ORIGINAL RESEARCH ARTICLE

Impact of an Electronic Handover System on Nursing Handover Performance: A Comparison between ICU and General Wards

Azadeh Tataei[1], Naser Parizad[2], Hadi Lotfnezhad Afshar[1], Vahid Alinejad[3], Bahlol Rahimi[1,4]

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Abstract

Background Ineffective clinical handover is a major contributor to communication failures and patient safety incidents. Electronic handover (e-handover) systems have been introduced to improve the accuracy and completeness of information transfer. However, comparative evidence regarding their performance across different clinical settings remains limited. This study aimed to evaluate and compare nurses' perceptions of handover performance in ICU and general wards following the implementation of an e-handover system.

Methods This comparative study included 59 nurses, comprising 29 ICU nurses and 30 general ward nurses. Handover performance was assessed across five dimensions, handover quality, efficiency, error reduction, time saving, and patient safety. Baseline equivalence between groups was confirmed. The e-handover system was piloted following individual training, small-group 45-minute sessions, and WhatsApp coordination; nurses received unique logins and used the system concurrently with paper handover for two months under continuous supervision and technical support. The Mann-Whitney U test was used for group comparisons. Data were analyzed using SPSS software version 26, and statistical significance was set at $p < 0.05$.

Results After implementation of the e-handover system, ICU nurses reported significantly higher scores for handover quality ($p = 0.016$), efficiency ($p < 0.001$), time saving ($p < 0.001$), and patient safety ($p < 0.001$) compared with general ward nurses. Although error reduction scores were higher among ICU nurses, this difference did not reach statistical significance ($p = 0.056$).

Conclusion Implementation of an e-handover system was associated with significant improvements across multiple dimensions of nursing handover performance, particularly in ICUs. These findings support the effectiveness of e-handover systems in enhancing communication efficiency and patient safety in high-acuity environments. Healthcare organizations should consider contextual differences between clinical settings and provide targeted training to optimize e-handover adoption in general wards.

Keywords Continuity of patient care, Intensive care units, Interprofessional relations, Medical informatics applications, Patient safety

✉ Bahlol Rahimi
bahlol.rahimi@gmail.com

1. Department of Health Information Technology, School of Allied Medical Sciences, Urmia University of Medical Sciences, Urmia, Iran
2. Patient Safety Research Center, Clinical Research Institute, Urmia University of Medical Sciences, Urmia, Iran
3. Department of Epidemiology and Biostatistics, School of Medicine, Urmia University of Medical Sciences, Urmia, Iran
4. Health and Biomedical Informatics Research Center, Urmia University of Medical Sciences, Urmia, Iran

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1 Introduction

Effective clinical handover is a fundamental component of safe and high-quality healthcare delivery. Failures in handover communication have been identified as leading contributors to preventable adverse events, medical errors, and fragmented continuity of care.[1,2] Despite increasing awareness of these risks, many healthcare organizations continue to rely on traditional paper-based tools, such as Kardex systems, which are prone to illegibility, incomplete documentation, lack of standardization, and limited accessibility.[3,4] These limitations are particularly problematic in fast-paced clinical environments, where timely and accurate information exchange is essential for maintaining patient safety.[5-7] In response to these challenges, electronic handover (e-handover) systems have emerged as a promising strategy to enhance communication quality, streamline clinical workflows, and improve patient safety.[8,9] Electronic platforms enable standardized data entry, real-time access to patient information, and improved traceability, which may collectively reduce information omissions and transcription errors.[8,10] Previous studies have reported improvements in handover completeness, staff satisfaction, and efficiency following the implementation of e-handover tools.[11,12]

