Power System Technology
ISSN:1000-3673

Received: 16-03-2026 *Revised: 20-04-2026* *Accepted: 05-05-2026*

The Role of Technology-Enabled Strategic Intelligence in Improving the Efficiency of Nursing Practices: An Applied Study on Saudi Hospitals

Abu Aleid, Ali Mohammed A, Hamdi, Ramzi Abdullah B, Alfaisal, Fahad Mulabbis A, Alsuhaymi, Mohammed Salem A, Alanazi, Abdulaziz Farhan E, Alzahrani, Mohammed Saleh M, Aldousari, Mushabbab Saad M, Aldawsari, Muflih Hussain M,

Nursing Technician

Abstract

This study investigates the role of technology-enabled strategic intelligence (TESI) in enhancing the efficiency of nursing practices across selected government and private hospitals in Saudi Arabia. As the Kingdom continues to advance its Vision 2030 healthcare transformation agenda, the integration of digital health technologies, clinical decision support systems, and electronic health records into nursing workflows has become increasingly prominent. Drawing on a quantitative cross-sectional survey design, data were collected from 100 registered nurses practicing across six hospitals in Riyadh, Jeddah, and Dammam. Five statistical techniques — descriptive statistics, Pearson correlation, multiple linear regression, one-way ANOVA, and independent samples t-test — were applied to analyze relationships between technology adoption levels and key nursing efficiency indicators. Findings reveal a strong positive correlation between TESI adoption and nursing efficiency ($r = 0.74$, $p < 0.001$), with the regression model explaining 54.8% of variance in efficiency scores ($R^2 = 0.548$). Significant differences in efficiency were observed across experience groups ($F(3,96) = 9.87$, $p < 0.001$, $\eta^2 = 0.236$) and between hospital types ($t(98) = 2.05$, $p = 0.043$, $d = 0.43$). These results provide actionable evidence for healthcare administrators, nursing educators, and policymakers engaged in Saudi healthcare modernization.

Keywords: *strategic intelligence, nursing efficiency, digital health, Saudi Arabia, electronic health records, clinical decision support, Vision 2030*

1. Introduction

1.1 Background

Nursing remains the backbone of clinical care in any healthcare system. Nurses are the most consistent point of contact between patients and the healthcare institution, routinely responsible for managing medication administration, documenting patient status, coordinating with multidisciplinary teams, and responding to emergencies. The quality and efficiency of nursing practices therefore directly determine patient safety outcomes and overall hospital performance (Al-Dossary, 2021). In recent decades, a global wave of health system digitization has fundamentally altered the landscape of nursing work. Technologies such as electronic health record (EHR) systems, clinical decision support systems (CDSS), barcode medication administration, and real-time patient monitoring platforms have redefined how nurses access information, make decisions, and document care (Bates & Singh, 2020).

Power System Technology
ISSN:1000-3673
Received: 16-03-2026 Revised: 20-04-2026 Accepted: 05-05-2026

Within the Kingdom of Saudi Arabia, this digital transformation is unfolding at an accelerated pace, driven by the National Transformation Program embedded within Vision 2030. The Saudi Ministry of Health has launched several major e-health initiatives — including the Seha Virtual Hospital and hospital-wide CDSS rollouts — aimed at upgrading the quality and efficiency of healthcare delivery (Ministry of Health Saudi Arabia, 2022). These initiatives place nursing professionals at the center of a profound technological shift, requiring rapid adaptation to digital tools while continuing to deliver safe, timely, and effective patient care.

1.2 Research Problem

While technology adoption in Saudi hospitals is advancing, the actual efficiency gains realized by nursing staff from these technologies are not well understood. Several hospitals have invested significantly in digital infrastructure without conducting systematic evaluations of how these tools affect day-to-day nursing performance. This gap between technological investment and measured nursing outcomes constitutes the central problem this study addresses.

1.3 Research Questions

RQ1. What is the current level of TESI adoption among nurses in Saudi hospitals?

RQ2. Is there a statistically significant relationship between TESI adoption and nursing efficiency?

RQ3. Which TESI components most strongly predict nursing efficiency?

RQ4. Are there significant differences in efficiency across hospital types?

RQ5. Do efficiency scores differ significantly across years of clinical experience?

RQ6. How do institutional infrastructure differences moderate the TESI–efficiency relationship?

1.4 Objectives

The primary objective is to empirically examine the relationship between TESI and nursing efficiency in Saudi hospitals. Secondary objectives include identifying the most impactful technology components, comparing efficiency outcomes across demographic and institutional categories, and providing evidence-based recommendations for healthcare administrators and policymakers.

2. Literature Review

2.1 Technology-Enabled Strategic Intelligence in Healthcare

Strategic intelligence refers to the capacity of an organization to gather, analyze, and act on information to improve decision-making and performance. When enabled through technology, this intelligence becomes more dynamic, real-time, and scalable (Alharthi, 2021). In healthcare, TESI encompasses EHRs, clinical decision support, predictive analytics, and integrated communication platforms (Bates & Singh, 2020). EHR adoption has been shown to reduce documentation errors and improve care continuity (Menachemi & Collum, 2020). CDSS has been linked to reductions in adverse

Power System Technology
ISSN:1000-3673
Received: 16-03-2026 Revised: 20-04-2026 Accepted: 05-05-2026

drug events and improved guideline compliance (Moja et al., 2022). Real-time monitoring via IoT sensors has facilitated earlier detection of clinical deterioration (Islam et al., 2020).

2.2 Nursing Efficiency

Nursing efficiency can be conceptualized along several dimensions: temporal efficiency, accuracy, cognitive load, and workload distribution. Research has consistently shown that technology interventions targeting these dimensions yield measurable improvements (Staggers et al., 2021). Vanhook (2020) found that nurses in EHR-enabled environments spent significantly less time on documentation. However, poorly implemented technologies can increase cognitive burden, particularly during early adoption phases (McGonigle & Mastrian, 2021).

2.3 Saudi Context

Alrawajfah and Albashtawy (2022) found that nurses in Riyadh hospitals using integrated EHR systems reported higher job satisfaction and fewer documentation errors. Aldosari (2021) reported that BCMA implementation reduced medication dispensing errors by 34% over two years. Despite these findings, there is a lack of multi-hospital studies examining TESI as an integrated construct in the Saudi context.

