

Assessing the Perceived Effectiveness of Hospital Information Systems in Ghana: Agreement Between Two Information System Success Models Using Bland–Altman Analysis

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Abstract

Introduction: This study evaluated the effectiveness of hospital information systems (HIS) in 25 hospitals under the National Catholic Health Service in Ghana, using two information system success models (ISSM): an extended six-dimensional ISSM and the upgraded seven-dimensional DeLone and McLean model. The aim was to assess HIS effectiveness from the users' perspectives and determine the level of agreement between the two models. **Methods:** A cross-sectional survey design was employed. Data were collected using two structured self-administered questionnaires based on the respective ISSM frameworks. Descriptive statistics were used to summarize user characteristics and system performance. The HIS effectiveness rate was calculated as a normalized percentage score. Within each construct, all items were weighted equally, and no differential weighting scheme was applied to the items. Effectiveness rates were classified as high ($\geq 75\%$), moderate ($50\% - < 75\%$), low ($25\% - < 50\%$), or very low ($< 25\%$). We used Bland–Altman analysis in a descriptive way to assess the agreement between hospital-level normalized effectiveness scores from the E-ISSM framework and the U-DM framework. **Results:** A total of 1,416 (81%) out of 1,738 HIS users participated in the study. The majority of respondents were men (729, 51.48%). More than 77% were in the 30–44 years age bracket. More than 90% had a tertiary education. Most of the users (1232, 87%) had more than six years' experience with HIS. The overall HIS effectiveness rate was above 80%, indicating high perceived HIS performance among users. Bland–Altman analysis showed that 96% of hospital mean effectiveness scores fell within acceptable limits (75.5%–87.0%), and regression analysis found no significant proportional bias between the models. **Conclusion:** The findings indicate that HIS in the surveyed Ghanaian hospitals is perceived to be highly effective. Both ISSM tools are reliable and can be used in future assessments of HIS effectiveness.

Keywords: Assessment; Bland-Altman; Hospital Information Systems (HIS); Effectiveness; Rate.

Introduction

Health information systems have been adopted worldwide to provide timely and accurate information to support healthcare decision-making and improve the efficiency, quality, and cost-effectiveness of healthcare delivery [1]. Hospital information systems (HISs) are among the many health information systems widely used to support clinical and administrative processes in health care organizations. Despite broad adoption, users have expressed concerns about system quality, usability and overall performance. Thus, a regular evaluation of HISs is

necessary to identify areas for improvement and ensure that these systems continue to meet the needs of users and the objectives of the organization.

The implementation of HISs requires considerable financial investment. For example, the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009 estimated a total investment of approximately US\$10 million in HIS implementation per healthcare provider in the United States [2]. Given these large investments, post-implementation evaluation is needed to safeguard resources and to get the most value from HISs [3]. The effectiveness of HIS is being evaluated periodically, and this evaluation provides evidence to support informed decision-making for researchers, healthcare providers, managers and policymakers. Such assessments support the identification of the strengths and weaknesses of existing systems and produce evidence to inform future improvements and digital health investments [4].

There are several frameworks developed to evaluate the success of HIS. The Information Systems Success Model (ISSM) [5] is one of the most used and validated frameworks to evaluate the HISs. The ISSM was proposed by DeLone and McLean in 1990 [6] and revised in 2003. It comprises seven dimensions: system quality, information quality, service quality, system use, perceived usefulness, user satisfaction, and net benefits. The model evaluates information systems through the eyes of users. The model explains the impact of system features on usage, satisfaction and organizational outcomes. As these dimensions jointly affect the success of the system, ISSM has been widely used to evaluate the effectiveness of HIS in different healthcare settings [4,5,7–11].

To improve access to health care services, the Government of Ghana introduced the National Health Insurance Scheme in 2005 [12]. The scheme was rolled out with various digital health initiatives, such as electronic claims processing, which helped in fast-tracking the adoption of HISs across the country. Against this background, National Catholic Health Service (NCHS) health facilities began to implement HISs from 2010 to automate clinical and administrative processes, with facilities in different phases of implementation. The impact of similar implementations of electronic health records and HISs has been evaluated in countries such as Saudi Arabia [13], Korea [2], Taiwan [14,15] and Iran [8,16], which provides valuable evidence on the performance of systems and the perceptions of users.

However, few studies have assessed the success of HISs in Ghana [17–21]. The prior research has primarily focused on individual healthcare organizations, thus restricting the ability to compare the HIS effectiveness across multiple healthcare organizations within the same healthcare network. As a result, there is a lack of evidence on the effectiveness of HISs at health facilities under organizations such as the Ghana Health Service or the National Catholic Health Service. Furthermore, while several instruments using the ISSM have been developed to measure HIS success, it is unclear whether these instruments yield comparable estimates when applied in the same healthcare setting. These knowledge gaps are important for hospital managers, policymakers and other stakeholders who are searching for ways to standardize HIS performance evaluation and to inform investments in digital health infrastructure in Ghana.

The current study fills three important gaps in the existing literature. First, in contrast to previous studies conducted in Ghana that have evaluated the performance of a single healthcare facility, this is one of the largest multi-site assessments of HIS effectiveness in Ghana, evaluating 25 healthcare facilities over a broad spectrum of healthcare delivery settings within the NCHS network [22]. This allows benchmark estimates of HIS effectiveness across multiple institutions within the same provider network. Second, this study differs from previous research that has used a single ISSM-based assessment tool as it directly compares two ISSM-based instruments using data from the same healthcare facilities, providing empirical evidence on the level of agreement and potential interchangeability of the instruments [4]. Third, methodologically this study contributes by adapting Bland–Altman agreement analysis to assess agreement between composite HIS effectiveness scores derived from Likert-scale measurements. Bland–Altman analysis is widely used in clinical and measurement studies, but its use in composite HIS effectiveness indices remains limited [23]. The results provide methodological evidence for the comparability of estimates obtained from different ISSM-based instruments, thus supporting the standardization of HIS evaluation methods, but also allowing for more homogeneous performance evaluations in healthcare settings with limited resources [24,25].

In this study, the effectiveness or success of HIS is defined as the overall performance of the HIS from the users' perspectives on the seven dimensions of ISSM, including system quality, information quality, service quality, system use, perceived usefulness, user satisfaction and net benefits [6,22]. HIS performance is operationalized as

a weighted percentage index based on these dimensions, thus reflecting the perceived effectiveness of the system by users, rather than technical efficiency in terms of input-output or cost-time optimization. This composite index, as in other studies based on ISSM, is a summary measure of the degree to which the HIS meets its intended objectives from the users' perspective [22]. Hence, this study evaluates HIS effectiveness using two adapted assessment instruments based on ISSM in hospitals and healthcare delivery settings in the NCHS in Ghana. It also examines the degree of concordance between the performance indices of the two instruments to assess the similarity of the HIS success estimates they provide. It is expected that the findings will contribute to the standardization of approaches to evaluate HIS and provide evidence for benchmarking, policy formulation and investment decisions for strengthening digital health systems in Ghana and other resource-limited settings.

