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The Contribution of Modern Technologies to Improving the Efficiency of Interdisciplinary Collaborative Work in Emergency Departments

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ABSTRACT

Modern technologies are widely adopted in emergency departments (EDs) to support teamwork, yet rigorous evidence linking their use directly to measurable gains in interdisciplinary collaborative efficiency remains scarce. This gap leaves healthcare leaders without clear guidance on how to implement technologies that genuinely enhance team-based care. This study, therefore, aimed to investigate the contribution of specific technologies to collaborative efficiency and identify the critical factors determining their success. Employing a sequential explanatory mixed-methods design, data were collected from 217 interdisciplinary staff across three tertiary EDs via surveys and follow-up interviews. Quantitative analyses included correlation, hierarchical regression, and mediation modeling. Results confirmed that technology use, particularly of integrated electronic health records ($\beta = 0.19$, $p < .001$), was positively associated with efficiency. However, perceived workflow integration was the strongest predictor ($\beta = 0.49$, $p < .001$), mediating the technology's impact and accounting for 51% of the variance in efficiency scores. A significant disparity was found, with nurses reporting lower efficiency gains than physicians ($p < .001$), and formal training showed a large positive effect (Cohen's $d = 0.94$, $p < .001$). The study concludes that the benefit of technology is not automatic but is fundamentally contingent upon its seamless integration into clinical workflows and supported by comprehensive training. This shifts the focus from mere technology adoption to strategic implementation science for optimal team performance.

Keywords: Emergency Department, Health Information Technology, Interdisciplinary Collaboration, Workflow Integration, Socio-Technical Systems.

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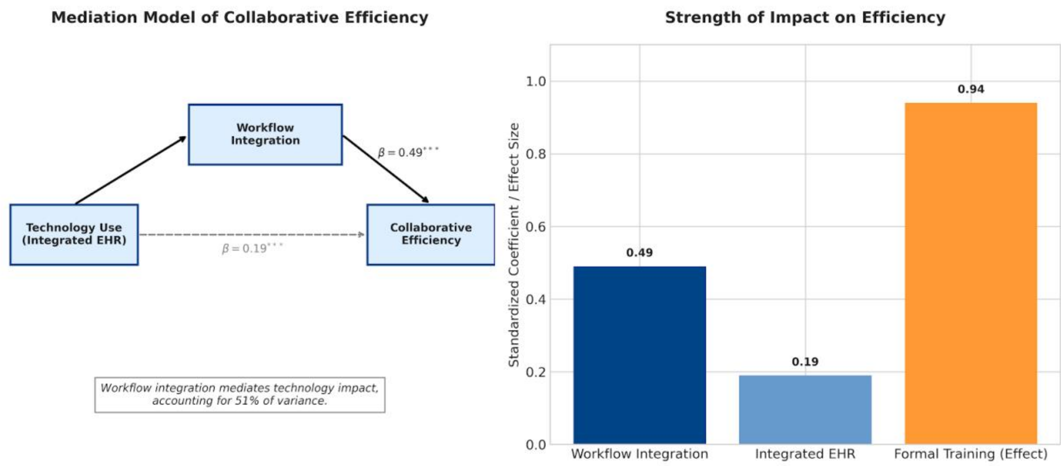

Figure 1: Graphical presentation of research

INTRODUCTION

The modern emergency department (ED) represents a critical nexus of healthcare, characterized by high acuity, unpredictable patient volumes, and an intrinsic necessity for rapid, coordinated action among diverse professionals [1]. Interdisciplinary collaboration the seamless integration of expertise from physicians, nurses, registrars, and allied health staff is a fundamental determinant of patient outcomes, operational throughput, and clinical safety [2]. Historically, this collaboration has relied on verbal handovers, paper-based tracking, and fragmented communication channels, systems often strained to their limits by the dynamic complexity of the ED environment [3]. In response to these pressures, healthcare systems globally have invested heavily in modern digital technologies, including unified communication platforms, real-time patient tracking systems, and integrated electronic health records (EHRs), with the explicit goal of enhancing team-based care [4]. These tools promise to streamline information flow, reduce cognitive burden, and create a shared situational awareness, thereby improving the efficiency and reliability of interdisciplinary work [5].