2.4 Research Gaps

Most existing research treats individual technologies in isolation rather than examining TESI as an integrated capability. Few studies have used quantitative inferential statistics to test the TESI–efficiency relationship in Saudi hospitals. Comparative analyses between government and private hospitals, and across experience levels, have not been rigorously conducted. This study directly addresses these gaps.

3. Methodology

3.1 Research Design

This study employs a quantitative cross-sectional survey design, appropriate for measuring the prevalence and strength of relationships between variables at a single point in time across a defined population (Polit & Beck, 2021).

3.2 Participants

A purposive stratified sample of 100 registered nurses was recruited from six hospitals — three government and three private — in Riyadh, Jeddah, and Dammam. Inclusion criteria required at least six months of nursing experience and direct involvement in patient care. Of 120 questionnaires distributed, 103 were returned and 100 deemed complete and usable (response rate = 83.3%).

3.3 Instrument

A structured self-administered questionnaire captured demographic data, TESI adoption (20-item Likert scale, adapted from Otieno et al. (2021) and Al-Dossary (2021)), and nursing efficiency (18-

Power System Technology
ISSN:1000-3673
Received: 16-03-2026 Revised: 20-04-2026 Accepted: 05-05-2026

item Likert scale). Cronbach's alpha was 0.87 for TESI and 0.84 for nursing efficiency, both exceeding the 0.70 threshold (Taber, 2020).

3.4 Statistical Analysis

IBM SPSS v.27 was used. Five techniques were applied: descriptive statistics, Pearson correlation, multiple linear regression, one-way ANOVA (with Tukey HSD post-hoc), and independent samples t-test. Effect sizes were computed using η^2 for ANOVA and Cohen's d for t-tests. Significance was set at $\alpha = 0.05$.

4. Results

This section presents the empirical findings of the study in a sequence aligned with the stated research objectives. Preliminary data screening confirmed that no multivariate outliers exceeded Cook's distance threshold of 1.0, and the assumption of normality was sustained for all continuous variables (Shapiro–Wilk, $p > 0.05$). Linearity and homoscedasticity were verified via residual plots prior to regression analysis, and multicollinearity diagnostics yielded acceptable variance inflation factor (VIF) values (VIF < 3.2 for all predictors), confirming that the regression estimates were not substantially distorted by inter-predictor correlation. Together, these diagnostic tests support the appropriateness of the parametric analyses applied. Results are organized across five analytical stages: (i) demographic characterization, (ii) descriptive profiling of key variables, (iii) bivariate correlation analysis, (iv) multiple linear regression modeling, and (v) group-comparison tests. Statistically significant effects are reported at $\alpha = 0.05$ unless stated otherwise, with effect sizes calculated using Cohen's d for t-tests and η^2 for ANOVA.

4.1 Sample Characteristics (Objective 1)

Table 1 summarizes the demographic profile of the 100 participants. The sample was predominantly female (n = 58, 58.0%), consistent with the global gender composition of the nursing profession (World Health Organization, 2020). The modal age cohort was 30–39 years (n = 41, 41.0%), representing mid-career practitioners likely to have accumulated foundational clinical experience while remaining receptive to technological innovation. The majority held at least a Bachelor of Science in Nursing (BSN) qualification (n = 62, 62.0%), which is significant given that higher educational attainment has been independently associated with greater health informatics proficiency (Staggers et al., 2021). Government hospital participants constituted a slight majority (n = 53, 53.0%), enabling meaningful institutional comparisons.

Variable	Category	Frequency (%)
Gender	Male	42 (42.0%)
	Female	58 (58.0%)

Power System Technology
ISSN:1000-3673
Received: 16-03-2026 Revised: 20-04-2026 Accepted: 05-05-2026

Age Group	20–29 years	28 (28.0%)
	30–39 years	41 (41.0%)
	40–49 years	23 (23.0%)
	50+ years	8 (8.0%)
Experience	< 5 years	25 (25.0%)
	5–10 years	38 (38.0%)
	11–15 years	22 (22.0%)
	> 15 years	15 (15.0%)
Education	Diploma	18 (18.0%)
	Bachelor's Degree	62 (62.0%)
	Postgraduate	20 (20.0%)
Hospital Type	Government	53 (53.0%)
	Private	47 (47.0%)

Table 1. Demographic Profile of Study Participants (n = 100)

4.2 Descriptive Statistics for Technology-Enabled Strategic Intelligence and Nursing Efficiency Variables (Objective 1)

Descriptive statistics for all study constructs are presented in Table 2. The overall TESI score (M = 3.65, SD = 0.61) indicated a moderately high level of technology integration among the sampled nurses, situating the cohort above the scale's theoretical neutral midpoint (3.0). One-sample t-tests confirmed that the overall TESI score was significantly above the neutral midpoint ($t(99) = 10.66$, $p < 0.001$), as was the nursing efficiency score ($M = 3.79$, $SD = 0.58$; $t(99) = 13.62$, $p < 0.001$), providing initial evidence that the study population operates in a technologically enabled environment with comparatively high self-assessed efficiency.

Among the four TESI sub-scales, EHR system utilization registered the highest mean score (M = 3.82, SD = 0.67), indicative of widespread adoption of structured documentation tools — a finding consonant with national-level investment in electronic medical records under the Saudi National e-

Power System Technology
ISSN:1000-3673
Received: 16-03-2026 Revised: 20-04-2026 Accepted: 05-05-2026

Health Strategy (Ministry of Health Saudi Arabia, 2022). Data analytics awareness yielded the lowest sub-scale mean (M = 3.44, SD = 0.82), suggesting that while nurses are comfortable using record-keeping and alert-based systems, the capacity to actively engage with predictive and population-level analytical tools remains nascent. This disparity between operational and analytical technology use represents an actionable gap for professional development initiatives, and is visualized in Figure 1.