Materials and Methods

Study Design

This study used a survey design across 25 NCHS hospitals. At the time of the study, implementation of the electronic hospital information systems varied across the hospitals, with different levels of implementation for clinical and transactional processes.

Study Population

The study population comprised healthcare professionals aged 18-59 years who were willing to participate and used the electronic HIS to provide services in their respective health facilities.

Study Settings

The NCHS, now known as the Catholic Health Service Trust, Ghana, is a private, not-for-profit healthcare provider owned by the Catholic Church in Ghana and operates under the Department of Health of the National Catholic Secretariat. The NCHS has 144 health facilities, comprising 45 hospitals, 82 clinics, 10 health training institutions, and five specialized institutions.

The study was conducted in 25 NCHS-accredited hospitals located across 11 regions and three ecological zones of Ghana. These facilities have provided health services in Ghana since 2010 and have adopted HIS to automate claims processes, improve efficiency in claims management, and support clinical outcomes through various HIS claims management systems.

Study Sites Selection

All 45 NCHS hospitals were considered eligible for the study and were initially screened based on their use of electronic HISs. Of the 45 hospitals, 31 were identified as using electronic HISs, while 14 were excluded at the first screening stage because they did not use such systems. At the second screening stage, six hospitals were excluded because the HIS was operational only at the outpatient department. This resulted in 25 hospitals with electronic HISs covering both outpatient department and inpatient services, which constituted the final sample for the study.

Participants Selection

Healthcare professionals who were willing to participate were conveniently selected from six departments comprising physicians, nurses, dispensary officers, medical laboratory officers, health insurance claims/account officers, and health information officers. Participants were permanent staff who had worked in the hospital for at least six months and had prior experience using the HIS.

Sample Size Determination

The minimum sample size for this research was determined according to an a priori power analysis [26,27]. The minimum sample is 194 respondents because this would provide sufficient statistical power (0.80) to detect small correlation coefficients (0.20) [26]. This allowed for the possibility of a larger sample size, which would increase

the robustness of our findings and increase the statistical power needed to detect smaller effects. A priori power sample size calculation is denoted by $n = \left\lceil \frac{(Z_{\alpha} + Z_{\beta})^2}{c} \right\rceil + 3$

where n = required sample size; α (two-tailed) = 0.05, the significance level (Type I error rate, or probability of rejecting the null hypothesis when it is true); β = 0.20, the type II error rate or the probability of failing to reject the null hypothesis when the alternative hypothesis is true.; r = 0.20, the expected correlation coefficient (effect size); the standard normal deviation for α = Z_{α} = 1.9600; the standard normal deviation for β = Z_{β} = 0.8416, and

$$C = 0.5 \times \ln \left| \frac{(1+r)}{(1-r)} \right| = 0.2027$$

resulting

$$n = \left\lceil \frac{(1.9600 + 0.8416)^2}{0.2027} \right\rceil + 3 = 194$$

Hospitals were purposively selected for the study. The participants were conveniently selected in each hospital until a desired sample size was reached.

Inclusion and Exclusion criteria

The study included all permanent health professionals using the HIS for at least six months and handling, generating, and utilizing data for decision-making. All permanent healthcare professionals who have been using the HIS for less than six months and have not handled, generated, or utilized data for decision-making were excluded from the study.

Data Collection Instrument

This study used an adapted structured survey questionnaire based on the upgraded DeLone and McLean model [28] and extended ISSM [29] to obtain data from health professionals on their perceived HIS effectiveness. The questionnaires were distributed and completed anonymously by users (i.e. health professionals) of the HIS across the 25 health facilities within the NCHS. The targeted users included physicians, nurses, dispensary staff, medical laboratory staff, accounting staff, health insurance claims officers, and health information management officers. The questionnaires comprised two sections: Section 1 collected information on respondent characteristics, and Section 2 covered HIS evaluation measures on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) (Table 1). The study was approved by the ethical committee of the NCHS.

The questionnaire covered five interconnected thematic areas of the extended ISSM (E-ISSM) model (i.e., system quality, information quality, service quality, system use, and user satisfaction. It also assessed six dimensions of the upgraded DeLone and McLean (U-DM) model (i.e., system quality, information quality, service quality, system use, user satisfaction, and potential net benefit). The specific dimensions of the information systems measured are defined as follows:

- Hospital Information System Quality has three dimensions: namely, “system quality,” “information quality,” and “service quality,” which together affect system use and “user satisfaction.” System quality refers to the characteristics and capabilities of the HIS to support healthcare activities and processes. In this study, it reflects the ability of the HIS to support healthcare services delivery and facilitate interrelated workflows that may contribute to improved patient care [30,31].
- “Information quality” refers to the value and worth of the output emanating from HISs to the users [31]. Users would be much happier to use HISs for patient-related activities at any time when the output is complete, current, secure, and easy to comprehend.
- “Service quality” can be defined as the ability of the HIS managers to troubleshoot HISs and users’ requests due to downtime [31]. The objective of service quality is to measure the support system provided by HIS managers because poor user support can lead to inadequate trust and low motivation to use the HIS.
- “System use” is defined as the level at which users utilize the HIS to provide healthcare services. The extent or frequency of use by the users is used as a measurement yardstick.

- “User satisfaction” refers to the manner in which users feel that the HIS is key to enhancing the quality and effectiveness of the service delivery offered to patients[28,31].
- “Potential net benefits” refers to the overall benefits (negative or positive) that stakeholders of the organization obtain from the total use of the HIS. This is measured by evaluating the organizational or individual impact [31]. For this study, individual impact was assessed because the primary users were the focus.

Table 1. Study construct and measures of assessment

Construct	Construct Definition	No. of items		Scale
		E-ISSM	U-DM	
System quality	HISs capabilities are required to offer healthcare services to patients [30,31].	16	4	5 – Point Likert
Information quality	The value and worth of output emanating from HISs by the users [31].	22	4	5 – Point Likert
Service quality	The ability of the HIS managers to troubleshoot HISs and users’ requests due to downtime [31].	6	4	5 – Point Likert
System use	The level at which users are using the HIS to provide healthcare services	3	4	5 – Point Likert
User satisfaction	The manner in which users felt that the HIS was key to enhancing the quality and effectiveness of the service delivery offered to patients [28,31]	4	3	5 – Point Likert
Perceived net benefits	Overall benefits (negative or positive) that stakeholders of the organisation obtain from the total use of the HIS [31].	N/A	5	5 – Point Likert

E-ISSM – extended Information System Success Model [29]; U-DM – upgraded DeLone and McLean model [28]; N/A – Not applicable

Primary Outcome

The main outcome of interest was the rate of HIS effectiveness, which is the overall level of perceived HIS performance from the healthcare professionals’ perspective. The HIS effectiveness score was calculated as a normalized percentage score using the weighted average method (equal item weighting), where each questionnaire item contributed equally to the final score. This approach has been widely used to standardize Likert scale scores and enable comparison across domains and studies.