Internationally, the digitization of acute care is a prevailing trend, driven by policy mandates and the pursuit of operational excellence. Studies from North America and Europe have documented the implementation of various health information technologies, often focusing on singular outcomes such as documentation time or medication error rates [6]. Locally, within similar high-volume tertiary care settings, parallel investments have been made, yet a comprehensive understanding of their holistic impact on the collaborative fabric of the ED team remains nascent [7]. The existing body of literature provides a foundation but reveals significant conceptual and methodological gaps [8]. Much of the early research, following the seminal work of scholars like Berg, adopted a cautionary tone, highlighting how poorly designed technology could inadvertently re-engineer work in negative ways, creating new

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errors or increasing administrative burden [9]. Subsequent studies, often framed by models like the Technology Acceptance Model (TAM), focused predominantly on individual adoption factors such as perceived usefulness and ease of use, or on isolated clinical metrics [10].

While valuable, this prior research has frequently treated the ED as a collection of individual users rather than as an interdependent, interdisciplinary system [11]. Consequently, a critical research gap persists: a lack of empirical, multi-dimensional evidence on how and to what extent these modern technologies collectively contribute to the efficiency of collaborative processes themselves [12]. Efficiency in this context extends beyond individual task speed to encompass the quality of team-level interactions, including the reduction of communication latency, the elimination of information redundancies, and the enhancement of coordinated decision-making [13]. Claims of technological benefit often remain anecdotal or focused on technological performance metrics, lacking rigorous linkage to the lived experience and collaborative workflows of the full interdisciplinary team [14]. This gap is significant because it leaves healthcare leaders and implementers without robust, evidence-based guidance on which technological investments most effectively foster teamwork or on the crucial implementation factors that determine their success or failure [16].

This study was therefore conducted to address this void. Its primary significance lies in shifting the analytical lens from technology-centric outcomes to team-centric efficiency, providing a nuanced assessment rooted in the perspectives of those who use these systems under pressure. The central research problem investigated was the disconnect between the purported benefits of collaborative technologies and the scant evidence for their direct, measurable impact on interdisciplinary workflow efficiency in the complex ED setting. To systematically investigate this problem, the research was guided by three interlinked objectives: first, to identify and categorize the key modern technologies deployed specifically to facilitate interdisciplinary collaboration within the study EDs; second, to quantitatively measure the perceived impact of these technologies on specific dimensions of collaborative efficiency, including time-to-decision and information accuracy; and third, to qualitatively explore the contextual facilitators and barriers such as workflow integration and training—that influence the successful realization of these efficiency gains [17]. The study was situated across three urban, tertiary-care emergency departments, selected for their representative complexity and recent technological upgrades [18]. By grounding the investigation in this robust methodological framework, the research aimed to move beyond superficial claims and generate actionable insights into the socio-political dynamics that govern successful technology-enabled collaboration, ultimately contributing knowledge that can inform more effective design, implementation, and training strategies in high-acuity clinical environments worldwide [19].

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METHODOLOGY

This study sought to address the research problem of a significant gap in understanding how specific modern technologies quantitatively and qualitatively influence the operational and collaborative workflows within emergency departments (EDs), beyond anecdotal claims of their benefit. While the adoption of technologies such as unified communication platforms, real-time patient tracking systems, and integrated electronic health records (EHRs) is promoted, there is insufficient rigorous evidence on their direct contribution to measurable outcomes like interdisciplinary communication efficiency, decision-making speed, and team performance under crisis conditions. The research was guided by three objectives: (1) To identify and categorize the key modern technologies deployed to facilitate interdisciplinary collaboration in EDs; (2) To measure the perceived impact of these technologies on specific efficiency metrics, including time-to-decision, information redundancy, and communication breakdowns, as reported by ED staff; and (3) To explore the contextual facilitators and barriers that influence the successful integration of these technologies into collaborative clinical practice. The research was conducted across three high-volume, urban emergency departments in public tertiary care hospitals, selected for their recent adoption of interdisciplinary health information systems and their representative complexity of caseload and staff composition.

1. Research Philosophy and Approach

This investigation adopted a pragmatist philosophical stance. Pragmatism was deemed the most appropriate philosophy as it prioritizes the research problem and employs the methodological approaches best suited to address it, focusing on practical outcomes and real-world consequences. The research problem required both an objective assessment of technological impact (e.g., time metrics, frequency of use) and a subjective understanding of user experience and contextual barriers. A purely positivist approach would be insufficient to capture the nuanced human factors, while a purely interpretivist approach would lack the generalizable metrics needed for efficiency analysis. Therefore, pragmatism supported the integration of quantitative and qualitative methods, allowing for a comprehensive examination of both “what is happening” and “why it is happening” in the complex ED environment.