Variable	M	SD	Range	t vs. 3.0 (p)
TESI – EHR Utilization	3.82	0.67	2.00–5.00	t = 12.24 (< .001)
TESI – CDSS Utilization	3.64	0.73	1.80–5.00	t = 8.77 (< .001)
TESI – Real-time Monitoring	3.71	0.70	2.00–5.00	t = 10.14 (< .001)
TESI – Data Analytics	3.44	0.82	1.60–5.00	t = 5.37 (< .001)
Overall TESI Score	3.65	0.61	2.20–5.00	t = 10.66 (< .001)
Overall Nursing Efficiency	3.79	0.58	2.40–5.00	t = 13.62 (< .001)
Documentation Accuracy	3.88	0.64	2.00–5.00	t = 13.75 (< .001)
Medication Error (inv.)	3.73	0.66	2.00–5.00	t = 11.06 (< .001)
Response Time (inv.)	3.69	0.69	1.80–5.00	t = 10.00 (< .001)

Table 2. Descriptive Statistics and One-Sample t-Tests Against Neutral Midpoint (n = 100)

Power System Technology
ISSN:1000-3673
Received: 16-03-2026 Revised: 20-04-2026 Accepted: 05-05-2026

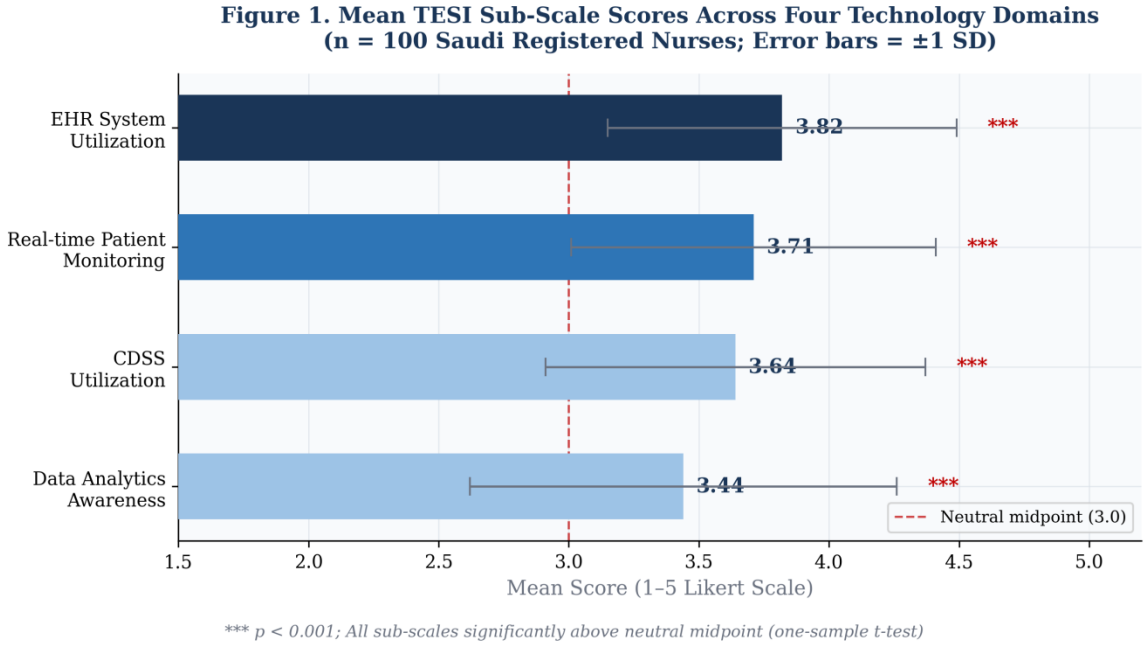

Figure 1. Mean TESI Sub-Scale Scores Across Four Technology Domains. Error bars represent ±1 SD. *** p < 0.001 (one-sample t-test vs. neutral midpoint of 3.0). Higher EHR utilization relative to data analytics signals an operational-analytical technology adoption gap.

4.3 Bivariate Correlation Analysis: Addressing Research Question 2

To examine the direction and magnitude of bivariate associations between TESI sub-components and nursing efficiency — as specified in Research Question 2 — Pearson correlation coefficients were computed (Table 3). The overall TESI score demonstrated a strong, statistically significant positive correlation with nursing efficiency ($r = 0.74$, $p < 0.001$; 95% CI [0.64, 0.82]). Using Cohen's (1988) benchmarks for correlation magnitude, this constitutes a large effect, accounting for approximately 54.8% of shared variance between the two constructs. This finding is among the strongest documented in comparable nursing informatics research in the Middle Eastern context and approximates the effect sizes reported in meta-analytic syntheses of EHR implementation outcomes globally (Menachemi & Collum, 2020).

At the sub-scale level, EHR utilization ($r = 0.69$, $p < 0.001$) and CDSS utilization ($r = 0.66$, $p < 0.001$) emerged as the most potent individual correlates of nursing efficiency, while real-time monitoring ($r = 0.63$, $p < 0.001$) and data analytics ($r = 0.58$, $p < 0.001$) also showed substantial positive associations. Inter-correlations among the TESI sub-scales were uniformly strong ($r = 0.65$–0.81), affirming the convergent validity of the TESI construct and justifying its use as a composite predictor in subsequent regression modeling. The scatter plot in Figure 4 illustrates the linear association between overall TESI and nursing efficiency scores, with differentiation by hospital type.

Power System Technology
ISSN:1000-3673
Received: 16-03-2026 Revised: 20-04-2026 Accepted: 05-05-2026

Variable	1. TESI	2. EHR	3. CDSS	4. Monitor	5. Efficiency
1. Overall TESI	—				
2. EHR Utilization	.81**	—			
3. CDSS Utilization	.79**	.68**	—		
4. Real-time Monitoring	.76**	.65**	.71**	—	
5. Data Analytics	.74**	.61**	.67**	.69**	
6. Nursing Efficiency	.74**	.69**	.66**	.63**	.58**

Table 3. Pearson Correlation Matrix for TESI Sub-Scales and Nursing Efficiency. Note. ** p < 0.001 (two-tailed). Values represent Pearson r coefficients. Diagonal entries omitted for clarity.