For each respondent, the effectiveness rate of the HIS was calculated for each assessment measure separately, for each dimension of the questionnaire and for the overall score of the questionnaire, for the two assessment tools, the E-ISSM and the U-DM. The normalized percentage scores of individual respondents were then averaged to arrive at an overall HIS effectiveness rate [8,32].

The calculation was performed as follows:

- Maximum possible score = Number of questionnaire items × 5 (maximum score on the 5-point Likert scale).
- Obtained score = Sum of the respondent's scores across all questionnaire items.
- HIS effectiveness rate (%) was calculated using the formula:

$$\text{HIS effectiveness rate (\%)} = \left(\frac{\text{Obtained score}}{\text{Maximum possible score}} \right) \times 100$$

The overall HIS effectiveness rate was categorized as follows: high ($\geq 75\%$), moderate (50% to $< 75\%$), low (25% to $< 50\%$), and very low ($< 25\%$). Bloom’s modified cutoff point was used to determine a high HIS effectiveness rate ($\geq 75\%$) and a very low HIS effectiveness rate ($< 25\%$). Thus, health facilities with higher percentage scores ($\geq 75\%$) were considered as having “high HIS performance rate”, while those with lower percentage scores ($< 25\%$) were considered “low HIS performance rate” [33]. This normalized percentage score provides an intuitive measure of perceived HIS effectiveness, as it expresses the achieved score as a percentage of the maximum achievable score and gives equal weight to all questionnaire items.

Data Collection Procedures

The adapted paper-based questionnaire included the extended Information System Success Model (51 items) and the upgraded DeLone and McLean model (24 items). The survey instrument was pre-tested in a hospital with similar characteristics, but not one of those selected for the study. Data was collected from 25 health facilities among health professionals from 10th April to 30th June 2022. Data were collected using a self-administered paper-based questionnaire. The research team members personally distributed the questionnaires to all eligible health professionals in all clinical and administrative units. The questionnaires were anonymous and did not contain any personal identifiers. Respondents were not required to provide any names, employee numbers, or other identifying information. Participation was voluntary, and completion of the questionnaire was taken as implied consent. Participants were informed both orally and in writing about their right to refuse or withdraw at any time without penalty. Health personnel who were not present during the first visits were contacted at their units during the subsequent visits.

Analysis

Descriptive statistics were used to summarize respondent characteristics and construct scores. Negative items were reverse-coded before analysis. Shapiro–Wilk test was used as a diagnostic assessment of score distributions; given the ordinal Likert-based scoring and observed departures from normality, associations between overall HIS effectiveness scores and their dimensions were evaluated using Spearman rank correlations. Analysis of variance (ANOVA) was conducted to determine the mean difference in HIS Effectiveness Rate among professions. The HIS effectiveness rate was computed as a normalized percentage score: the sum of item scores divided by the maximum possible score for the same items, multiplied by 100. All items were weighted equally within each construct; no differential item weighting scheme was applied. Effectiveness rates were categorized as high ($\geq 75\%$), moderate ($50\% - < 75\%$), low ($25\% - < 50\%$), or very low ($< 25\%$). Bland–Altman analysis was used descriptively to assess concordance between hospital-level normalized effectiveness scores from the E-ISSM and U-DM frameworks. Individual respondents were the unit of analysis for descriptive summaries, construct scoring, reliability analyses, and Spearman correlations. For the Bland–Altman analysis, respondent-level normalized effectiveness scores were aggregated to the hospital level by averaging within each hospital, producing 25 paired hospital-level observations (one E-ISSM score and one U-DM score per hospital). All statistical analyses were performed using Stata MP version 18 (StataCorp, College Station, Texas, USA) and a p-value < 0.05 was considered statistically significant.

Reliability and Validity of the Study Construct

Both instruments, the U-DM model [6] and the E-ISSM model [29] were adapted. The overall Cronbach's alpha was 0.79 and 0.89, respectively, indicating high reliability. Individual Cronbach's alphas for the study's various dimensions were also determined (Supplementary Tables 9 and 11). The reliability and validity of the study constructs were also evaluated using Confirmatory Factor Analysis (CFA). The constructs of the E-ISSM and the U-DM were tested separately by means of a CFA. The analysis was performed to test whether the observed indicators were adequate to represent their respective latent constructs and to test the adequacy of the measurement models before proceeding with the analysis (Supplementary Tables 10 and 12). The content validity index (CVI) and content validity ratio (CVR) for both tools (Table 4) were determined based on the following formula:

$$I - CVI = \frac{\text{Number of experts rating 4 or higher}}{\text{Total number of experts}}, \text{ where CVI is the content validity index.}$$

The scale-level CVI (S-CVI) was calculated as the average of all I-CVI values across items [34].

CVR is Content Validity Ratio. CVR was calculated using Lawshe's formula [35]: $CVR = \frac{(n_e - \frac{n}{2})}{\frac{n}{2}}$, where n_e = number of experts indicating an item as "agree" (here, ratings ≥ 4), and n = total number of experts. CVR values range from -1 to +1; positive values indicate that more than half of the experts rated the item as essential.

Results

Distribution of Respondents by Health Facility and Department

The total number of questionnaires distributed was 1738. A total number of 1416 (81%) responses were collected. Table 2 shows the distribution of the number of respondents by health facility.

Table 2. Distribution of respondents by health facility and department.

