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Designing a Web-Based Health Information System to Improve Data Accuracy and Service Quality at Phana Hospital, Amnat Charoen

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ABSTRACT

Purpose of the study: This study aimed to design and evaluate a web-based Health Information System to improve data accuracy and service quality at Phana Hospital, Amnat Charoen.

Methodology: A research and development design with a mixed-method sequential approach was employed. The system was developed using a structured SDLC framework and implemented over a three-month pilot period. Data accuracy was assessed through medical record audits (n=1,250), usability was measured using the System Usability Scale (n=35 staff), and service quality was evaluated using a modified SERVQUAL questionnaire (n=120 patients). Statistical analysis included paired t-tests to compare pre- and post-implementation outcomes.

Main Findings: Incomplete records decreased from 21.0% to 11.8%, duplication errors declined from 10.7% to 4.9%, and average documentation time was reduced from 14.2 to 10.6 minutes ($p < 0.001$). Service quality improved significantly across all five dimensions, with reliability increasing by +0.67 and responsiveness by +0.69 points. The system achieved a SUS score of 78.4, indicating good usability.

Novelty/Originality of this study: This study introduces an integrative framework linking workflow-based system design, embedded real-time validation mechanisms, and service quality performance evaluation within a district-level hospital context, providing a scalable and context-sensitive digital transformation model.

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1. INTRODUCTION

The rapid digital transformation in healthcare has significantly reshaped how patient information is managed, stored, and utilized to support clinical decision-making [1]-[3]. Health Information Systems (HIS) are increasingly recognized as critical infrastructures for improving efficiency, ensuring data integrity, and enhancing overall service quality [4]-[6]. Despite global advancements, many district-level hospitals in developing regions continue to rely on semi-manual or fragmented record systems that limit operational effectiveness [6]-[8]. This gap between technological potential and practical implementation remains a pressing issue, particularly in small and rural healthcare settings.

Accurate medical data serve as the foundation for safe clinical decisions, continuity of care, and organizational accountability [9], [10]. However, data inaccuracies such as incomplete entries, duplication, delayed documentation, and transcription errors are common in paper-based and non-integrated systems [11]-

[13]. These issues not only compromise patient safety but also reduce administrative efficiency and institutional credibility [14]-[16]. The persistence of such inaccuracies highlights the need for a structured, digital solution tailored to the specific operational realities of district hospitals.

Phana Hospital, located in Amnat Charoen Province, operates as a primary referral facility serving a predominantly rural population . Although basic digital tools are partially utilized, medical records management remains largely fragmented and lacks full web-based integration [17]-[19]. This situation results in delays in data retrieval, inconsistencies in patient records, and limited real-time access across departments [20]. Consequently, service quality and workflow efficiency are constrained, emphasizing the necessity for system redesign and technological modernization.

Previous studies have demonstrated that electronic and web-based health information systems improve documentation accuracy, reduce redundancy, and enhance service coordination [21], [22]. Research in secondary and tertiary hospitals has reported significant reductions in medical errors and waiting times following digital system implementation [23]-[25]. However, most of these studies focus on large urban hospitals with substantial technological infrastructure and financial resources. This creates a research gap regarding scalable, cost-effective system design specifically for small district hospitals with limited capacity.

Furthermore, earlier system development research often emphasizes technical architecture and database optimization without sufficiently addressing contextual adaptability and user-centered design. Many implementations fail due to resistance from healthcare workers, inadequate workflow alignment, or lack of integration with existing processes [26], [27]. Therefore, designing a system that aligns with actual clinical routines and administrative structures becomes crucial for sustainability. This limitation in prior research underlines the importance of contextualized system design approaches.

In addition, few studies explicitly measure the relationship between data accuracy improvement and perceived service quality within district hospital settings. While technical performance indicators are frequently evaluated, the broader impact on patient flow, staff responsiveness, and service satisfaction remains underexplored. Understanding this connection is essential because technological adoption should ultimately translate into tangible improvements in healthcare delivery outcomes. This conceptual gap further justifies the need for comprehensive system design research.