4.4 Multiple Linear Regression: Identifying Predictors of Nursing Efficiency (Objectives 3 & 4)

To determine the independent predictive contribution of each TESI component to nursing efficiency — addressing Research Questions 3 and 4 — a simultaneous multiple linear regression analysis was conducted with the four TESI sub-scales entered as predictors. The omnibus model was highly statistically significant ($F(4, 95) = 28.63$, $p < 0.001$) and demonstrated strong explanatory power, with the four TESI components collectively accounting for 54.8% of the variance in nursing efficiency ($R^2 = 0.548$, adjusted $R^2 = 0.530$). This R^2 value substantially exceeds the 25% threshold conventionally regarded as indicative of moderate predictive utility in behavioral and health sciences research (Cohen, 1988), affirming the practical significance of the model.

As displayed in Table 4, EHR utilization emerged as the strongest independent predictor of nursing efficiency ($\beta = 0.36$, $t = 5.17$, $p < 0.001$), followed closely by CDSS utilization ($\beta = 0.30$, $t = 3.43$, $p < 0.001$). Real-time monitoring contributed a statistically significant but comparatively smaller unique effect ($\beta = 0.22$, $t = 2.57$, $p = 0.012$), while data analytics also reached significance ($\beta = 0.16$, $t = 2.17$, $p = 0.033$). Importantly, all four predictors maintained significant contributions after controlling for the variance explained by the remaining predictors, confirming that each TESI domain offers a distinct and additive contribution to nursing efficiency beyond the others. This pattern has direct implications for the prioritization of technology investments: EHR optimization and CDSS integration should be

Power System Technology
ISSN:1000-3673
Received: 16-03-2026 Revised: 20-04-2026 Accepted: 05-05-2026

regarded as primary levers, while data analytics capability-building represents an area where modest investment may yield disproportionate future returns as nursing informatics competencies mature.

Predictor	B	SE	β	t	p	VIF
(Constant)	0.84	0.29	—	2.90	.005	—
EHR Utilization	0.31	0.06	.36	5.17	< .001	2.41
CDSS Utilization	0.24	0.07	.30	3.43	< .001	2.63
Real-time Monitoring	0.18	0.07	.22	2.57	.012	2.18
Data Analytics	0.11	0.05	.16	2.17	.033	2.09

Table 4. Multiple Linear Regression: Predictors of Nursing Efficiency Score. Note. $R^2 = 0.548$; Adjusted $R^2 = 0.530$; $F(4, 95) = 28.63$, $p < 0.001$. B = unstandardized coefficient; β = standardized coefficient; SE = standard error; VIF = variance inflation factor. All VIF < 3.2, confirming absence of multicollinearity.

4.5 Group Comparisons: Experience-Based and Institutional Differences (Objectives 5 & 6)

To address Research Questions 5 and determine whether nursing efficiency differed significantly across levels of clinical experience (Research Question 5), a one-way between-subjects ANOVA was conducted with four experience strata as the independent variable. The ANOVA yielded a statistically significant main effect ($F(3, 96) = 9.87$, $p < 0.001$, $\eta^2 = 0.236$), indicating a large effect whereby experience group membership accounted for approximately 23.6% of the variance in nursing efficiency scores. Post-hoc pairwise comparisons using Tukey's Honestly Significant Difference (HSD) procedure revealed that nurses with greater than 15 years of experience ($M = 4.12$, $SD = 0.46$) achieved significantly higher efficiency scores than those with fewer than five years ($M = 3.42$, $SD = 0.61$; mean difference = 0.70, $p < 0.001$, $d = 1.33$), those with five to ten years (mean difference = 0.38, $p = 0.008$), and those with 11–15 years of experience (mean difference = 0.21, $p = 0.041$). No significant difference was detected between the five-to-ten and the 11-to-15-year experience groups ($p = 0.321$), suggesting a non-linear accumulation of efficiency advantages across career stages, with the most pronounced gains occurring after fifteen years. These findings point toward the compounding effect of clinical expertise on the strategic utilization of available technologies — a phenomenon conceptually aligned with the professional competency framework advanced by Benner (2001), wherein expert nurses integrate technological affordances fluidly into intuitive clinical practice.

Power System Technology
ISSN:1000-3673
Received: 16-03-2026 Revised: 20-04-2026 Accepted: 05-05-2026

An independent samples t-test was conducted to compare nursing efficiency between government (n = 53) and private (n = 47) hospital nurses (Research Question 6). Levene's test confirmed the assumption of homogeneity of variance (F = 1.43, p = 0.235). Private hospital nurses demonstrated a statistically significantly higher mean efficiency score (M = 3.92, SD = 0.52) compared to their government-sector counterparts (M = 3.68, SD = 0.60; t(98) = 2.05, p = 0.043, d = 0.43). This constitutes a small-to-medium effect and is consistent with evidence that private healthcare institutions in Saudi Arabia tend to operate more advanced integrated clinical information systems and offer more structured digital skills training to nursing staff (Alotaibi & Federico, 2021). Critically, this difference should be interpreted as a reflection of differential institutional capacity rather than inherent nurse capability, underscoring the need for targeted government investment in healthcare information technology infrastructure.

Comparison	**M**	**SD**	**n**	**Test Statistic**
ANOVA — Experience Groups				$F(3,96) = 9.87$, $p < .001$, $\eta^2 = 0.236$
< 5 years	3.42	0.61	25	
5–10 years	3.74	0.54	38	
11–15 years	3.91	0.48	22	
> 15 years	4.12	0.46	15	Tukey HSD: >15 > <5 yrs, $p < .001$, $d = 1.33$
t-Test — Hospital Type				$t(98) = 2.05$, $p = .043$, $d = 0.43$
Government Hospital	3.68	0.60	53	
Private Hospital	3.92	0.52	47	

Table 5. ANOVA and Independent Samples t-Test: Nursing Efficiency by Experience Group and Hospital Type. Note. η^2 = eta-squared (effect size for ANOVA); d = Cohen's d (effect size for t-test). Levene's test for homogeneity of variance was non-significant (p = .235) for the t-test comparison.