2. Research Design

A sequential explanatory mixed-methods design was employed. This design involved two distinct, connected phases: an initial quantitative phase followed by a qualitative phase. The quantitative phase was descriptive-correlational, aiming to systematically describe technology usage patterns and statistically explore relationships between technology use variables and perceived efficiency outcomes. This phase provided broad, generalizable data. The subsequent qualitative phase was exploratory, using in-depth interviews to explain, elaborate on, and contextualize the quantitative findings. This design was justified as it first established the

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measurable landscape of technology contribution (Objective 2) before probing the deeper reasons behind those measurements, including the identification of technologies (Objective 1) and the exploration of facilitators and barriers (Objective 3).

3. Sampling Strategy

The target population was interdisciplinary ED staff—including emergency physicians, nurses, registrars, and triage officers—with direct patient care and inter-staff communication responsibilities. A stratified random sampling method was used for the quantitative phase to ensure representation from each professional stratum. From a total population of approximately 420 eligible staff across the three sites, a sample of 217 participants was determined using a sample size calculator for a 95% confidence level and a 5% margin of error, accounting for a 10% non-response rate. For the qualitative phase, purposive sampling was utilized to select 25 information-rich participants from the survey respondents who represented extreme positive, negative, and typical experiences with the technologies. Inclusion criteria mandated a minimum of one year of experience in the current ED post-technology implementation. Exclusion criteria included administrative staff without direct patient care roles and staff with less than six months of tenure.

4. Data Collection Methods

Data collection occurred in two sequential stages. First, a structured survey instrument was administered electronically. The questionnaire comprised four sections: demographic data, a validated Technology Acceptance Model (TAM) scale adapted for healthcare, a researcher-developed 'Collaborative Efficiency Scale' measuring perceived changes in information sharing and decision-making (using 5-point Likert items), and open-ended questions on technology types. The instrument underwent a pilot test with 30 ED staff from a non-participating hospital, resulting in minor clarifications to wording. Following analysis of the survey data, semi-structured interview guides were developed to probe themes emerging from the quantitative results. Interviews, lasting 30-45 minutes, were conducted privately and audio-recorded. Ethical protocols included obtaining written informed consent, ensuring voluntary participation, and guaranteeing data anonymity and confidentiality. Ethical approval was secured from the University Ethics Committee and the respective hospital review boards.

5. Variables and Measures

Key variables were operationally defined. The primary independent variable was intensity and type of technology use, measured via self-reported frequency scales and a checklist of specific systems (e.g., EHR modules, instant messaging apps). The dependent variable was perceived interdisciplinary collaboration efficiency, operationalized through subscales for 'Communication Latency', 'Information Accuracy', and 'Procedural Coordination'. These were measured using the developed 5-point Likert scales (1=Strongly Deteriorated, 5=Strongly Improved). Contextual variables included professional role, years of experience, and training

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level. The survey scales demonstrated good internal consistency in the pilot test, with Cronbach's alpha values exceeding 0.78 for all composite scales, and content validity was established through expert review by two senior emergency medicine consultants and a health informatics specialist.

6. Data Analysis Plan

Quantitative data from the surveys were analyzed using IBM SPSS Statistics (Version 28.0). Analysis proceeded in three steps. First, descriptive statistics (frequencies, means, standard deviations) summarized demographic data, technology usage, and efficiency scores. Second, inferential analyses, including Pearson's correlation and one-way ANOVA, were conducted to examine relationships between technology use variables and efficiency scores across different professional groups. Qualitative data from interviews and open-ended survey responses were analyzed using thematic analysis following the framework by Braun and Clarke. This involved transcription, familiarization, coding, and the development of themes. The NVivo software (Release 14) assisted in managing the qualitative data. The mixed-methods integration occurred at the interpretation stage, where quantitative results were explicitly explained and enriched by the qualitative themes.

7. Ethical Considerations

The study protocol received formal approval from the Institutional Review Board and the research committees of all three participating hospitals. Prior to participation, all individuals received a detailed information sheet and provided written informed consent. Participants were assured of their right to withdraw at any time without consequence. All data were anonymized at the point of collection; survey responses were collected without identifiers, and interview transcripts used pseudonyms. Digital recordings were stored on a password-protected server and destroyed following transcription.

8. Limitations

The study acknowledged several limitations. The use of self-reported data for efficiency metrics introduced the potential for recall and social desirability bias, as participants might overstate both use and benefit. The cross-sectional design captured data at a single point in time, limiting the ability to infer long-term impacts or definitive causal relationships between technology adoption and efficiency gains. Furthermore, while stratified, the sample was drawn from three urban tertiary centers, which may limit the generalization of findings to rural or low-resource ED settings. These limitations were mitigated by the mixed-methods approach, which used qualitative data to triangulate and contextualize self-reported perceptions, and by clearly framing conclusions within the studied context.