However, the existing evidence base remains heterogeneous. Variations in system design, outcome measures, and clinical contexts limit the comparability and generalizability of reported findings. Importantly, much of the published literature has focused on single clinical settings or aggregated hospital level data, with limited examination of how e-handover systems perform across distinct care environments.[8,10] In particular, comparisons between intensive care units (ICUs) and general wards remain scarce. This gap is clinically relevant, as ICUs are characterized by higher patient acuity, rapid physiological changes, and complex multidisciplinary coordination,[13,14] whereas general wards typically manage larger patient volumes with lower acuity and different workflow demands.[15] Such contextual differences may influence both the effectiveness of e-handover systems and nurses' perceptions of their impact.[16, 17] Furthermore, although patient safety is frequently cited as a key rationale for adopting e-handover systems, few studies have examined safety as a multidimensional construct encompassing handover quality, efficiency, error reduction, and time-saving.[9,10] Instead, prior research has often assessed these dimensions in isolation, resulting in an incomplete understanding of how improvements in communication processes translate into broader patient safety outcomes.[18,19]

Therefore, there remains a clear need for comparative evidence evaluating the impact of e-handover systems across different clinical settings using multidimensional performance indicators. Addressing this gap is essential to inform context-sensitive implementation strategies and optimize resource allocation. Accordingly, the present study aimed to evaluate and compare nurses' perceptions of e-handover performance between ICUs and general wards following implementation of an e-handover system. Specifically, the study assessed handover quality, efficiency, error reduction, time-saving, and patient safety. It was hypothesized that perceived handover performance would differ between ICU and general ward nurses after implementation of the e-handover system.

2 Methods

Study Design and Setting

This study employed a quasi-experimental pretest–posttest design to assess nurses' perspectives on the Electronic Nursing Handover System (ENHS) and its impact on patient safety. The study was conducted over a 14-month period from October 2021 to December 2022 at two university hospitals, Imam Khomeini and Taleghani Hospitals, both tertiary care centers affiliated with Urmia University of Medical Sciences in Urmia, Iran. Nurses working in ICUs and general wards were eligible for participation. Sampling was conducted between April 16 and August 1, 2022. Group allocation was based on clinical unit (ICU versus general ward), with no randomization or allocation concealment. Accordingly, the study followed CONSORT extension guidelines for non-randomized interventions

Participants and Sampling

A total of 59 registered nurses participated in the study, including 29 ICU nurses and 30 general ward nurses. Eligible participants were actively involved in shift handovers and had at least six months of clinical experience in their respective units. Nurses on extended leave or those not directly participating in handover activities were excluded.

Census sampling was used. All eligible nurses working in the selected units were invited to participate, and written informed consent was obtained before data collection. Participants were allocated by clinical unit (ICU versus general ward). Recruitment occurred between April 16 and August 1, 2022.

Sample size

Given the exploratory nature of the study and the limited number of eligible nurses, a census approach was adopted, and no a priori sample size calculation was performed. A post hoc power analysis indicated that the available sample provided approximately 80 percent power to detect moderate between-group differences, assuming an

effect size of d = 0.6 and an alpha level of 0.05. Of the 65 eligible nurses, 59 consented to participate and completed both baseline and post-intervention assessments (29 ICU nurses and 30 general ward nurses). Six nurses declined participation because of workload constraints. No participants were lost to follow-up during the study period (Figure 1).