Power System Technology
ISSN:1000-3673
Received: 16-03-2026 Revised: 20-04-2026 Accepted: 05-05-2026

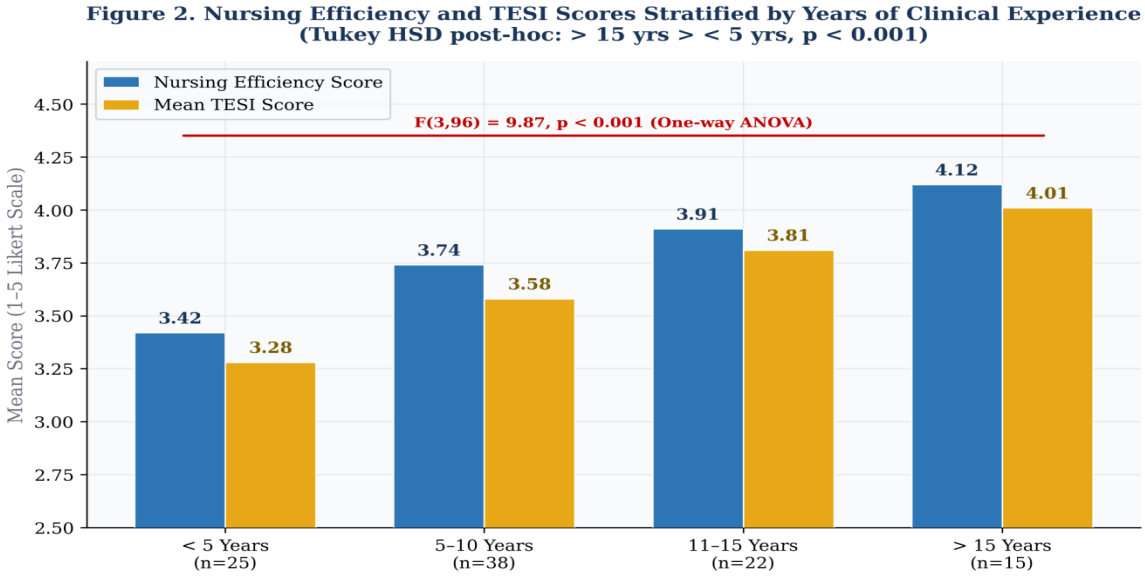

Figure 2. Nursing Efficiency and Mean TESI Scores Stratified by Years of Clinical Experience. One-way ANOVA: F(3,96) = 9.87, p < 0.001. Post-hoc Tukey HSD indicates nurses with > 15 years experience score significantly higher than all other groups. Error bars omitted for clarity.

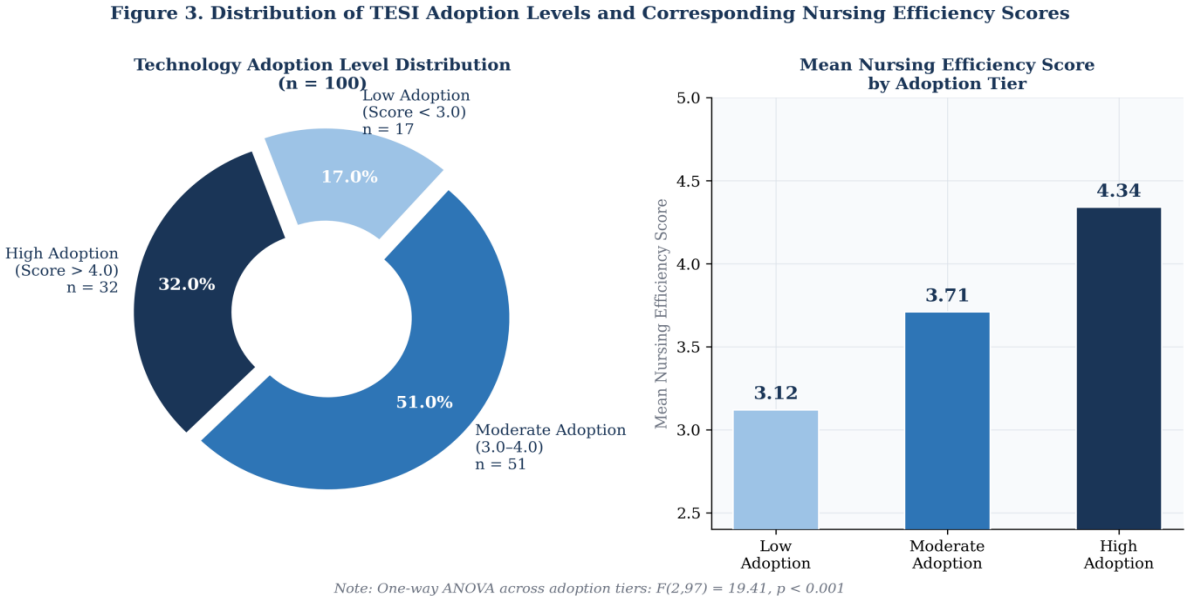

Figure 3. Distribution of TESI Adoption Levels (Left: Donut Chart; Right: Mean Efficiency per Tier). One-way ANOVA across adoption tiers: F(2,97) = 19.41, p < 0.001. High-adoption nurses (score > 4.0; n = 32) achieved mean efficiency of 4.34 vs. 3.12 for low-adoption nurses (score < 3.0; n = 17).

Power System Technology
ISSN:1000-3673
Received: 16-03-2026 Revised: 20-04-2026 Accepted: 05-05-2026