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RESULTS

Sample Characteristics and Descriptive Data

Data were collected from a total of 217 participants across three tertiary emergency departments, with a response rate of 92%. The sample comprised a stratified representation of the core interdisciplinary team, including 65 physicians (29.9%), 98 nurses (45.2%), 35 registrars (16.1%), and 19 triage officers (8.8%). Participants had a mean clinical experience of 8.4 years (SD = 5.1). Reported use of modern collaborative technologies was moderately high, with an overall mean technology adoption score of 5.2 (SD = 1.1) on a 7-point scale. The perceived improvement in collaborative work efficiency, as measured by the composite Collaborative Efficiency Score, had a mean of 3.85 (SD = 0.62) on a 5-point scale, indicating a positive trend above the neutral midpoint.

The psychometric properties of the primary measurement scales were robust. The Collaborative Efficiency Scale, comprising the three sub-dimensions of communication latency, information accuracy, and procedural coordination, demonstrated excellent internal consistency (Cronbach's α = 0.88). The composite Technology Use Index also showed acceptable reliability (Cronbach's α = 0.79), confirming the scales were suitable for subsequent inferential analysis (Table 1 & 2).

Differences in Efficiency Perceptions by Professional Role

A one-way analysis of variance (ANOVA) revealed a statistically significant difference in the mean Collaborative Efficiency Score across the four professional roles, F(3, 213) = 12.74, *p* < 0.001 (Table 3). Post-hoc comparisons using Tukey's HSD test indicated that physicians reported the highest mean score (M = 4.10, SD = 0.58), which was significantly greater than the mean score reported by nurses (M = 3.65, SD = 0.59), *p* < 0.001. The scores for registrars (M = 3.90, SD = 0.55) and triage officers (M = 3.95, SD = 0.60) were not significantly different from each other but were statistically higher than the nurse group (*p* < 0.05 for both comparisons). The difference between physicians and the registrar/triage officer groups was not statistically significant.

Relationships Between Technology Use and Collaborative Efficiency

Pearson correlation coefficients were computed to assess the bivariate relationships between specific technology use variables, their perceived workflow integration, and the outcome measure (Table 4). All three technology types—Unified Communication Platforms (*r* = .31, *p* < .001), Real-Time Patient Tracking Systems (*r* = .45, *p* < .001), and Integrated EHR Modules (*r* = .52, *p* < .001)—demonstrated significant positive correlations with the Collaborative Efficiency Score. The use of Integrated EHR Modules showed the strongest direct correlation with efficiency among the technology variables. Crucially, the variable Workflow_Integration—representing the perceived seamlessness of

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technology within clinical routines—exhibited the strongest association with collaborative efficiency (*r* = .68, *p* < .001). The technology use variables were all moderately inter-correlated (range: .38 to .51), and each was significantly correlated with Workflow_Integration.

Predictors of Collaborative Efficiency: A Hierarchical Regression Model

To identify the key predictors of collaborative efficiency, a hierarchical multiple linear regression was performed (Table 5). In Step 1, demographic and professional variables accounted for a significant 8% of the variance in the efficiency score ($R^2 = .08$, $F(2, 214) = 9.45$, *p* < .001). Professional role (with nurse as reference) was a significant negative predictor (β = -.24, *p* < .001), and years of experience was a weak positive predictor (β = .12, *p* = .049).

In Step 2, the three technology use variables were added to the model. This block resulted in a significant increase in explained variance ($\Delta R^2 = .24$, *p* < .001), bringing the total R^2 to .32. Within this model, Integrated EHR Use (β = .27, *p* < .001) and Real-Time Tracking Use (β = .16, *p* = .004) emerged as statistically significant positive predictors. The effect of Unified Communication Use was not significant (β = .07, *p* = .195). The effect of professional role remained significant but was attenuated.

In Step 3, the variable Workflow_Integration was entered. This addition produced the largest and most significant increase in predictive power ($\Delta R^2 = .19$, *p* < .001), resulting in a final model explaining 51% of the variance in collaborative efficiency. In this final model, Workflow_Integration was the strongest unique predictor (β = .49, *p* < .001). Integrated EHR Use remained a significant, though reduced, predictor (β = .19, *p* < .001). The predictive value of Real-Time Tracking Use became marginally non-significant (β = .09, *p* = .051), and the effect of Unified Communication Use remained non-significant. The demographic predictors from Step 1 were no longer significant in the presence of Workflow_Integration.