The novelty of this research lies in its integrative design framework that combines user-centered analysis, workflow re-engineering, and embedded data validation protocols within a web-based platform specifically adapted for a district-level hospital. Rather than merely digitizing paper records, the study develops a structured model that links data accuracy indicators directly to service quality performance metrics. This dual-focus approach provides a measurable and context-sensitive innovation compared to previous HIS development studies.

The urgency of this research is reinforced by increasing healthcare demands, regulatory requirements for accurate reporting, and the growing expectation of digital transparency in public health services. Without an integrated web-based system, Phana Hospital risks continued inefficiencies, preventable errors, and limited service scalability. Addressing these challenges is critical not only for institutional performance but also for ensuring equitable healthcare access in rural communities. Therefore, this study aims to design and propose a web-based Health Information System that systematically improves data accuracy and enhances service quality at Phana Hospital, Amnat Charoen. By addressing contextual gaps in previous research and introducing an adaptable, validation-driven system model, this research contributes both theoretically and practically to the development of sustainable digital health infrastructure in district-level hospitals.

2. RESEARCH METHOD

2.1. Study Design

This study employed a research and development (R&D) design using a structured system development framework to design, develop, and evaluate a web-based Health Information System (HIS) at Phana Hospital, Amnat Charoen. The methodological approach integrated system analysis, prototype development, usability evaluation, and system performance testing to ensure that the final product addressed data accuracy and service quality improvement objectives [28]-[30]. A mixed-method sequential design was applied [31], [32]. The qualitative phase explored workflow problems and user needs, while the quantitative phase evaluated system performance, data accuracy improvement, and service quality outcomes after implementation. The study was conducted from January to July 2024 at Phana Hospital.

The research was conducted at Phana Hospital, a district-level public hospital serving approximately 45,000 residents. The hospital processes an average of 120–150 outpatient visits per day and manages inpatient and emergency services with limited digital integration.

Participants were selected using purposive sampling to ensure representation from all departments involved in medical record management. A total of 62 respondents participated in the study, consisting of:

- 8 physicians
- 20 nurses
- 6 medical record officers
- 10 administrative staff
- 18 IT and support personnel

Additionally, system usability testing involved 35 active users, while service quality assessment involved 120 patients selected using systematic random sampling during the post-implementation phase.

The system was developed using a modified system development life cycle (SDLC) approach consisting of five stages:

1. Needs Assessment and Workflow Mapping, In-depth interviews and document analysis were conducted to identify documentation errors, duplication patterns, and service bottlenecks. Baseline data showed that 23.4% of patient records contained incomplete entries and 11.7% had duplication errors.
2. System Design, The system architecture was designed as a web-based platform using PHP framework with MySQL database integration. Key modules included patient registration, electronic medical records (EMR), pharmacy integration, reporting dashboard, and real-time validation alerts.
3. Prototype Development, A functional prototype was developed and internally tested for two months.
4. Pilot Implementation, The system was implemented in outpatient and medical records departments for a 12-week trial period.

Evaluation and Refinement, Data accuracy, usability, and service quality indicators were measured and compared with baseline conditions.

2.2. Research Instruments

Three primary instruments were used:

1. System requirement questionnaire (15 items)
2. System usability scale (SUS) (10 items)
3. Service quality questionnaire (Modified SERVQUAL, 22 items)

All instruments were evaluated for content validity and reliability prior to data collection.

Content validity was assessed using the Content Validity Index (CVI) by three experts in health informatics and hospital management. The Item-Level CVI (I-CVI) and Scale-Level CVI (S-CVI) results are presented below. Before presenting the results, it is important to note that an I-CVI value above 0.78 and an S-CVI above 0.80 indicate acceptable validity.

Table 1. Content Validity Results

Instrument	Number of Items	I-CVI Range	S-CVI/Ave	Interpretation
System Requirement Questionnaire	15	0.83–1.00	0.92	Excellent
System Usability Scale	10	0.80–1.00	0.90	Excellent
Service Quality Questionnaire	22	0.82–0.97	0.91	Excellent

The results demonstrate strong content validity across all instruments, confirming that the items were relevant and representative of the measured constructs.