Hosp code	Nurses		Physicians		Dispensary		Medical Laboratory		Accounts/Claims		Health Information		Total	
	ND	NR (%)	ND	NR (%)	ND	NR (%)	ND	NR (%)	ND	NR (%)	ND	NR (%)	ND	NR (%)
HP01	75	63 (84)	6	4 (67)	9	9 (100)	7	7 (100)	8	8 (100)	6	6 (100)	111	97 (87)
HP02	90	77 (86)	15	13 (87)	7	7 (100)	11	11 (100)	11	11 (100)	6	6 (100)	140	125 (89)
HP03	31	21 (68)	11	9 (83)	5	5 (92)	7	7 (94)	3	3 (100)	8	6 (75)	66	51 (77)
HP04	53	40 (75)	10	8 (80)	9	9 (100)	12	10 (83)	11	11 (100)	12	9 (75)	107	87 (81)
HP05	60	48 (80)	10	6 (60)	3	2 (59)	7	7 (94)	6	6 (100)	5	5 (100)	92	74 (80)
HP06									5	4 (80)			5	4 (80)
HP07									12	10 (83)			12	10 (83)
HP08	51	37 (73)	8	5 (63)	6	6 (100)	5	5 (100)	3	3 (100)	5	5 (100)	78	61 (78)
HP09	55	48 (87)	9	6 (67)	6	6 (100)	20	17 (85)	5	5 (100)	6	6 (100)	101	88 (87)
HP10	44	30 (68)	12	8 (67)	10	10 (100)	10	9 (90)	15	13 (87)	15	12 (80)	106	82 (77)
HP11	32	27 (84)	5	5 (100)	6	6 (100)	8	8 (100)	8	7 (88)	5	5 (100)	64	58 (91)
HP12	30	23 (77)	4	4 (100)	5	5 (100)	6	6 (100)	10	9 (90)	12	10 (83)	67	57 (85)
HP13	45	37 (82)	7	6 (86)	5	5 (100)	7	7 (100)	6	6 (100)	4	4 (100)	74	65 (88)
HP14	40	26 (65)	6	6 (100)	6	6 (100)	6	6 (100)	4	4 (100)	6	6 (100)	68	54 (79)
HP15									8	5 (63)			8	5 (63)
HP16	58	35 (60)	3	3 (91)			2	2 (100)	2	2 (100)	2	2 (100)	7	44 (65)
HP17	35	22 (63)	4	4 (100)	4	4 (100)	7	7 (100)	9	9 (100)	3	3 (100)	2	49 (79)
HP18									10	7 (70)			0	7 (70)
HP19	57	36 (64)	6	4 (62)	2	2 (100)	4	4 (100)	5	5 (100)	5	5 (100)	79	56 (71)
HP20	35	25 (71)	6	4 (67)	2	2 (100)	5	5 (100)	8	6 (75)	4	4 (100)	60	46 (77)
HP21									8	5 (63)			8	5 (63)
HP22	60	49 (82)	15	11 (73)	10	9 (90)	10	6 (60)	15	10 (67)	10	9 (90)	120	94 (78)
HP23	45	36 (80)	6	6 (100)	7	7 (100)	7	7 (100)	7	7 (100)	10	8 (80)	82	71 (87)
HP24	40	32 (80)	4	4 (100)	6	6 (100)	5	5 (100)	6	4 (67)	5	5 (100)	66	56 (85)
HP25	40	36 (90)	10	6 (60)	10	8 (80)	5	4 (80)	10	8 (80)	10	8 (80)	85	70 (82)
Total	976	748 (77)	158	122 (77)	119	114 (96)	152	140 (92)	195	168 (86)	139	124 (89)	1738	1416 (81)

Hosp code – Hospital code; ND – Number distributed; NR – Number returned; Source: Authors' analysis, 2022

Background Characteristics

More than 50% of the respondents came from the nursing department; the majority (51.48%) of the respondents were men (Table 3).

Table 3. Background characteristics of all users from the 25 healthcare facilities

Users' characteristics	Frequency	Percentage
Age-group		
Below 30	130	9.18
30-44	1,100	77.68
45 plus	186	13.14
Sex		
Male	729	51.48
Female	687	48.52
Level of education		
SHS	120	8.47
Diploma	906	63.98
Degree	307	21.68
Masters or Higher	83	5.86
Work experience		
Below 1 year	0	0
1-5 years	177	12.5
6-10 years	528	37.29
More than 10 years	711	50.21
HIS usage experience		
Below 1 year	5	0.35
1-5 years	94	6.64
6-10 years	1232	87.01
More than 10 years	85	6
Working hours spent on using HIS for-service provision by HP		
Less than 30 minutes	4	0.28
Between 30 minutes and 1 hour	24	1.69
Between 1 and 2 hours	298	21.05
Between 2 and 3 hours	600	42.37
Between 3 and 4 hours	108	7.63
More than 4 hours	382	26.98
Department		
Nursing	748	52.82
Physicians/Doctors	122	8.62
Dispensary	114	8.05
Medical Laboratory	140	9.89
Accounts/Claims	168	11.86
Health Information	124	8.76

Data are presented as numbers and percentages. HP, healthcare providers; HIS, hospital information system.

Descriptive Statistics, Scale and Item Reliability Test

Table 4 presents the descriptive statistics, reliability coefficients, and validity indices for the Extended Information System Success Model (E-ISSM) and Upgraded DeLone and McLean (U-DM) model instruments administered to health professionals. Both instruments demonstrated satisfactory to excellent internal consistency and strong content validity. Mean scores across dimensions ranged from 3.93 to 4.27, suggesting generally positive perceptions of system quality, information quality, service quality, usage, satisfaction, and perceived net benefits among health professionals.

Table 4. Descriptive statistics, Scale and Item reliability test.

Dimensions	Number of Items	Cronbach's Alpha Coefficient	Content Validity Index	Content Validity Ratio	Health Professionals (n=1416)		
					Mean	SD	Mean Values under 95% CI
E-ISSM model	51	0.79	96.1	94.1			
System Quality	16	0.89			3.99	0.67	[3.96 - 4.03]
Information Quality	22	0.88			3.93	0.59	[3.89 - 3.96]
Service Quality	6	0.85			4.23	0.79	[4.19 - 4.28]
System use	3	0.86			4.27	0.94	[4.21 - 4.32]
User satisfaction	4	0.79			3.93	0.88	[3.88 - 3.98]
U-DM model	24	0.89	100.0	95.8			
System Quality	4	0.80			4.23	0.90	[4.18 - 4.28]
Information Quality	4	0.80			4.17	0.82	[4.12 - 4.21]
Service Quality	4	0.76			3.96	0.90	[3.91 - 4.01]
System use	4	0.66			4.05	0.81	[4.00 - 4.10]
User satisfaction	3	0.79			4.12	0.94	[4.07 - 4.17]
Perceived net benefits	5	0.80			4.02	0.82	[3.97 - 4.07]

The Extended Information System Success Model (E-ISSM) and Upgraded DeLone and McLean (U-DM) model were adapted for this study. CI, confidence interval; SD, standard deviation

HIS Effectiveness Rate of dimensions stratified by profession

Table 5 presents the analysis of the mean HIS Effectiveness rate for all dimensions used for the E-ISSM and U-DM models for assessment. The analysis shows that system use, and service quality recorded the highest mean HIS effectiveness rate of 80% and higher for the E-ISSM model, while system quality, information quality, user satisfaction, system use, and perceived net benefits obtained the highest score of 80% and above for the U-DM model. Only service quality recorded a score less than 80% using the U-DM model. In the case of the E-ISSM model, system quality, information quality and user satisfaction had scores less than 80%.