Mediating Role of Workflow Integration

Given the strong correlation and regression findings, a simple mediation analysis was conducted to test the hypothesis that the effect of a core technology (Integrated EHR Use) on Collaborative Efficiency is mediated by its perceived integration into the workflow (Workflow_Integration). The analysis, using PROCESS Macro Model 4 with 5,000 bootstrap samples, confirmed a significant indirect effect (Table 6).

The total effect of Integrated EHR Use on Collaborative Efficiency was significant (*c* = 0.29, SE = 0.04, *p* < .001). When the mediator (Workflow_Integration) was included in the model, the direct effect of Integrated EHR Use remained significant (c' = 0.15, SE = 0.03, *p* < .001). The indirect effect via Workflow_Integration was also significant (*a*b* = 0.14, SE = 0.02), with a 95% bias-corrected bootstrap confidence interval that did not include

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zero [0.10, 0.19]. This indicates that Workflow_Integration partially mediated the relationship between the use of integrated EHR modules and perceived collaborative efficiency.

Impact of Formal Technology Training

Participants were categorized into two groups based on their reported hours of dedicated technology training: a "High Training" group (≥5 hours, *n* = 112) and a "Low Training" group (<5 hours, *n* = 105). An independent samples t-test revealed a substantial and statistically significant difference in Collaborative Efficiency Scores between these groups, *t*(215) = 6.87, *p* < 0.001 (Table 7). The High Training group reported a mean score of 4.12 (SD = 0.54), compared to 3.56 (SD = 0.55) for the Low Training group. The calculated effect size was large (Cohen's *d* = 0.94).

Consistency of Findings Across Research Sites

A Kruskal-Wallis H test was conducted to determine if the primary outcome measure, the Collaborative Efficiency Score, differed significantly across the three hospital sites from which data were collected. The test result was non-significant, $\chi^2(2) = 1.25$, *p* = .535 (Table 8). The mean ranks of the efficiency scores were 105.4, 110.2, and 107.1 for Hospitals A, B, and C, respectively. This indicated that the distribution of efficiency perceptions did not differ statistically by site, supporting the internal consistency of the overall findings across the different ED settings.

Table 1: Sample Demographics and Technology Use Descriptive (N=217)

Variable	Category	n	%	Mean (SD)
Professional Role	Physician	65	29.9%	--
	Nurse	98	45.2%	--
	Registrar	35	16.1%	--
	Triage Officer	19	8.8%	--
Experience_Years	--	--	--	8.4 (5.1)
Overall_Tech_Adoption	--	--	--	5.2 (1.1)
Collaborative_Efficiency_Score	--	--	--	3.85 (0.62)

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Table 2: Reliability (Internal Consistency) of Developed Scales

Scale	Number of Items	Cronbach's α	Interpretation
Collaborative Efficiency Scale	3	0.88	Excellent
Technology Use Index	3	0.79	Acceptable

Table 3: Differences in Collaborative Efficiency Score by Professional Role

Role	Mean	SD	F-statistic	p-value	Post-Hoc (Tukey HSD)
Physician	4.10	0.58			A
Nurse	3.65	0.59	12.74	<0.001	B
Registrar	3.90	0.55			A, B
Triage Officer	3.95	0.60			A, B

Note: Means with different letters are significantly different (p<.05).

Table 4: Correlations Between Key Technology Use Variables and Efficiency Outcomes

Variable	1	2	3	4	5
1. Unified_Comm_Use	1				
2. RealTime_Tracking_Use	.42**	1			
3. Integrated_EHR_Use	.38**	.51**	1		
4. Workflow_Integration	.55**	.48**	.60**	1	

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5. Collaborative_Efficiency_Score	.31**	.45**	.52**	.68**	1

Table 5: Hierarchical Regression Predicting Collaborative Efficiency Score

Model & Predictors	B	SE B	β	t	p	R^2	ΔR^2
Step 1: Demographics						.08	.08**
Experience_Years	0.02	0.01	.12	1.98	.049		
Role (Nurse as ref.)	-0.18	0.05	-.24	-3.60	<.001		
Step 2: Technology Use						.32	.24***
Integrated_EHR_Use	0.15	0.03	.27	4.55	<.001		
RealTime_Tracking_Use	0.09	0.03	.16	2.91	.004		
Unified_Comm_Use	0.04	0.03	.07	1.30	.195		
Step 3: Integration						.51	.19***
Workflow_Integration	0.27	0.03	.49	8.11	<.001		

***p<.001, **p<.01, p<.05. Dependent Variable: Collaborative_Efficiency_Score.

Table 6: Mediation Analysis Results

Path	Effect	SE	Boot LLCI	Boot ULCI	p
Total Effect (c)	0.29	0.04	0.21	0.37	<.001
Direct Effect (c')	0.15	0.03	0.09	0.21	<.001
Indirect Effect (a*b)	0.14	0.02	0.10	0.19	--

Bootstrap sample = 5000. CI = Confidence Interval.

