functionality	Extent to which the system provides functions that meet stated needs.
Usability	Ease of use, learnability, and user satisfaction.
Reliability	Ability of the system to maintain performance under given conditions.
Efficiency	Resource and time efficiency during operations.
Maintainability	Ease with which the system can be modified or updated.
Portability	Ability to operate across different environments.
Security	Protection of data against unauthorized access.
Compatibility	Capacity of the system to interact with other applications.

➢ *Data Gathering Procedure*

- *Baseline Assessment of Existing System*

RHU staff rated the current manual vaccination system using the same ISO 25010-derived instrument, serving as a comparison benchmark.

- *System Implementation*

Kid Guard was deployed at the RHU for one vaccination cycle (1 month).

- *Evaluation Survey*

Respondents rated Kid Guard on the eight quality dimensions. Results were statistically analyzed through weighted means and compared with baseline scores.

➢ *Data Analysis*

Data from questionnaires were analyzed using descriptive statistics (mean, weighted mean, standard deviation). Interpretation followed conventional ranges:

- 4.50–5.00 = Strongly Agree
- 3.50–4.49 = Agree
- 2.50–3.49 = Moderately Agree
- 1.50–2.49 = Disagree
- 1.00–1.49 = Strongly Disagree

Comparisons were made between the manual system and Kid Guard across the eight quality dimensions to determine relative improvements.

IV. RESULTS

➢ *Baseline Assessment of the Existing System*

Before introducing Kid Guard, respondents evaluated the existing manual, paper-based immunization system using ISO/IEC 25010-derived criteria. Results highlighted weaknesses in several areas. While confidentiality (mean = 4.0, Strongly Agree) was perceived as relatively strong due to the physical control of records, other areas were rated low. Specifically, report generation speed (1.0, Disagree) and transferability of records (1.0, Disagree) emerged as the weakest points, underscoring inefficiencies in generating timely reports and sharing records between barangay health stations and the RHU.

Table 3 Evaluation of the Existing Manual System

Quality Dimension	Weighted Mean	Interpretation
Ease of Use	3.0	Agree
Accessibility	3.0	Agree
Data Security	3.0	Agree
Confidentiality	4.0	Strongly Agree
Communication of Schedules	2.0	Moderately Agree
Reliability	2.0	Moderately Agree
Report Generation Speed	1.0	Disagree
Transferability of Records	1.0	Disagree

These findings confirm earlier observations in related literature: paper-based immunization registries often limit timeliness and accuracy, leading to delays in monitoring and follow-up [8,10].

➢ *System Evaluation of KidGuard*

Following one vaccination cycle of pilot implementation, Kid Guard was evaluated on the same dimensions. Results show consistent improvements across all quality characteristics. Respondents rated functionality (4.7, Strongly Agree) and usability (4.6, Strongly Agree) highest, reflecting that the system provided the needed functions and was easy to learn and use. Report generation speed (4.5, Strongly Agree) and communication of schedules (4.6, Strongly Agree) showed dramatic gains compared to the baseline. Security and confidentiality also received favorable ratings (4.3–4.5),

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indicating that users trusted the system's protection of sensitive vaccination data.

Table 4 Evaluation of Kid Guard

Quality Dimension	Weighted Mean	Interpretation
Functionality	4.7	Strongly Agree
Usability	4.6	Strongly Agree
Reliability	4.4	Agree
Efficiency	4.5	Strongly Agree
Maintainability	4.2	Agree
Portability	4.0	Agree
Security	4.3	Agree
Compatibility	4.2	Agree

➢ *Comparative Analysis*

A side-by-side comparison highlights the significant impact of Kid Guard. Whereas the manual system was often rated between Moderately Agree and Disagree in critical aspects, Kid Guard consistently scored in the Agree to Strongly Agree range.

Table 5 Comparison of Existing Manual System and Kid Guard

Quality Dimension	Manual System	Kid Guard	Improvement
Ease of Use / Usability	3.0	4.6	+1.6
Accessibility	3.0	4.2	+1.2
Data Security / Security	3.0	4.3	+1.3
Confidentiality	4.0	4.5	+0.5
Communication of Schedules	2.0	4.6	+2.6
Reliability	2.0	4.4	+2.4
Report Generation Speed	1.0	4.5	+3.5
Transferability / Compatibility	1.0	4.2	+3.2

These findings demonstrate that Kid Guard addresses the pain points identified in the baseline: report generation, transferability of records, and communication with parents. The integration of SMS reminders directly improved schedule adherence and parent engagement, supporting earlier global evidence on the effectiveness of reminder/recall systems [7,9].