Further analysis of the E-ISSM model shows that there is a statistically significant mean variation in system use HIS effectiveness rate among professional categories: nurses, physicians, dispensary staff, medical laboratory staff, accounts/claims officers, and health information officers ($p = 0.0147$) (Table 5). U-DM model analysis revealed a statistically significant mean variation in system use ($p = 0.0159$) and perceived net benefits ($p = 0.0002$) in HIS effectiveness rates among professional categories. The total HIS effectiveness rates for the professional categories ranged from 79.79% to 83.45% for E-ISSM and 80.40% to 85.43% for U-DM models, respectively (Table 5). Further analysis of the U-DM model shows a statistically significant mean variation in the total HIS effectiveness rate for the professional categories ($p = 0.0040$), with the highest HIS effectiveness rate coming from the health information cadre group (85.43%, 95% Confidence Interval (CI)[83.65% – 87.20%]) (Table 5).

Overall HIS effectiveness Rate based on the E-ISSM and U-DM models

The overall mean total HIS Effectiveness rate for the E-ISSM and U-DM models was 81.41% with a 95%CI [80.90%–81.92%] and 81.79% with a 95% CI [81.17%–82.41%], respectively (Tables 6 and 7). Considering the E-ISSM model, only one (4%) out of 25 healthcare providers was in the moderate HIS effectiveness rate category (moderate – $50\% \leq \text{HIS effectiveness rate} < 75\%$), and the remaining 24 (96%) out of 25 healthcare providers were in the high HIS effectiveness rate category (high – $75\% \leq \text{HIS effectiveness rate}$) (Table 6). The analysis of the U-DM model shows that four (16%) out of 25 healthcare providers were in the moderate HIS effectiveness rate category (moderate – $50\% \leq \text{HIS effectiveness rate} < 75\%$), and the remaining 21 (84%) out of 25 healthcare providers were in the high HIS effectiveness rate category (high – $75\% \leq \text{HIS effectiveness rate}$) (Table 7).

Table 5. Mean HIS Effectiveness Rate of dimensions stratified by profession.

Dimensions	All users	Nurses	Physicians/ Doctors	Dispensary	Medical Laboratory	Accounts/ Claims	Health Information	F-value; p-value
E-ISSM model								
System Quality	79.77 [79.07 – 80.46]	79.95 [78.98 – 80.90]	78.77 [76.31 – 81.24]	79.53 [77.19 – 81.86]	79.92 [77.63 – 82.21]	81.14 [79.18 – 83.09]	77.84 [75.37 – 80.31]	1.05; 0.3886
Information Quality	78.48 [77.87 – 79.09]	78.53 [77.70 – 79.37]	77.94 [75.80 – 80.09]	78.00 [75.86 – 80.13]	77.80 [75.78 – 79.82]	79.89 [78.16 – 81.62]	77.95 [75.83 – 80.07]	0.72; 0.6079
Service Quality	84.45 [83.63 – 85.27]	84.31 [83.23 – 85.40]	84.73 [81.83 – 87.62]	85.26 [82.43 – 88.10]	84.71 [81.98 – 87.44]	84.33 [81.82 – 86.84]	84.11 [81.04 – 87.19]	0.10; 0.9920
System use	85.33 [84.27 – 86.40]	85.36 [84.00 – 86.71]	80.44 [76.74 – 84.13]	85.91 [82.54 – 89.27]	87.14 [83.01 – 91.28]	86.00 [82.17 – 89.83]	90.78 [87.06 – 94.50]	2.84; 0.0147*
User satisfaction	78.25 [77.34 – 79.17]	78.30 [77.04 – 79.55]	77.09 [74.00 – 80.18]	78.82 [75.59 – 82.04]	75.64 [72.37 – 78.92]	78.90 [76.51 – 81.29]	80.69 [77.58 – 83.79]	1.27; 0.275
Total HIS Effectiveness rate	81.41 [80.90 – 81.92]	81.31 [80.65 – 81.97]	79.79 [78.08 – 81.51]	81.50 [79.91 – 83.10]	81.85 [80.04 – 83.65]	82.67 [80.99 – 84.36]	83.45 [81.41 – 85.50]	1.81; 0.1073
U-DM model								
System Quality	84.22 [83.28 – 85.15]	84.39 [83.09 – 85.69]	83.69 [80.63 – 86.75]	83.68 [80.63 – 87.10]	83.43 [80.46 – 86.40]	82.35 [79.62 – 85.08]	87.58 [84.73 – 90.43]	1.35; 0.2406
Information Quality	83.64 [82.79 – 84.49]	82.95 [81.77 – 84.14]	84.26 [81.55 – 86.97]	83.03 [79.83 – 86.23]	84.75 [81.88 – 87.62]	83.33 [80.93 – 85.74]	86.90 [84.26 – 89.53]	1.45; 0.2027
Service Quality	79.39 [78.45 – 80.32]	79.31 [78.02 – 80.60]	77.87 [74.56 – 81.18]	78.86 [75.56 – 82.15]	80.32 [77.27 – 83.37]	77.59 [74.87 – 80.31]	83.23 [80.34 – 86.11]	1.75; 0.1203
System use	81.08 [80.23 – 81.92]	80.80 [79.62 – 81.97]	78.89 [75.87 – 81.92]	82.85 [80.11 – 85.59]	82.25 [79.54 – 84.96]	78.99 [76.47 – 81.51]	84.84 [82.31 – 87.36]	2.80; 0.0159*
User satisfaction	82.03 [81.05 – 83.01]	81.29 [79.91 – 82.68]	81.86 [78.88 – 84.83]	84.15 [80.78 – 87.52]	84.57 [81.74 – 87.40]	80.36 [77.56 – 83.16]	84.14 [80.64 – 87.64]	1.62; 0.1518
Perceived net benefits	80.38 [79.53 – 81.24]	78.97 [77.76 – 80.19]	79.90 [77.20 – 82.61]	81.68 [78.82 – 84.55]	82.97 [80.24 – 85.70]	79.93 [77.52 – 82.34]	85.87 [83.30 – 88.44]	4.82; 0.0002*
Total HIS Effectiveness rate	81.79 [81.17 – 82.41]	81.29 [80.42 – 82.15]	81.08 [79.01 – 83.15]	82.05 [80.24 – 84.51]	83.05 [81.01 – 85.09]	80.42 [78.50 – 82.35]	85.43 [83.65 – 87.20]	3.48; 0.0040*

Data are reported as Mean % [95%CI]. ANOVA was conducted to determine the mean difference in HIS Effectiveness Rate among professions. p-value<0.05 was considered statistically significant. CI - Confidence Interval; HIS - Hospital Information System

Table 6. HIS effectiveness Rate based on the E-ISSM model.