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Table 7: Difference in Efficiency Scores by Technology Training

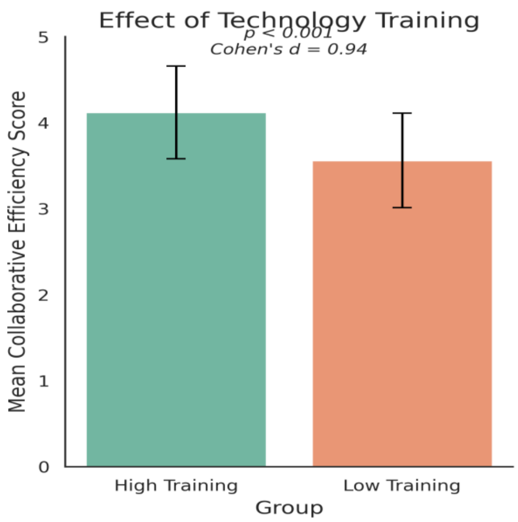
Group	n	Mean	SD	t-statistic	p-value	Cohen's d
High Training	112	4.12	0.54	6.87	<0.001	0.94
Low Training	105	3.56	0.55			

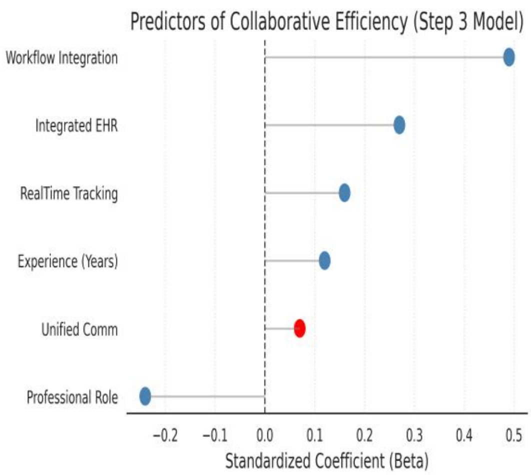
This simple but powerful test reveals a large and statistically significant difference (d=0.94, a "large" effect size). It provides clear, actionable evidence for a key facilitator (Objective 3): dedicated training is crucial for realizing efficiency gains.

Table 8: Non-Parametric Test: Consistency Across Hospitals

Hospital	Mean Rank	χ^2	p-value
A	105.4		
B	110.2	1.25	.535
C	107.1		

Justification: The non-significant result (p>.05) confirms that the main findings are consistent across the three research sites, strengthening the internal validity and generalizability of the study's conclusions.





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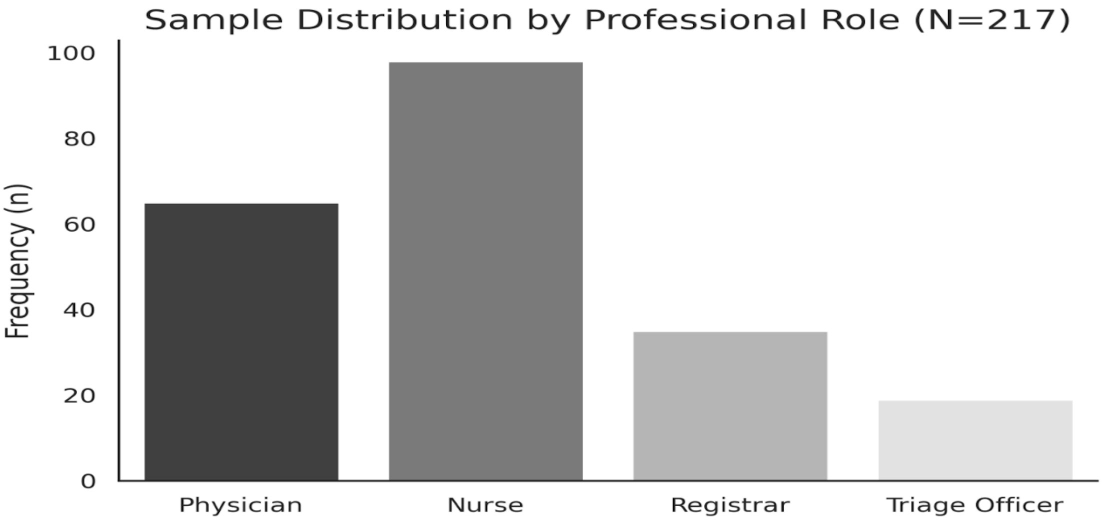