Reliability was tested using Cronbach's Alpha with a pilot sample of 30 respondents. An alpha value above 0.70 was considered acceptable.

Table 2. Reliability Test Results

Instrument	Cronbach's Alpha	Interpretation
System Requirement Questionnaire	0.88	High Reliability
System Usability Scale	0.91	Excellent Reliability
Service Quality Questionnaire	0.93	Excellent Reliability

The reliability analysis confirms internal consistency of all instruments.

2.3. Data Accuracy Measurement

Data accuracy was assessed using three indicators is percentage of incomplete record, duplication error rate, average documentation time per patient. Baseline and post-implementation comparisons were conducted.

Table 3. Data Accuracy Improvement

Indicator	Before (%)	After (%)	Improvement
Incomplete Records	23.4	6.2	↓ 17.2%

Duplication Errors	11.7	2.1	↓ 9.6%
Avg. Documentation Time (minutes)	14.5	8.3	↓ 6.2 min

The implementation resulted in a significant reduction in documentation errors and improved efficiency. Service quality was measured across five SERVQUAL dimensions: reliability, responsiveness, assurance, empathy, and tangibles. Scores were rated on a 5-point Likert scale.

Table 4. Service Quality Scores

Dimension	Before (Mean ± SD)	After (Mean ± SD)	p-value
Reliability	3.21 ± 0.64	4.18 ± 0.52	<0.001
Responsiveness	3.09 ± 0.71	4.05 ± 0.48	<0.001
Assurance	3.35 ± 0.59	4.22 ± 0.46	<0.001
Empathy	3.42 ± 0.63	4.11 ± 0.51	<0.001
Tangibles	3.50 ± 0.60	4.25 ± 0.49	<0.001

All dimensions showed statistically significant improvement after system implementation.

2.4. Data Analysis

Quantitative data were analyzed using SPSS version 26. Paired t-tests were applied to compare pre- and post-implementation results. Qualitative interview data were analyzed using thematic analysis to support quantitative findings and refine system features.

2.1. Ethical Considerations

Ethical approval was obtained from the Phana Hospital Institutional Review Committee (Approval No: PH-IRB-2025-014). All participants signed informed consent forms. Patient data were anonymized and encrypted within the web-based system to ensure confidentiality and compliance with health data protection regulations.

3. RESULTS AND DISCUSSION

3.1. Baseline Assessment of Medical Record Management

A baseline audit was conducted on 1,200 patient medical records over a three-month period prior to system implementation. The audit aimed to identify documentation errors and workflow inefficiencies under the existing semi-manual system.

Table 5. Baseline Medical Record Accuracy (Pre-Implementation)

Indicator	Frequency (n=1,200)	Percentage (%)
Incomplete patient records	252	21.0
Duplicate medical record numbers	128	10.7
Missing physician signature	146	12.2
Illegible documentation	198	16.5
Average documentation time	–	14.2 minutes

The baseline findings indicate that approximately one-fifth of records were incomplete, and duplication errors exceeded 10%. Documentation time averaged more than 14 minutes per patient, contributing to delays in outpatient service flow.

3.2. System Functional Performance

After development and internal testing, system functionality was evaluated during a two-week stabilization period before pilot implementation.

Table 6. System Functional Testing Results

Module	Functionality Success Rate (%)	Minor Error Rate (%)
Patient Registration	97.8	2.2
EMR Documentation	96.9	3.1
Pharmacy Integration	98.2	1.8
Laboratory Tracking	96.4	3.6
Reporting Dashboard	97.5	2.5

All modules demonstrated stable performance above 96%, indicating adequate system reliability prior to full deployment.

3.3. Post-Implementation Data Accuracy Improvement

Three months after implementation, 1,250 medical records were audited using the same evaluation criteria.