Hospital Code	HIS Effectiveness Rate categories*			
	Very low Mean % [95%CI]	Low Mean % [95%CI]	Moderate Mean % [95%CI]	High Mean % [95%CI]
HP01	–	–	–	80.18 [78.13 – 82.23]
HP02	–	–	–	85.13 [83.54 – 86.72]
HP03	–	–	–	82.51 [80.90 – 84.12]
HP04	–	–	–	83.91 [82.08 – 85.74]
HP05	–	–	–	76.70 [75.43 – 77.98]
HP06	–	–	–	83.63 [82.93 – 84.34]
HP07	–	–	–	79.34 [71.67 – 87.02]
HP08	–	–	–	81.94 [80.08 – 83.80]
HP09	–	–	–	82.43 [80.75 – 84.11]
HP10	–	–	67.63 [65.42 – 69.84]	–
HP11	–	–	–	81.96 [79.98 – 83.93]
HP12	–	–	–	82.91 [80.38 – 85.43]
HP13	–	–	–	81.68 [79.87 – 83.48]
HP14	–	–	–	81.33 [78.75 – 83.92]
HP15	–	–	–	77.58 [69.90 – 85.27]
HP16	–	–	–	84.36 [80.94 – 87.78]
HP17	–	–	–	84.39 [81.49 – 87.30]
HP18	–	–	–	80.67 [75.03 – 86.32]
HP19	–	–	–	86.55 [83.71 – 89.39]
HP20	–	–	–	77.74 [74.76 – 80.72]
HP21	–	–	–	81.09 [72.58 – 89.61]
HP22	–	–	–	82.04 [80.27 – 83.81]
HP23	–	–	–	77.48 [75.67 – 79.30]
HP24	–	–	–	80.79 [78.02 – 83.56]
HP25	–	–	–	84.04 [81.61 – 86.49]
Overall	–	–	–	81.41 [80.90 – 81.92]

HP – Healthcare Provider; HIS - Hospital Information System

Measuring Agreement between the E-ISSM and U-DM using the Bland-Altman Method

The agreement between the E-ISSM and U-DM was assessed with Bland-Altman analysis (n=25 paired measurements). The mean difference (bias) was 0.40, which suggests a small systematic difference between the two methods (Table 8). Regression analysis of the differences of the mean measurements showed no significant proportional bias ($\beta = -0.497$, $p = 0.123$; $R^2 = 0.100$). Regression modelling of the standard deviation suggested a decreasing trend in variability with increasing measurement magnitude ($\beta = -0.530$, $p = 0.069$), but this was not statistically significant. Therefore, regression-based limits of agreement were estimated as Lower Limit of Agreement (LLOA) = $-51.37 + 0.54 \times \text{Mean (A, B)}$ and Upper Limit of Agreement (ULOAA) = $132.64 - 1.53 \times \text{Mean (A, B)}$. Thus, the assumption of no proportional bias for Bland–Altman analysis was considered to be met. Figure 1 shows a Bland-Altman plot of the difference between the expanded ISSM and upgraded DM models against the mean of the expanded ISSM and upgraded DM models in the 25 health facilities in the study. Only one hospital fell outside the limits of agreement. The majority (24) of the hospitals were between averages of 75.5% and 87.0%.

Table 7. HIS Effectiveness Rate based on U-DM model.

Hospital Code	HIS Effectiveness Rate categories*			
	Very low Mean % [95%CI]	Low Mean % [95%CI]	Moderate Mean % [95%CI]	High Mean % [95%CI]
HP01	–	–	–	75.07 [72.54 – 77.61]
HP02	–	–	–	79.08 [76.86 – 81.31]
HP03	–	–	–	81.36 [78.92 – 83.79]
HP04	–	–	–	88.08 [86.15 – 90.01]
HP05	–	–	–	80.11 [78.71 – 81.49]
HP06	–	–	–	84.25 [71.54 – 96.96]
HP07	–	–	73.75 [63.73 -83.77]	–
HP08	–	–	–	82.94 [79.15 – 86.72]
HP09	–	–	–	85.21 [83.04 – 87.39]
HP10	–	–	–	84.51 [81.49 – 87.54]
HP11	–	–	–	88.72 [85.76 – 91.67]
HP12	–	–	–	84.45 [80.75 – 88.14]
HP13	–	–	–	83.21 [80.46 – 85.96]
HP14	–	–	–	83.49 [80.39 – 86.59]
HP15	–	–	–	77.51 [67.37 - 87.65]
HP16	–	–	–	81.47 [78.60 – 84.34]
HP17	–	–	–	85.27 [82.55 – 87.98]
HP18	–	–	70.52 [61.35 – 79.68]	–
HP19	–	–	–	86.80 [83.70 – 89.89]
HP20	–	–	–	77.68 [73.72 – 81.64]
HP21	–	–	70.19 [57.14 – 83.23]	–
HP22	–	–	–	81.54 [79.64 – 83.44]
HP23	–	–	73.73 [72.04 – 75.41]	–
HP24	–	–	–	78.17 [74.86 – 81.48]
HP25	–	–	–	82.35 [80.36 – 84.34]
Overall	–	–	–	81.79 [81.17 – 82.41]

HP – Healthcare Provider; HIS - Hospital Information System

Table 8. Bland–Altman analysis of agreement between the expanded ISSM and upgraded DM (n = 25).

Parameter	Estimate	P-value	Interpretation
Number of paired observations	25	–	Paired measurements included in the analysis.
Mean difference (bias)	0.4	–	The expanded ISSM, on average, 0.40 units higher than the upgraded DM Tool, indicating negligible systematic bias.
Standard deviation of differences	5.46	–	Represents the variability of the differences between the two methods.
Regression slope (difference vs. mean)	–0.497	0.123	No statistically significant proportional bias was detected.
R ²	0.1	–	Approximately 10.0% of the variability in the differences was explained by the mean measurement.
Regression-based SD	46.94 – 0.53 × Mean (A, B)	0.069	The variability of the differences tended to decrease with increasing measurement magnitude, although this trend was not statistically significant.
Regression-based Lower Limit of Agreement	–51.37 + 0.54 × Mean (A, B)	–	Lower limit varies according to the average measurement.
Regression-based Upper Limit of Agreement	132.64 – 1.53 × Mean (A, B)	–	Upper limit varies according to the average measurement.