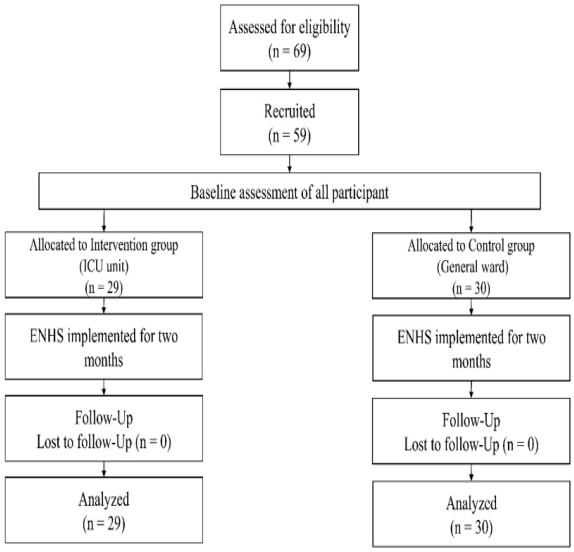

Figure 1 CONSORT flow diagram of the study

Design of the ENHS

The ENHS was developed using a user-centered design approach informed by a literature review and interviews with experienced nurses and supervisors to identify a minimum essential data set for handover. An initial prototype was validated by nursing and medical informatics experts before final implementation. Technically, the system was developed as a web-based application using C#, ASP.NET Core MVC, Bootstrap, Ajax, and SQL Server, enabling responsive access and secure data storage. The ENHS captured structured patient information, including demographics, vital signs, medications, laboratory results, and ICU- free specific assessments (e.g., Glasgow Coma Scale and pain scores). Selectable fields were emphasized over free-text entry to reduce documentation errors and workload. Individual user accounts were implemented to maintain confidentiality and support standardized, accurate, and efficient shift handovers .[9]

Intervention

The intervention consisted of pilot implementation of the ENHS in both ICUs and general wards. Following informed consent, 59 nurses participated using census sampling. Head nurses received individual training first, followed by group-based education for staff coordinated via WhatsApp and delivered through 45-minute face to face sessions in small groups. Each nurse received a unique username and password to ensure data security. After training, nurses used the ENHS alongside conventional paper based documentation for two months. During this period, the research team provided ongoing supervision and technical support to address operational issues and facilitate integration into routine clinical workflows. The system supported structured entry of demographic data, clinical status, medications, investigations, and nursing care priorities through predefined fields, minimizing reliance on free-text documentation. Prior to implementation, participating nurses attended two one-hour training sessions focused on system navigation and data entry procedures. Technical support remained available throughout the implementation phase to promote consistent system use.[9]

Study outcomes

The primary outcome was perceived patient safety. Secondary outcomes included handover quality, efficiency, error reduction, and time saving.

Data Collection Instruments

Data were collected using a structured, self-administered questionnaire developed specifically for this study. The instrument comprised two sections. The first section collected demographic information, including age, gender, education level, and work experience. The second section assessed handover performance across five domains, handover quality, efficiency, error reduction, time saving, and patient safety. Items were rated on a Likert-type scale, with higher scores indicating more favorable perceptions of handover performance. Patient safety was treated as a composite outcome derived from the preceding domains. Content validity was established by a panel of nursing and health informatics experts. Internal consistency reliability was evaluated using Cronbach's alpha coefficients, which demonstrated acceptable reliability across all domains.[9] Baseline data were collected using the conventional Kardex-based handover method. Following ENHS implementation, the same questionnaire was re-administered to assess changes in nurses' perceptions.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics, version 26. Descriptive statistics summarized participant characteristics. Baseline comparability between groups was assessed using chi-square tests. Normality of outcome variables was evaluated using the Shapiro-Wilk test, which indicated non normal distributions. Accordingly, non-parametric methods were applied. Differences between ICU and general ward nurses were analyzed using the Mann-Whitney U test. Statistical significance was set at $p < 0.05$.

3 Results

A total of 59 nurses were enrolled and allocated to two groups, including the ICU group (n = 29) and the general ward group (n = 30). Most participants were female (n = 48, 81.4%), while male nurses accounted for 18.6% (n = 11). Regarding age distribution, the largest proportion of ICU nurses were aged 31 to 40 years (54.5%), whereas the predominant age category among general ward nurses was 21 to 30 years (53.8%). Most participants held a bachelor's degree (89.8%). Comparative analyses showed no statistically significant differences between the ICU and general ward groups with respect to gender (p = 0.506), educational level (p = 0.548), age category (p = 0.332), or work experience (p = 0.167). These findings indicate that the two groups were demographically comparable, suggesting that baseline characteristics were unlikely to confound the study outcomes (Table 1).

Baseline comparisons of handover performance using the conventional Kardex based system are presented in Table 2. At baseline, no statistically significant differences were observed between the ICU and general ward groups across any evaluated handover domains, including handover quality, efficiency, error reduction, time saving, and patient safety (all p > 0.05). These findings confirm that the two groups were comparable in handover performance before implementation of the e-handover system. Post implementation comparisons of handover performance following introduction of the e-handover system are presented in Table 3. Significant differences were observed between the ICU and general ward groups across most handover domains. ICU nurses reported significantly higher scores for handover quality (p = 0.016), efficiency (p < 0.001), time saving (p < 0.001), and patient safety (p < 0.001) compared with nurses working in general wards. Although the mean error reduction score was higher in the ICU group, this difference did not reach statistical significance (p = 0.056) (Table 3).