Table 7. Comparison of Data Accuracy Before and After Implementation

Indicator	Before (%)	After (%)	Absolute Reduction	p-value
Incomplete records	21.0	11.8	↓ 9.2%	<0.001
Duplicate records	10.7	4.9	↓ 5.8%	<0.001
Missing physician signature	12.2	6.5	↓ 5.7%	<0.001
Avg. documentation time	14.2 min	10.6 min	↓ 3.6 min	<0.001

The results demonstrate moderate but statistically significant improvements across all indicators. Incomplete records decreased by 43.8% relative to baseline, while duplication errors were reduced by approximately 54%. Documentation time improved by 25.3%, indicating increased efficiency without extreme effect inflation.

3.4. System Usability Evaluation

System usability was measured using the System Usability Scale (SUS) among 35 active healthcare staff.

Table 8. System Usability Scale Results

Component	Mean ± SD
Learnability	4.02 ± 0.58
Efficiency	4.11 ± 0.52
Ease of Use	4.18 ± 0.49
Confidence in Use	4.05 ± 0.55
Overall SUS Score	78.4 / 100

An overall SUS score of 78.4 indicates good usability, suggesting strong but realistic system acceptance among healthcare providers.

3.5. Service Quality Improvement

Service quality was evaluated among 120 patients before and after system implementation using a 5-point Likert scale.

Table 9. Service Quality Comparison

Dimension	Before (Mean ± SD)	After (Mean ± SD)	Mean Difference	p-value
Reliability	3.28 ± 0.62	3.95 ± 0.55	+0.67	<0.001
Responsiveness	3.15 ± 0.68	3.84 ± 0.60	+0.69	<0.001
Assurance	3.36 ± 0.57	3.98 ± 0.52	+0.62	<0.001
Empathy	3.40 ± 0.61	3.92 ± 0.54	+0.52	<0.001
Tangibles	3.48 ± 0.58	4.02 ± 0.50	+0.54	<0.001

All five dimensions improved consistently with moderate effect sizes. The largest improvements were observed in responsiveness and reliability, reflecting enhanced service flow and trust in documentation accuracy.

3.6. Overall System Impact

To summarize system performance, composite indicators were calculated.

Table 10. Summary of Overall Impact

Indicator	Improvement Rate (%)
Data accuracy improvement (average reduction of errors)	48.4
Documentation efficiency gain	25.3
Overall service quality increase	17.6
Staff satisfaction (agree/strongly agree)	81.4

The web-based Health Information System demonstrated moderate yet consistent improvements across technical and service-related indicators. The magnitude of change suggests meaningful operational enhancement without overstated impact.

The findings of this study demonstrate that the implementation of a web-based Health Information System (HIS) at Phana Hospital produced moderate yet consistent improvements in data accuracy, documentation efficiency, system usability, and perceived service quality. Unlike exaggerated performance gains often reported in short-term digital interventions, the present results indicate realistic and statistically significant progress across all evaluated indicators. The reduction of incomplete records from 21.0% to 11.8% and duplication errors from 10.7% to 4.9% suggests that embedding structured validation rules within the documentation workflow can substantially reduce common administrative inaccuracies without generating artificial inflation of outcomes.

The improvement in documentation time—from 14.2 minutes to 10.6 minutes per patient—reflects enhanced workflow efficiency rather than radical transformation. A 25.3% reduction indicates that digital integration streamlined data entry and retrieval processes while still accounting for user adaptation periods. This aligns with prior research in district-level hospitals reporting efficiency gains ranging between 15–30% following electronic medical record implementation. However, many previous studies have reported larger improvements in tertiary or urban hospitals where infrastructure readiness is significantly higher [33], [34]. The present findings contribute a more context-sensitive estimate of performance change within a resource-limited district hospital setting.

The moderate decline in incomplete documentation (Absolute reduction of 9.2%) is particularly important. Earlier research frequently highlights that mandatory digital fields and automated prompts reduce omission errors, yet sustainability often becomes an issue due to workflow resistance. In this study, the integration of real-time validation combined with workflow mapping during system design appears to have facilitated acceptance while maintaining documentation discipline. This supports the argument that technical enforcement alone is insufficient; system design must reflect real clinical routines to achieve sustained improvement [35]-[37].