SD, standard deviation; R², coefficient of determination; Mean (A, B), average of the expanded ISSM and upgraded DM Tool measurements. Regression-based limits of agreement were estimated because the Bland–Altman procedure evaluated the possibility of non-constant variability across the measurement range.

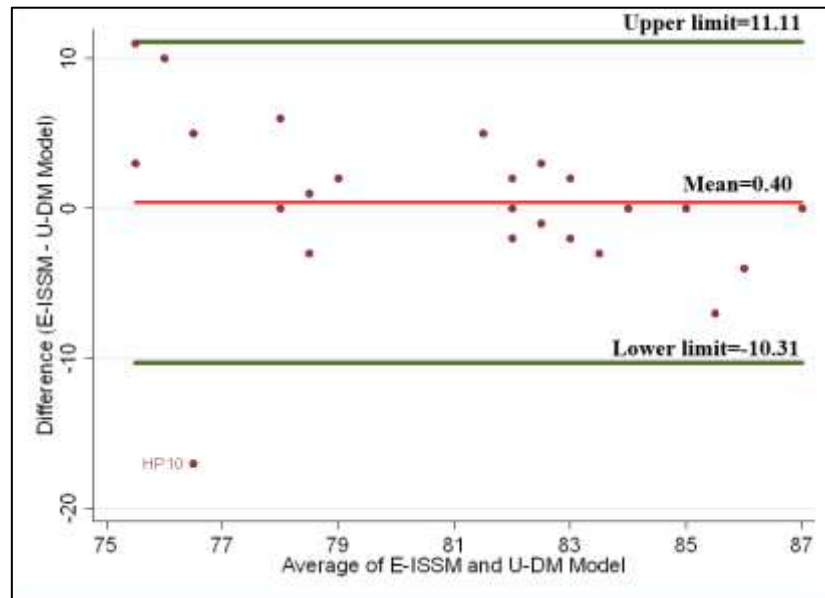


Figure 1. Bland-Altman plot of the difference between E-ISSM and U-DM models against the mean of E-ISSM and U-DM models in the 25 health facilities in the study. Point outside limits labelled by hospital code.

Validation of the E-ISSM and U-DM Mean HIS Effectiveness Rates

The E-ISSM revealed a strong statistically significant correlation between the total mean HIS effectiveness rate and its dimensions (Figure 2). Similarly, the U-DM model also revealed a strong statistically significant correlation between the total mean HIS effectiveness rate and its dimensions (Figure 2).

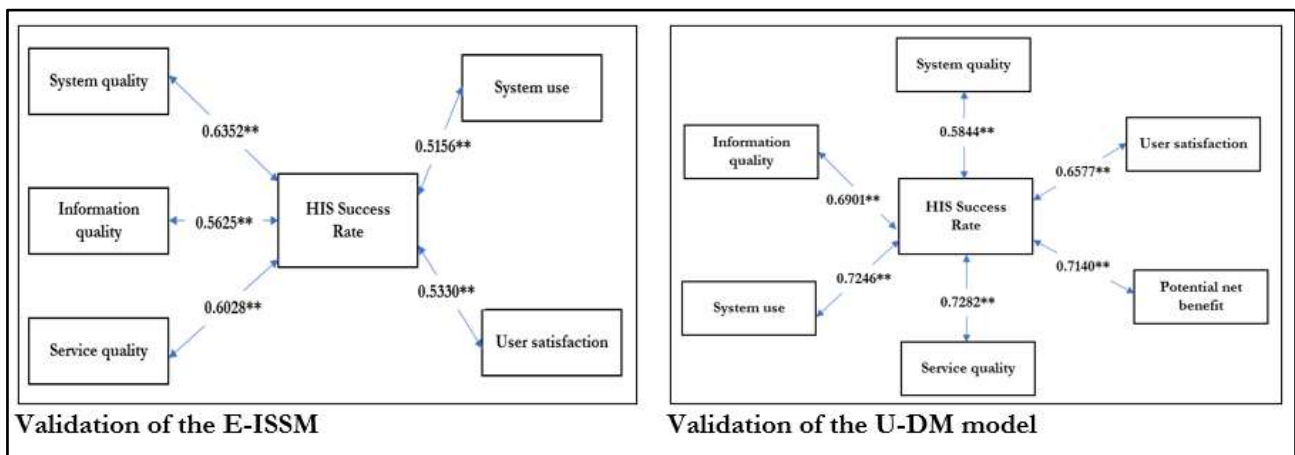


Figure 2. Validation of the E-ISSM and U-DM models HIS effectiveness Rate using Spearman correlation analyses. **Statistically significant at p-value<0.0001

Discussion

The current study modified an extended ISSM and improved DM models to evaluate HIS effectiveness in 25 NCHS hospitals in Ghana. The demonstrated high validity and reliability for both instruments suggest they are suitable for assessing HIS performance or effectiveness in similar low- and middle-income country settings. These findings align with the initial validation of the extended ISSM by Ebnehoseini et al., where the strength of the framework in evaluating electronic health records was illustrated through the dimensions of system quality, information quality, service quality, system use, user satisfaction, and net benefits [16]. However, in addition to confirming previous validation studies, the findings should be interpreted in light of the specific organizational

and technological context of Ghanaian hospitals. All hospitals had high HIS effectiveness scores, but differences in the maturity of implementation, the availability of infrastructure, technical support and the digital competencies of staff probably influence how users perceive them and could explain the variation between facilities. Similar contextual influences have been reported among Ghanaian health leaders in the context of the implementation of electronic health records [36]. These contextual factors were not studied in the present study, but deserve further study.

Consistent with the previous studies [16,37] users had positive perceptions of system quality, information quality, service quality, system use, user satisfaction and potential net benefits. In Ghana, positive relationships between system effectiveness, user satisfaction and system utilization have also been reported for the Lightwave Health Information Management System (LHIMS) [18]. Although these results are consistent with previous evaluations of HISs and electronic health records, the high scores overall in this study may also partly be attributed to the relatively advanced stage of HIS implementation in the NCHS hospitals involved in this study, which have been investing in digital health systems for several years. Moreover, strong organizational commitment to faith-based delivery of health services may contribute to positive user experiences through greater institutional support and continuity of system use, which has been corroborated by Attafuah et al. [36].

The significant correlations between the study constructs also support the theoretical assumptions of the ISSM and the DeLone and McLean Information Systems Success Model that system quality, information quality, and service quality influence system use, user satisfaction, and perceived benefits [4,16]. Similar relationships have been demonstrated in Ghanaian information systems research, where improvements in system quality and information quality significantly predicted system use and user satisfaction [38]. From a practical point of view, these relationships imply that improved technical infrastructure, data quality management and user support services are likely to lead to better overall HIS performance and user acceptance.