Table 1 Distribution of demographic variables of the participants

Variable	Group	ICU		General		
		Frequency	Percentage	Frequency	Percentage	*P-value
Gender	Male	4	36.4	7	63.6	0.506
	Female	25	52.1	23	47.9	
Education	Diploma	0	0.0	2	100	0.548
	Bachelor	27	50.9	26	49.1	
	Master	2	50.0	2	50.0	
Age	21-30	12	46.2	14	53.8	0.332
	31-40	12	54.5	10	45.5	
	41-50	5	62.5	3	37.5	
	51-60	0	0.0	3	100	
Experience	0-5	9	39.1	14	60.9	*0.167*
	6-10	9	45.0	11	55.0	
	10<	11	68.8	5	31.3	

*Chi-squared test

Table 2 Baseline comparison of Kardex based handover performance

	Dimensions	General	ICU	*P-value
Kardex-based handover	Handover quality	74.96 ± 2.40	69.00 ± 2.40	p = 0.281 z = -1.078
	Handover efficiency	57.20 ± 1.86	52.20 ± 1.93	p = 0.278 z = -1.085
	Error reduction	52.46 ± 1.71	49.65 ± 1.64	p = 0.255 z = -1.139
	Time-saving	18.90 ± 0.84	19.03 ± 0.52	p = 0.951 z = -0.061
	Patient safety	203.53 ± 6.44	189.89 ± 5.75	P = 0.268 z = -1.107

*Mann-Whitney Test

Table 3 Post implementation comparison of e-handover performance

	Dimensions	General	ICU	*P-value
E-handover	Handover quality	83.26 ± 0.92	87.17 ± 1.31	p = 0.016 z = -2.415
	Handover efficiency	67.46 ± 0.75	79.89 ± 2.72	p = 0.0001 z = -4.503
	Error reduction	63.03 ± 0.96	65.00 ± 2.22	p = 0.056 z = -1.913
	Time-saving	18.40 ± 0.43	26.44 ± 0.60	p = 0.0001 z = -6.284
	Patient Safety	231.90 ± 2.59	258.51 ± 5.15	p = 0.0001 z = -3.824

*Mann-Whitney Test

4 Discussion

This study evaluated the impact of an e-handover system on multiple dimensions of nursing handover performance among ICU and general ward nurses. The findings demonstrated that, following implementation of the e-handover system, ICU nurses reported significantly higher scores for handover quality, efficiency, time saving, and patient safety compared with nurses working in general wards. These results suggest that e-handover systems may be particularly beneficial in high acuity clinical environments, where timely, accurate, and structured communication is essential.[20-22]

Baseline comparisons revealed no significant differences between ICU and general ward groups in demographic characteristics or Kardex based handover performance. This comparability strengthens the internal validity of the study and supports the interpretation that the observed post implementation differences were attributable to the e-handover system rather than pre-existing group disparities. The observed improvements in handover quality and efficiency among ICU nurses are consistent with previous studies reporting enhanced completeness, clarity, and accessibility of clinical information following adoption of e-handover tools.[8,9,23] Intensive care settings are characterized by rapid changes in patient condition, frequent interdisciplinary communication, and complex care trajectories.[8,24] These contextual features may amplify the benefits of structured electronic documentation. Real time data availability and standardized information formats likely facilitated more comprehensive and streamlined exchanges, contributing to higher perceived efficiency among ICU nurses.[22,25]