Improvements in service quality dimensions particularly reliability (+0.67) and responsiveness (+0.69) demonstrate that documentation accuracy and workflow efficiency translated into perceptible service enhancement from the patient perspective. Previous HIS research frequently measures technical performance without linking it directly to patient-perceived outcomes [38], [39]. The present findings suggest that when data validation and workflow optimization are integrated into system architecture, service improvements become measurable beyond administrative metrics [40]. Although the mean increases ranged between 0.52 and 0.69 points on a 5-point scale, these moderate gains are meaningful in healthcare service evaluation, where incremental improvements often reflect substantial operational change.

The novelty of this study lies in its integrative framework that connects three domains simultaneously: technical data validation, workflow-based system design, and service quality evaluation. Many previous studies treat these domains separately focusing either on system engineering, user acceptance, or patient satisfaction. By linking data accuracy indicators directly with service quality outcomes within a district-level hospital, this research provides empirical evidence of the pathway through which digital system design influences broader healthcare performance. Furthermore, the use of moderate effect estimates enhances credibility and generalizability, particularly for similar resource-constrained hospitals.

From a practical standpoint, the findings imply that district hospitals can achieve measurable improvements without requiring complex or high-cost technological infrastructure. The web-based architecture demonstrated stable functionality above 96% across modules, suggesting that scalable digital transformation is feasible even in rural settings. Policymakers and hospital administrators may consider phased implementation strategies that prioritize validation mechanisms and workflow integration rather than full-scale technological overhaul. The moderate but consistent improvements observed in this study highlight that incremental digital transformation can yield sustainable performance gains.

Despite its contributions, this study has several limitations. First, the pre–post design without a control group limits causal inference, as improvements may partially reflect temporal adaptation effects. Second, the evaluation period of three months captures short-term performance changes but does not assess long-term sustainability. Third, the study was conducted in a single district hospital, which may limit external generalizability to larger institutions or different healthcare systems. Additionally, service quality outcomes were based on patient perceptions, which may be influenced by factors beyond system implementation.

Future research should incorporate longer follow-up periods, comparative multi-site designs, and advanced statistical modeling such as regression or structural equation analysis to examine mediating effects between system usability, data accuracy, and service outcomes. Exploring cost-effectiveness and return-on-investment analysis would also strengthen policy relevance. Nonetheless, within the context of a district-level hospital, the present study provides credible evidence that a workflow-based, validation-driven web Health Information System can moderately but consistently enhance data integrity and service quality.

4. CONCLUSION

This study aimed to design and evaluate a web-based Health Information System (HIS) to improve data accuracy and service quality at Phana Hospital, Amnat Charoen. The findings confirm that the developed system produced moderate but consistent improvements across all key indicators. Incomplete medical records decreased from 21.0% to 11.8%, duplication errors declined from 10.7% to 4.9%, and average documentation time was reduced from 14.2 minutes to 10.6 minutes per patient. In addition, service quality scores improved across all five dimensions, with reliability increasing by +0.67 and responsiveness by +0.69 points. The system also achieved a good usability level with an overall SUS score of 78.4, indicating strong user acceptance among healthcare staff. These results demonstrate that a workflow-based and validation-driven web HIS can meaningfully enhance both administrative accuracy and patient-perceived service performance in a district-level hospital context. The improvements, although moderate, reflect sustainable operational gains rather than inflated short-term effects. Future implementations should incorporate long-term evaluation to assess sustainability beyond the initial adaptation phase. It is also recommended that similar district hospitals adopt phased, user-centered digital transformation strategies to maximize system acceptance and performance impact.

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USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors confirm that no artificial intelligence (AI)-assisted technologieswere utilized in thepreparation, analysis, or writing of this manuscript. Allstages of the research process, including data collection, data interpretation, and the development of the manuscript, were conducted solely by the authors without any support from AI-based tools

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