The Bland-Altman analysis showed good agreement between the extended ISSM and upgraded DM tools at the aggregated hospital level. However, these findings should be interpreted with care. The results indicate that both instruments give similar estimates of hospital-level HIS effectiveness, but this does not necessarily imply that they are fully interchangeable. Interchangeability would need further evidence of agreement at the level of the individual user, sensitivity to change over time, consistency of decision thresholds and equivalence of the constructs being measured, particularly in light of the differences in dimensional structure and item composition between the two instruments. Thus, the results support comparability of the aggregated effectiveness assessments rather than absolute interchangeability of the tools in all evaluation contexts [4,5,39,40].

A key finding was the difference in system use and perceived net benefits across professional groups. Higher scores among dispensary, accounts/claims and health information professionals might be partly explained by greater access to computers among administrative and financial personnel, but differences in organizational workflow are also likely contributors. The HIS is the main platform for many administrative and claims staff in their day-to-day activities, such as billing, claims processing, reporting and inventory management. On the other hand, physicians and nurses may need to divide their attention between direct patient care activities and digital documentation requirements, which may limit the extent of interaction with the system and influence perceptions of benefit. Recently, similar differences were reported by Pertiwi et al. in user satisfaction and system perceptions across demographic and professional groups [41]; and Türkmen and Özkara showed that workflow integration and system quality significantly influence perceived HIS benefits [37]. These findings suggest that adoption strategies should be designed to fit professional roles. For example, interventions for clinicians may focus on workflow integration, usability, and reducing documentation burden; interventions for administrative staff may emphasise advanced functionality and performance.

Policy and Practice Implications

The findings have important practical implications for hospital managers and health system administrators. The specific operational improvement strategies can be correlated with the individual ISSM dimension evaluation scores. For example, lower scores could be an indicator of the need to improve helpdesk responsiveness, escalation pathways, technical support staffing and user training. Information quality scores may inform investment in data

governance procedures, data validation mechanisms and routine data quality audits. Findings about system quality can direct improvements in infrastructure, software optimization and system reliability. Indicators of user satisfaction and system use can be used to identify departments that need to be provided with additional change-management support or targeted capacity building. The recommendations align with the practical implementation of the extended ISSM proposed by Ebnehoseini et al. [16].

At the policy level, the consistently high perceived HIS effectiveness across NCHS hospitals supports continued digital health investments and broader scaling of HIS implementation across public, private and faith-based providers in Ghana. Similar recommendations have been made by recent studies in Ghana, emphasizing the need for sustained investment, organizational support, and standardized HIS evaluation to improve healthcare delivery [19,36]. The findings also highlight the need for the development of standard national HIS assessment frameworks that include validated multidimensional measures such as the ISSM and DM. Such frameworks would facilitate benchmarking between health facilities and support evidence-based policymaking in the domain of digital health.

Implications for Future Research

Future studies should examine the concordance between the two evaluation tools at the individual user level and assess their sensitivity to changes in HIS performance over time. Validation should combine user assessments with objective performance indicators, including patient turnaround time, claims processing time, system downtime, and data quality measures. Further research should also investigate organisational, technical and human factors that influence HIS performance and user perceptions. Longitudinal and mixed methods designs could provide deeper insights into changes in HIS effectiveness over time, while multilevel analytical approaches that account for the clustering of users within hospitals could help explain variations in HIS effectiveness across facilities[19].

Strengths and Limitations

This study offers one of the first large-scale evaluations of HIS effectiveness using both an extended ISSM and an improved DM framework in faith-based hospitals in Ghana. However, several limitations should be considered. First, the cross-sectional design limits causal inference regarding the relationships among the study variables [19]. Second, reliance on self-reported data may have introduced recall and social desirability biases, potentially resulting in more favourable ratings. Similar limitations have also been acknowledged in recent evaluations of HIS implementation in Ghana [19]. Third, convenience sampling may limit the ability to generalize the findings to facilities not included in the study. Fourth, respondents were clustered within hospitals, which may have led to non-independence of observations that was not explicitly accounted for in the analysis. Fifth, the generally high scores across the various dimensions may indicate ceiling effects, potentially limiting the ability of the instruments to detect meaningful differences between hospitals. Finally, the system use was assessed based on users' report rather than actual system log data. Because staff often shared workstation, individual usage could not be reliably tracked. Future studies should incorporate objective usage metrics where feasible.

Conclusions

The results showed that the E-ISSM and the U-DM instruments demonstrated good validity and reliability and produced similar estimates of HIS effectiveness at the hospital level. Bland-Altman analysis showed good agreement between the two instruments with no indication of proportional bias in the aggregated hospital-level efficiency scores. These findings suggest that both tools are useful for assessing perceived HIS effectiveness and can support comparative assessments in similar low- and middle-income country settings. However, the observed agreement supports comparability rather than full interchangeability.

Health professionals generally reported positive perceptions of HIS performance across system quality, information quality, service quality, system use, user satisfaction, and potential net benefits. Perceived HIS effectiveness was high in most participating hospitals, although differences were observed across professional

groups, particularly in system use and perceived net benefits. Overall, the findings demonstrate the potential of perceived HIS effectiveness in hospital settings.

List of Abbreviations: HIS–Hospital Information System; HISs–Hospital Information Systems; NCHS – National Catholic Health Service; DOH – Department of Health; EHR – Electronic Health Record; NHIA – National Health Insurance Authority; ISSM – Information System Success Model; DM – DeLone and McLean model; CVI – Content Validity Index; CVR – Content Validity Ratio; HITECH – Health Information Technology for Economic and Clinical Health

Author Contributions: The study was conceptualized and designed by GA and NKM. GA conducted the literature review for the study and coordinated the field data collection. GA, MPD, and NKM analyzed the data, interpreted the results, and produced a manuscript in line with the journal’s guidelines. MPD and NKM reviewed the manuscript. All authors thoroughly reviewed the draft manuscript and approved the final version. All authors have given their approval for the manuscript to be submitted for review and considered for publication.

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Ethics Statement: Ethical approval with reference number NCS/DOH/B2/2021/01 was obtained on 28th April 2021 from the National Catholic Health Service (NCHS) to use their facilities for this study. Permissions were also obtained from all the participating hospitals. Verbal informed consent was obtained from study participants in accordance with the Declaration of Helsinki. All identifiable personal information of respondents was not solicited to ensure anonymity. We also observed the COVID-19 protocols (i.e., social distancing, wearing a face mask, washing hands with soap under running water, and use of hand sanitizer) during the data collection process.

Data Availability Statement: The raw data will be made available upon reasonable request.

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Conflict of Interest: The authors declare that they have no competing interests.

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