Additional support for these findings is provided by a quasi-experimental study by Tataei et al., which compared electronic nursing handover with traditional paper based methods in general wards and COVID 19 ICUs. That study reported significantly higher scores for handover quality, efficiency, error reduction, handover time, and patient safety following implementation of e-handover systems.[9] Together, these findings suggest that structured e-handover platforms not only improve nurses' perceptions of communication processes but also contribute to meaningful enhancements in safety related domains, particularly in high acuity environments.[20,26] Time saving emerged as another domain with a marked difference favoring ICU nurses. This finding aligns with earlier research indicating that e-handover systems reduce redundant documentation and minimize time spent locating patient information.[9,10,27] In critical care settings, even modest gains in efficiency may have important clinical implications by allowing nurses to devote more time to direct patient care and clinical decision making.[28,29]

Patient safety scores were also significantly higher among ICU nurses following implementation of the e-handover system. In this study, patient safety was conceptualized as a composite outcome influenced by upstream domains, including handover quality, efficiency, error reduction, and time saving. The observed improvements suggest that enhancements in communication processes collectively contribute to safer care delivery. This interpretation is consistent with evidence linking structured handover practices to reductions in adverse events and improved continuity of care.[2,30] Although differences in error reduction between groups did not reach statistical significance, the higher mean scores observed in the ICU group indicate a positive trend that warrants further investigation using larger samples and objective outcome measures.

Overall, this study contributes to the literature by providing comparative evidence across ICU and general ward settings and by examining patient safety as an integrated outcome rather than isolated process measures. This multidimensional approach offers a more comprehensive understanding of how e-handover systems influence clinical practice and safety related perceptions.

Several limitations should be acknowledged. First, the relatively small sample size and single center design may

limit generalizability. Second, outcomes were based on self-reported perceptions rather than objective clinical indicators, such as documented error rates or adverse events. Third, the follow up period was relatively short and may not capture long term adaptation to or sustainability of e-handover system use. Future research incorporating larger, multi-site samples and objective safety metrics is recommended.

Implications for Practice and Future Research

Despite these limitations, the findings indicate that e-handover systems can meaningfully enhance handover performance, particularly in ICUs. Healthcare organizations should consider contextual differences between clinical environments when implementing e-handover platforms and provide targeted training and ongoing support to facilitate adoption in general wards. Future studies should examine longitudinal outcomes, integration with electronic health record systems, and the relationship between perceived improvements and objectively measured patient safety indicators.

5 Conclusion

Implementation of an e-handover system was associated with significant improvements in handover quality, efficiency, time saving, and patient safety, with more pronounced benefits observed in ICUs compared with general wards. These findings highlight the potential of e-handover tools to enhance communication processes in high acuity clinical environments and support safer, more efficient care delivery. Although perceptions of error reduction did not differ significantly between groups, the overall positive impact across multiple domains underscores the value of structured electronic handover systems. It is strongly recommended that healthcare managers adopt and implement the proposed ENHS as a hospital-wide tool for clinical handover. Further multi-center studies incorporating objective safety outcomes are needed to evaluate long term effectiveness and inform context specific implementation strategies.

Declarations

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Artificial Intelligence Disclosure

No artificial intelligence tools were used in the present study.

Authors' Contributions

Azadeh Tataei conducted the study and drafted the manuscript. Bahlol Rahimi conceptualized and supervised the study. Azadeh Tataei, Bahlol Rahimi, Hadi Lotfnezhad Afshar, Vahid Alinejad, and Naser Parizad collaborated on the development of the questionnaire and contributed to critical review of the manuscript. Azadeh Tataei, Vahid Alinejad performed the data analysis and interpreted the results. All authors reviewed and provided feedback on the manuscript, and all have read and approved the final version.

Availability of Data and Materials

The corresponding author can provide the datasets used and/or analyzed during this study upon reasonable request.

Conflict of Interest

The authors declare that they have no conflicts of interest related to this study.

Consent for Publication

Not applicable.

Ethical Considerations

Prior to the commencement of the study, ethical approval was obtained from the Ethics Committee of Urmia University of Medical Sciences (Ethics Code: IR.UMSU.REC.1400.331). All participants were provided with comprehensive information regarding the objectives and procedures of the study before written informed consent was obtained. Participants were assured that their personal information would remain confidential and anonymous throughout the research process. They were also informed that participation was entirely voluntary and that they could withdraw from the study at any stage without any penalty or negative consequences.

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