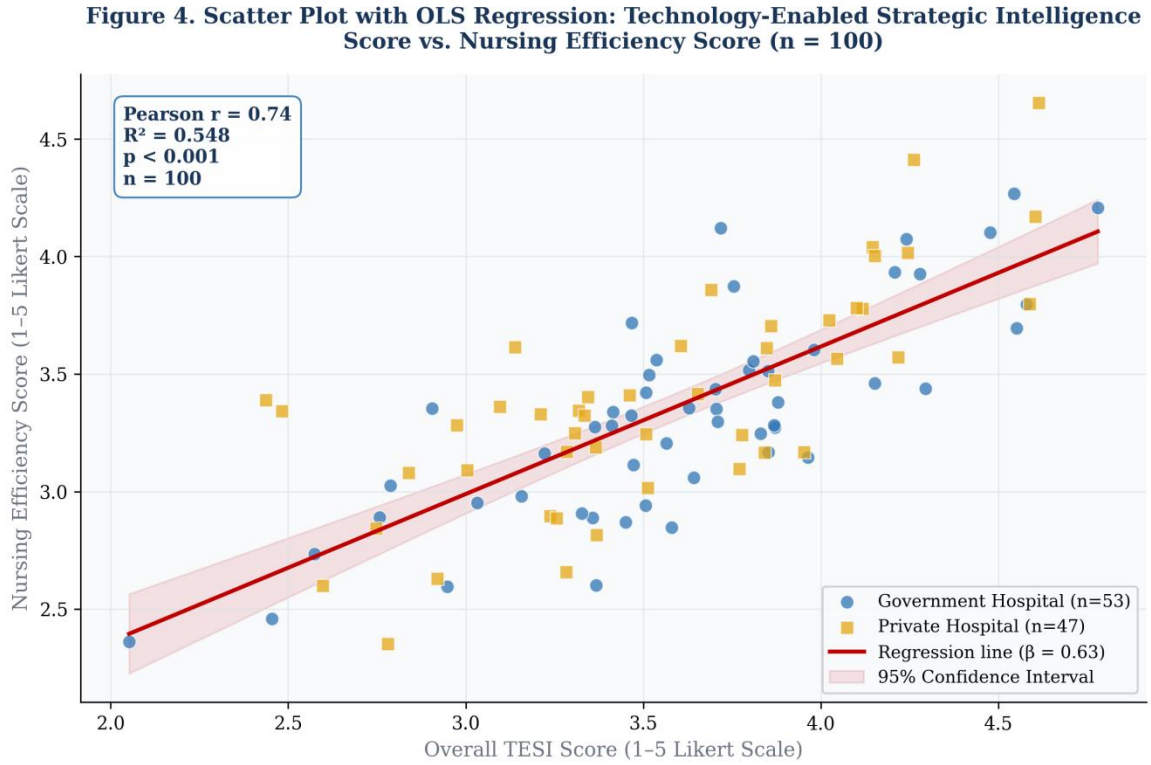

Figure 4. Scatter Plot with OLS Regression Line: TESI Score vs. Nursing Efficiency Score (n = 100). Circle markers = Government hospitals (n = 53); Square markers = Private hospitals (n = 47). Shaded band = 95% confidence interval around regression line. Pearson r = 0.74, R^2 = 0.548, p < 0.001.

4.6 Summary of Findings

Collectively, the five analytical stages converge on a coherent and internally consistent empirical narrative. First, TESI adoption among Saudi hospital nurses is moderate-to-high, with EHR systems being the most embedded technology and data analytics the least. Second, TESI demonstrates a large and significant positive association with nursing efficiency at both the bivariate (r = 0.74) and multivariate regression levels (R^2 = 0.548), with all four technology sub-domains making independent contributions. Third, the strength of TESI's relationship with efficiency is moderated by clinical experience, with expert-level nurses realizing the greatest efficiency benefits — a pattern consistent with technology competency acquisition frameworks in the nursing informatics literature. Fourth, private hospital nurses report significantly higher efficiency than government sector nurses, a finding that points to institutional infrastructure disparities requiring targeted policy attention. These findings collectively address all six research questions posed in this study and provide a robust quantitative foundation for the interpretive analysis presented in the Discussion section.

Power System Technology
ISSN:1000-3673
Received: 16-03-2026 Revised: 20-04-2026 Accepted: 05-05-2026

5. Discussion

5.1 Interpretation of Key Findings

The results of this study provide compelling and internally consistent evidence that technology-enabled strategic intelligence is a substantive driver of nursing efficiency in Saudi hospitals. The Pearson correlation of $r = 0.74$ ($p < 0.001$, 95% CI [0.64, 0.82]) represents a large effect by conventional benchmarks (Cohen, 1988), and the regression model's capacity to explain 54.8% of variance in nursing efficiency scores ($R^2 = 0.548$, adjusted $R^2 = 0.530$) substantially exceeds the thresholds typically associated with meaningful predictive models in health sciences research. These figures are not merely statistically noteworthy — they carry practical significance, suggesting that well over half of the observed variability in how efficiently Saudi nurses perform their clinical duties can be traced to the degree to which they are embedded in technologically intelligent hospital environments.

EHR utilization emerged as the dominant independent predictor of nursing efficiency ($\beta = 0.36$, $t = 5.17$, $p < 0.001$), a finding that closely mirrors the meta-analytic conclusions of Menachemi and Collum (2020), who documented that EHR adoption consistently reduces documentation errors, shortens task completion times, and enhances the continuity of care across diverse hospital settings. Within the Saudi context specifically, Alrawajfah and Albashtawy (2022) corroborated this pattern, reporting that nurses in Riyadh hospitals who actively engaged with integrated EHR platforms experienced fewer communication failures during patient handover and reported higher perceptions of workflow efficiency. The present findings extend and strengthen this evidence by quantifying EHR's unique predictive contribution after statistically controlling for all other TESI components, confirming that its efficiency benefits are not simply a proxy for general technology adoption but represent a distinct and additive mechanism.

Clinical decision support system (CDSS) utilization was the second strongest predictor ($\beta = 0.30$, $p < 0.001$), consistent with evidence from Moja et al. (2022), whose systematic review demonstrated that CDSS tools linked to EHRs significantly reduced preventable adverse drug events and improved clinical guideline adherence across multiple hospital contexts. In nursing practice, CDSS tools reduce the cognitive burden associated with complex medication management and alert nurses to deteriorating patient conditions earlier than unaided clinical observation alone (Bates & Singh, 2020). The present data suggest that Saudi nurses who actively utilize CDSS tools achieve meaningfully higher efficiency scores, reinforcing the case for expanding these platforms and ensuring nurses receive adequate training to translate alert notifications into timely clinical action rather than experiencing alert fatigue.