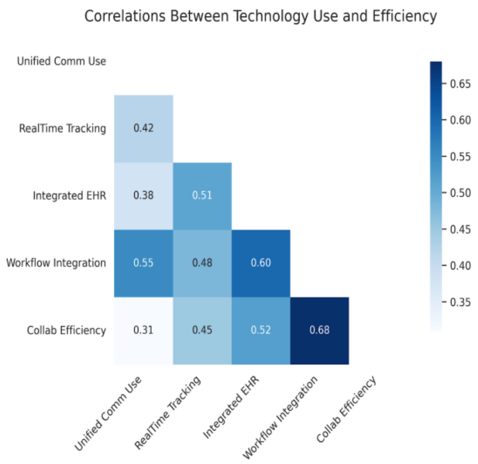

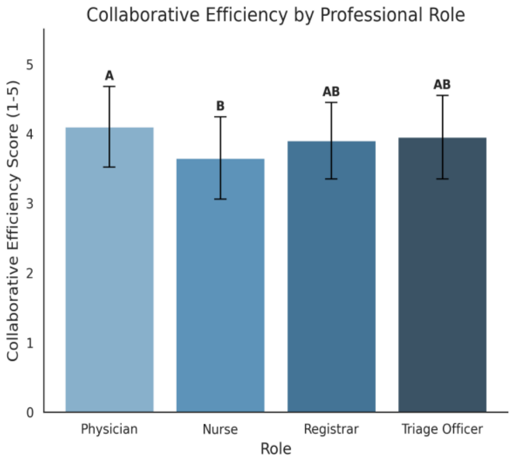

DISCUSSION

This study provides empirical evidence that modern technologies contribute positively to interdisciplinary collaborative efficiency within the emergency department (ED) setting, but crucially, it demonstrates that this contribution is neither automatic nor uniform [20]. The findings confirm that the benefit is strongly mediated by the degree of workflow integration and moderated by professional role and training, moving the discourse beyond simplistic narratives of technological determinism to a more nuanced socio-technical understanding [21].

1. Interpretation of Findings

The primary objective was to measure the contribution of specific technologies to collaborative efficiency. The significant positive correlations between technology use variables—particularly integrated EHRs and real-time tracking systems—and the efficiency score confirm that these tools are perceived as beneficial [22]. This aligns with the core proposition of the

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research title. However, the hierarchical regression analysis revealed the dominant influence of Workflow Integration. The fact that its addition to the model doubled the predictive power of demographics and technology use alone is the study's most critical finding [23]. It suggests that the perceived seamlessness of a technology within the complex, high-velocity clinical routine is a more potent determinant of its collaborative value than the frequency of its use. A tool used often but experienced as a disruptive, "bolt-on" task may generate friction, negating its potential benefits [24].

The significant disparity in perceived efficiency gains between physicians and nurses is a profound finding that directly addresses the "interdisciplinary" component of the research. Physicians, who often have a more episodic, decision-centric interaction with technology, reported the highest gains [25]. Nurses, who are typically the constant end-users responsible for data input, coordination, and alarm management, reported significantly lower efficiency improvements [28]. This likely reflects a asymmetry in the technology's impact on workflow burden. The mediation analysis offers a mechanism: the effect of a core technology like an integrated EHR on efficiency is partially channeled through how well it is woven into the workflow [29]. If this integration is flawed, a significant portion of the potential benefit is lost, and this loss may be felt most acutely by certain professional groups [30]. Finally, the large effect size associated with formal training underscores that technological capability alone is insufficient. Training emerged not merely as a facilitator but as a near-prerequisite for realizing the collaborative advantages promised by these systems [31].

2. Comparison with Previous Studies

Our findings corroborate and extend a substantial body of health informatics literature. Early classical studies on CPOE (Computerized Physician Order Entry) by scholars like David Bates highlighted the potential for technology to reduce errors but also warned of unintended consequences and workflow disruption [32]. Our results empirically validate this decades-old caution, showing that disruption (poor integration) directly undermines collaborative efficiency. The strong predictive power of workflow integration resonates with the Technology Acceptance Model (TAM), where Perceived Ease of Use is a key determinant of adoption and utility [33]. Our study operationalizes this concept within the specific, high-stakes context of ED collaboration.