V. DISCUSSION

The improvements observed resonate strongly with global literature on digital health interventions. The sharp increase in scores for report generation and transferability aligns with [8], who noted that electronic immunization registries reduce duplication and enhance reporting efficiency. Likewise, gains in schedule communication and usability mirror randomized trials demonstrating the effectiveness of SMS reminders in increasing childhood vaccination uptake [7,9].

From a systems perspective, KidGuard's positive evaluation under ISO/IEC 25010 validates the usefulness of this framework in assessing public health information systems. The results echo Cruz & Dela Cruz (2021), who showed that ISO 25010 can effectively guide local evaluation of health software in the Philippines [12]. By embedding quality assessment into the development process, KidGuard achieved user-centered refinements that boosted both usability and reliability.

Furthermore, the application of Agile SDLC allowed iterative improvements, ensuring that end-users—RHU staff and parents—were engaged in shaping the final system. This aligns with findings from Kokol (2022), who emphasized that agile methods in healthcare projects improve responsiveness to user needs [13].

In summary, the results provide evidence that a localized digital immunization hub can meaningfully enhance efficiency, reliability, and communication in rural health units. For Peñaranda RHU, KidGuard not only digitized existing workflows but also aligned with the national DigiVacc initiative, strengthening interoperability and sustainability prospects.

VI. CONCLUSION

This study set out to design, develop, and evaluate Kid Guard, a digital vaccination and information hub for the Peñaranda Rural Health Unit (RHU) in Nueva Ecija, Philippines. Anchored in the Design and Development Research (DDR) framework and guided by Agile SDLC principles, the project addressed the long-standing challenges of paper-based immunization systems. The baseline assessment of the manual system revealed inefficiencies in reporting, record transferability, and communication of schedules—issues that directly affect the timeliness and completeness of childhood vaccination.

Through iterative development and evaluation, Kid Guard demonstrated significant improvements across all ISO/IEC 25010 quality dimensions. Functionality, usability, and report generation speed were rated highest, while overall reliability and communication of schedules showed the most dramatic improvements compared to the baseline. These outcomes support evidence from global literature that digital health solutions, particularly SMS reminders and electronic

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immunization registries, enhance vaccination coverage and efficiency.

Ultimately, Kid Guard contributes to strengthening local immunization services in alignment with national and global initiatives such as the Department of Health's DigiVacc program and the WHO's Immunization Agenda 2030. The system demonstrates that localized, user-centered digital tools can empower RHUs to improve efficiency, reduce missed vaccinations, and ensure timely communication with parents.

RECOMMENDATIONS

➢ *This Based On the Findings, The Following Recommendations Are Proposed:*

- For *the RHU and Local Government Units (LGUs):*

Adopt Kid Guard as a complement to existing immunization programs and integrate it into municipal health information systems for continuity and scale.

- *For the Department of Health (DOH):*

Consider interoperability between Kid Guard and the national DigiVacc platform to avoid duplication and strengthen centralized reporting.

- *For Healthcare Workers:*

Provide capacity-building and regular training on the use of digital health tools to maximize system efficiency.

- *For Future Researchers:*

Conduct longitudinal studies to assess the impact of KidGuard on actual vaccination coverage and timeliness over multiple years. Comparative studies with other RHUs would help establish broader generalizability.

- *For System Development*:

Explore integration of mobile applications and multilingual support for parents to further enhance accessibility and engagement.

FUTURE WORKS

Future iterations of KidGuard may expand beyond childhood immunization by including maternal health tracking, adolescent vaccination, and integration with other health services. Research could also explore the use of machine learning algorithms for predictive analytics (e.g., identifying children at risk of defaulting vaccinations). Additionally, future projects should investigate user acceptability at scale, data privacy compliance under the Philippine Data Privacy Act, and integration with cloud-based national health infrastructures.

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