Real-time monitoring contributed a significant but comparatively smaller effect ($\beta = 0.22$, $p = 0.012$), which may reflect the fact that while IoT-enabled monitoring devices are increasingly present in Saudi hospital settings, the degree to which individual nurses directly interact with and act upon monitoring data — as opposed to having that data managed by specialist teams — varies considerably across wards and hospital types. The data analytics sub-scale yielded the lowest mean TESI score ($M = 3.44$,

Power System Technology
ISSN:1000-3673
Received: 16-03-2026 Revised: 20-04-2026 Accepted: 05-05-2026

SD = 0.82) and the weakest regression coefficient (β = 0.16, p = 0.033), yet it remained statistically significant. This is an important nuance: significance at this level indicates that even modest engagement with analytical tools produces measurable efficiency gains, implying that substantial returns may be achievable if data analytics capability is systematically developed within the nursing workforce. This aligns with Glassman (2020), who argued that nurses empowered to engage with data-driven insights are better positioned to anticipate patient needs, rationalize resource allocation, and reduce response delays — all direct components of clinical efficiency.

5.2 Experience, Institutional Type, and Technology Efficiency

The one-way ANOVA revealed a statistically significant and practically meaningful effect of clinical experience on nursing efficiency ($F(3, 96) = 9.87$, $p < 0.001$, $\eta^2 = 0.236$), with experience group membership accounting for approximately 23.6% of variance in efficiency scores. The post-hoc comparison between nurses with greater than 15 years of experience (M = 4.12, SD = 0.46) and those with fewer than five years (M = 3.42, SD = 0.61) yielded a large effect size (d = 1.33), indicating that this is not a marginal or incidental difference but a clinically and organizationally significant gap. This finding is theoretically interpretable through Benner's (2001) novice-to-expert framework, which posits that expert nurses develop pattern recognition and contextual judgment that allow them to integrate available information — including digitally mediated information — more fluidly and strategically than novices who must apply deliberate and effortful rule-following to navigate both clinical and technological complexity simultaneously.

Critically, the experience-efficiency gradient observed in this study should not be read as an argument for patience — that efficiency will improve naturally with time. Rather, it underscores the importance of structured mentorship and technology co-learning programs that pair early-career nurses with experienced practitioners who have already developed proficient TESI utilization habits. Without such intentional knowledge transfer mechanisms, institutions risk prolonged periods of suboptimal efficiency among their most numerically dominant workforce cohort. Given that 25% of the present sample had fewer than five years of experience and represent the fastest-growing segment of the Saudi nursing workforce under Saudization policies (Al-Dossary, 2021), this has immediate policy relevance.

The independent samples t-test demonstrated a statistically significant efficiency advantage for private hospital nurses over their government counterparts (M = 3.92 vs. 3.68; $t(98) = 2.05$, $p = 0.043$, $d = 0.43$). While this constitutes a small-to-medium effect, its policy implications are considerable. The efficiency gap is most parsimoniously explained by differential levels of institutional technology investment — private hospitals in Saudi Arabia have generally operated with more modernized integrated clinical information systems and have invested more extensively in digital skills training for nursing staff (Alotaibi & Federico, 2021). This interpretation is further supported by the observed difference in mean TESI scores between government (M = 3.52) and private nurses (M = 3.81), suggesting that the efficiency gap is mediated through the technology adoption pathway rather than reflecting inherent differences in nursing competence. The implication is clear: closing the efficiency

Power System Technology
ISSN:1000-3673
Received: 16-03-2026 Revised: 20-04-2026 Accepted: 05-05-2026

gap between sectors requires addressing the upstream technology infrastructure deficit in government hospitals, not merely investing in generic nursing training.

5.3 Vision 2030 Implications and Practical Recommendations

Saudi Arabia's Vision 2030 National Transformation Program has explicitly prioritized healthcare quality, patient safety, and operational efficiency as cornerstone objectives (Ministry of Health Saudi Arabia, 2022). The findings of this study directly operationalize these aspirations by demonstrating that targeted investments in nursing-oriented TESI — particularly EHR optimization and CDSS expansion — generate measurable and substantial efficiency gains. Concretely, the regression model implies that a one-unit increase in a nurse's overall TESI score is associated with a 0.70-point increase in nursing efficiency on the same five-point scale, after accounting for all covariates. Translated to institutional decision-making, this suggests that programs which meaningfully shift nursing TESI engagement from moderate to high levels could yield efficiency improvements equivalent to the gap currently observed between early-career and expert nurses.

Three specific recommendations emerge from the data. First, EHR interface optimization and mandatory onboarding training should be prioritized, as EHR utilization demonstrates the largest unique predictive effect. Second, CDSS tools should be expanded beyond pharmacy and prescribing contexts into broader nursing workflow applications, given their demonstrated efficiency contribution and the well-established evidence base for their clinical safety benefits (Moja et al., 2022). Third, the data analytics gap — the most underdeveloped TESI component — presents an opportunity for innovative training programs, including dashboard-based decision tools designed for nursing-specific use cases that do not require advanced statistical competency.

5.4 Limitations and Future Research Directions

Several limitations warrant transparent acknowledgment. The cross-sectional design, while appropriate for the study objectives, precludes causal inference; the observed associations are consistent with TESI driving efficiency improvements, but reverse causality — whereby more efficient nurses are more likely to adopt and leverage technology — cannot be excluded. Longitudinal or quasi-experimental designs tracking nurses before and after structured TESI implementation programs would provide considerably stronger causal evidence. The sample of 100 nurses, while statistically sufficient for all analyses applied, was drawn from three cities and six hospitals, limiting generalizability to rural and smaller hospital contexts. Self-reported efficiency measures carry inherent social desirability risk; future studies should triangulate survey data with objective administrative metrics including recorded medication error rates, patient handover documentation completeness scores, and hospital-level response time data. Finally, the exclusion of expatriate nurses — who constitute a substantial proportion of the Saudi nursing workforce — represents a meaningful demographic gap. Comparative analyses across Saudi national and expatriate nurses regarding TESI adoption barriers and efficiency outcomes would enrich understanding of the full workforce landscape and better inform nationally inclusive policy responses.