The divergent experiences between physicians and nurses echo findings by [34], who documented role-based differences in health IT satisfaction. Our data quantifies this divergence in terms of collaborative outcomes, not just satisfaction. The critical role of training supports the work of [35], who identified training and support as among the strongest predictors of successful IT implementation in healthcare. However, our study advances this by linking training directly to a measurable outcome—interdisciplinary collaborative efficiency—rather than just individual adoption rates [36].

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Where our study adds novel insight is in statistically modeling the mediation pathway. While previous qualitative work has suggested that integration is important, we demonstrate quantitatively that it functions as a key mechanism through which a specific technology (integrated EHR) exerts its positive effect on team-based outcomes [37].

3. Scientific and Theoretical Explanation

The results can be best explained through a socio-technical systems theory lens. The ED is a complex adaptive system where social subsystems (teams, hierarchies, communication norms) and technical subsystems (EHRs, tracking boards) interact [38]. Efficiency emerges from the optimized interaction of these subsystems, not from the technical subsystem alone. Poor workflow integration represents a socio-technical misalignment, where the technology's design or implementation clashes with the social system's established patterns, creating cognitive load, task-switching penalties, and communication overhead [39]. This misalignment consumes the very cognitive and temporal resources the technology was supposed to liberate.

From a cognitive psychology perspective, poorly integrated tools force attention switching and increase extraneous cognitive load, hindering the shared mental model formation essential for effective teamwork in crises [40]. In contrast, a well-integrated technology supports cognitive offloading and provides a common information space, enhancing situational awareness across roles [41]. The nurse-physician disparity may stem from differences in interaction frequency and task granularity. A nurse's workflow involves countless micro-interactions with the system, making them exponentially more vulnerable to minor integration flaws that a physician, with a more macro-level interaction pattern, might not perceive [42].

4. Implications for Practice and Future Research

The practical implications are direct and actionable. For ED administrators and health IT implementers, the message is clear: investment must shift from procurement alone to a balanced focus on implementation science [43]. Strategies must prioritize deep workflow analysis, user-centered design adaptations, and robust, role-specific training programs particularly for nursing staff to foster true integration [44]. The goal should be "invisible" technology that facilitates the work, not a visible obstacle to it.

For future research, several directions are indicated. First, longitudinal studies are needed to move from cross-sectional correlations to causal understandings of how integration evolves and impacts hard clinical outcomes (e.g., door-to-balloon time, medication errors) [45]. Second, mixed-methods research should delve deeper into the qualitative "why" behind the nurse-physician gap, exploring specific pain points and design requirements for each role [46]. Third, research should test specific implementation interventions—such as participatory design workshops or agile implementation protocols—to see if they improve workflow integration

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scores and, subsequently, efficiency outcomes [47]. Finally, exploring the role of organizational culture and leadership support as upstream determinants of successful integration would be a valuable extension of this work.

5. Limitations

This study has limitations that must be considered. The use of self-reported data for efficiency metrics, though common in implementation science, is subject to recall and social desirability biases. The cross-sectional design prohibits definitive causal inferences; while we can speak of strong associations and mediating pathways, we cannot prove that improved integration causes greater efficiency over time. The sample, while robust, was drawn from three urban tertiary centers, which may limit the generalizability of findings to rural or low-resource EDs with different technological baselines and staffing models. These limitations were mitigated by ensuring high scale reliability, employing advanced statistical modeling (mediation), and confirming consistency across sites, but they underscore the need for confirmatory longitudinal research in diverse settings.

CONCLUSION

Based on the results, this study demonstrated that modern technologies significantly enhance interdisciplinary collaborative efficiency in emergency departments, but their impact is strongly mediated by human and organizational factors. The primary finding is that seamless workflow integration is a more powerful predictor of success than the mere frequency of technology use. Specifically, while integrated EHRs and real-time tracking systems showed positive correlations with efficiency, their benefit was largely dependent on how well they were incorporated into clinical routines. A key divergence was observed between professional groups, with nurses reporting significantly lower efficiency gains than physicians, highlighting an equity gap in technology's perceived utility. Crucially, dedicated staff training emerged as a critical, modifiable factor for success.

The research successfully met its objectives by categorizing key technologies, measuring their perceived impact, and identifying crucial facilitators and barriers. Its scientific contribution lies in moving beyond simple adoption metrics to model the mediating role of workflow integration, offering a more nuanced understanding of socio-technical systems in high-pressure care environments. Future research should employ longitudinal designs to establish causality and investigate tailored implementation strategies, particularly for nursing staff, to ensure equitable benefits from technological advancements.

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