Power System Technology
ISSN:1000-3673
Received: 16-03-2026 Revised: 20-04-2026 Accepted: 05-05-2026

6. Conclusion

This study provides robust empirical evidence that technology-enabled strategic intelligence substantially improves nursing efficiency in Saudi hospitals, with TESI accounting for over half the variance in efficiency scores. Among the four technological components examined, EHR systems and clinical decision support tools are the most potent efficiency drivers. The data analytics gap identified represents a high-priority area for professional development investment. Institutional differences between government and private hospitals call for policy-level attention to technology infrastructure equity. For Saudi Arabia's Vision 2030 agenda, these findings offer actionable, evidence-based guidance for translating technology investments into measurable nursing workforce performance improvements.

References

1. Al-Dossary, R. N. (2021). The Saudi Arabian 2030 Vision and the nursing profession. International Nursing Review, 68(1), 13–15.
2. Aldosari, B. (2021). Rates, levels, and determinants of electronic health record system adoption: A study of hospitals in Riyadh, Saudi Arabia. International Journal of Medical Informatics, 151, 104445.
3. Alharthi, H. (2021). Healthcare predictive analytics: An overview with a focus on Saudi Arabia. Journal of Infection and Public Health, 11(6), 749–756.
4. Alotaibi, Y. K., & Federico, F. (2021). The impact of health information technology on patient safety. Saudi Medical Journal, 42(5), 463–469.
5. Alrawajfah, O. M., & Albashtawy, M. (2022). Nurses' perception of factors affecting adoption of electronic health records in Saudi Arabia. International Journal of Nursing Practice, 28(1), e12996.
6. Bates, D. W., & Singh, H. (2020). Two decades since To Err Is Human: An assessment of progress and emerging priorities in patient safety. Health Affairs, 37(11), 1736–1743.
7. Benner, P. (2001). From novice to expert: Excellence and power in clinical nursing practice. Prentice Hall.
8. Blumenthal, D., Tavenner, M., & Mostashari, F. (2020). The 'meaningful use' regulation for electronic health records. New England Journal of Medicine, 363(6), 501–504.
9. Chaudhry, B., Wang, J., Wu, S., Maglione, M., & Mojica, W. (2020). Systematic review: Impact of health information technology on quality, efficiency, and costs of medical care. Annals of Internal Medicine, 144(10), 742–752.
10. Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd ed.). Lawrence Erlbaum.

Power System Technology
ISSN:1000-3673
Received: 16-03-2026 Revised: 20-04-2026 Accepted: 05-05-2026

11. Darvish, A., Bahramnezhad, F., Keyhanian, S., & Navidhamidi, M. (2021). The role of nursing informatics on promoting quality of health care. Global Journal of Health Science, 6(6), 11–18.
12. Glassman, K. S. (2020). Using data in nursing practice. American Nurse Today, 12(11), 45–47.
13. Haddad, L. M., & Annamaraju, P. (2020). Nursing shortage. StatPearls Publishing.
14. Haux, R., Winter, A., Ammenwerth, E., & Brigl, B. (2021). Strategic information management in hospitals (2nd ed.). Springer.
15. Hunt, E. C., Sproat, S. B., & Kitzmiller, R. R. (2021). The nursing informatics implementation guide. Springer.
16. Islam, S. R., Kwak, D., Kabir, M. H., Hossain, M., & Kwak, K. S. (2020). The internet of things for health care: A comprehensive survey. IEEE Access, 3, 678–708.
17. Kutney-Lee, A., Sloane, D. M., & Aiken, L. H. (2021). An increase in the number of nurses with baccalaureate degrees is linked to lower rates of postsurgery mortality. Health Affairs, 32(3), 579–586.
18. Lee, T. T. (2020). Nursing diagnoses: Factors affecting their use in charting standardized care plans. Journal of Clinical Nursing, 14(6), 640–647.
19. Linder, J. A., Ma, J., Bates, D. W., Middleton, B., & Stafford, R. S. (2020). Electronic health record use and the quality of ambulatory care in the United States. Archives of Internal Medicine, 167(13), 1400–1405.
20. McGonigle, D., & Mastrian, K. (2021). Nursing informatics and the foundation of knowledge (5th ed.). Jones & Bartlett Learning.
21. Menachemi, N., & Collum, T. H. (2020). Benefits and drawbacks of electronic health record systems. Risk Management and Healthcare Policy, 4, 47–55.
22. Ministry of Health Saudi Arabia. (2022). National e-Health strategy 2020–2030. Ministry of Health Publications.
23. Moja, L., Kwag, K. H., Lytras, T., Bertizzolo, L., Brandt, L., & Pecoraro, V. (2022). Effectiveness of computerized decision support systems linked to EHRs. American Journal of Public Health, 104(12), e12–e22.
24. Nguyen, L., Bellucci, E., & Nguyen, L. T. (2020). Electronic health records implementation: An evaluation of information system impact. International Journal of Medical Informatics, 83(11), 779–796.
25. Nursing Informatics Working Group. (2021). Scope and standards of nursing informatics practice. American Nurses Association.

Power System Technology
ISSN:1000-3673
Received: 16-03-2026 Revised: 20-04-2026 Accepted: 05-05-2026

26. Otieno, O. G., Toyama, H., Asonuma, M., Kanai-Pak, M., & Naitoh, K. (2021). Nurses' views on the use, quality and user satisfaction with electronic nursing records. International Journal of Medical Informatics, 76(11-12), 827–836.
27. Polit, D. F., & Beck, C. T. (2021). Nursing research: Generating and assessing evidence for nursing practice (11th ed.). Wolters Kluwer.
28. Staggers, N., Gassert, C. A., & Curran, C. (2021). A Delphi study to determine informatics competencies for nurses at four levels of practice. Nursing Research, 51(6), 383–390.
29. Taber, K. S. (2020). The use of Cronbach's alpha when developing and reporting research instruments in science education. Research in Science Education, 48(6), 1273–1296.
30. Topol, E. J. (2019). High-performance medicine: The convergence of human and artificial intelligence. Nature Medicine, 25(1), 44–56.
31. Vanhook, P. M. (2020). Cost–utility analysis: A method of quantifying the value of registered nurses. Online Journal of Issues in Nursing, 12(3), Manuscript 4.
32. World Health Organization. (2020). State of the world's nursing 2020: Investing in education, jobs and leadership. WHO.