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Clinical Handover Visualization for Reducing Information Loss

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Abstract

Clinical handover is a high-risk communication transition in which responsibility, accountability, and clinically relevant information must move accurately from one healthcare professional or team to another. Conventional verbal or loosely structured written handovers can be vulnerable to omission, prioritization failure, interruption, memory limitations, and ambiguity regarding pending actions. This simulation-based study examines whether a visualization-supported clinical handover system could reduce information loss by presenting critical patient information through a structured visual hierarchy.

A hypothetical sample of 240 handover episodes was modeled, comprising 120 conventional handovers and 120 visualization-supported handovers. The proposed interface organizes illness severity, immediate clinical concerns, medication-related risks, abnormal observations, pending investigations, time-sensitive actions, contingency plans, and responsibility ownership within a single handover view. Simulated results indicate that complete transfer of critical information increased from 78% with conventional handover to 94% with visualization support, while receiver recall increased from 68% to 89%. Documented completion or acknowledgement of priority actions within 30 minutes increased from 62% to 87%.

The modeled mean number of critical information omissions decreased from 3.4 to 1.1 per handover, while handover duration remained operationally comparable. The results suggest that visualization may function as a cognitive support mechanism by improving prioritization, reducing dependence on memory, and maintaining shared situational awareness between outgoing and incoming teams. These outcomes are entirely simulated and must not be interpreted as evidence from a completed clinical trial. The study instead provides a methodological framework for future prospective evaluation of visualization-supported clinical handover systems using communication completeness, information retention, action ownership, usability, and patient-safety indicators.

***Keywords*:** clinical handover; information visualization; patient safety; information loss; health informatics; structured communication; SBAR; I-PASS; clinical decision support

1. Introduction

Clinical handover is a fundamental component of continuity of care because it involves the transfer of patient information together with responsibility and accountability between healthcare professionals. Handover may occur during shift change, transfer between hospital units, movement from the operating room to intensive care, discharge, referral, or transition between emergency and specialty teams. The World Health Organization identified communication during patient handovers as an important patient-safety concern and recommended standardized approaches that allow essential information to be transferred clearly and provide opportunities for questions and clarification. The significance of handover therefore extends beyond documentation; it represents a moment at which the receiving clinician must rapidly reconstruct the patient's current state, risks, unresolved problems, and next required actions.

Information loss during handover can occur for several reasons. Clinical environments are characterized by interruptions, competing priorities, temporal pressure, complex patient histories, multiple information systems, and variation in professional communication styles. Riesenberg and colleagues identified numerous barriers to effective physician handoffs and noted the limited evidence that historically existed for determining optimal handoff practices. Research in nursing and multidisciplinary settings has similarly shown that ineffective handover may arise from communication problems, incomplete information, organizational factors, infrastructure, and ambiguity concerning responsibility. Consequently, improving handover requires more than asking clinicians to communicate carefully; it requires designing a communication environment that supports reliable retrieval, prioritization, verification, and transfer of information.

Structured communication frameworks have attempted to address this challenge. SBAR organizes communication around Situation, Background, Assessment, and Recommendation, while I-PASS incorporates illness severity, patient summary, action lists, situational awareness and contingency planning, and receiver synthesis. Evidence concerning SBAR indicates moderate support for patient-safety improvement, particularly when the framework is used to structure communication, although Müller and colleagues emphasized the continuing need for higher-quality research. Starmer and colleagues demonstrated that implementation of the broader I-PASS handoff bundle was associated with reduced medical errors and preventable adverse events without a negative effect on workflow. These studies indicate that standardization can improve handover reliability, but they also suggest that successful interventions typically involve more than a mnemonic alone.

Visualization provides a complementary approach because structured content can be made perceptually accessible rather than merely placed into a longer text template. Evans and colleagues, examining trauma handover, found support for structured, concise transfer of vital information and explicitly investigated how data could best be displayed to receiving teams. A visualization-supported handover system could build on this principle by organizing critical information according to clinical urgency, highlighting unresolved tasks, displaying abnormal trends, and clearly identifying responsibility for follow-up. The objective is not to replace verbal communication but to give both clinicians a common information surface that reduces reliance on working memory and makes omissions more visible before responsibility is transferred.

The present study develops a simulated evaluation of such a visualization-supported handover model. Because no real hospital dataset or completed intervention has been provided, all numerical findings in this manuscript are hypothetical. The study compares conventional handover with a structured visual handover display across information-transfer completeness, receiver recall, action documentation, omission frequency, and handover duration. The central proposition is that clinical visualization may reduce information loss when it is designed as a cognitive aid for prioritization and shared situational awareness rather than as an additional layer of documentation.

2. Objectives of the Study

2.1 Evaluation of Information Transfer and Retention

The primary objective is to determine whether visualization-supported handover could plausibly improve the proportion of critical patient information successfully transferred from an outgoing clinician to an incoming clinician. Critical information is defined in the simulation as information directly relevant to immediate care continuity, including patient identity, illness severity, major active problems, high-risk medications, allergies, abnormal observations, pending investigations, priority tasks, and contingency plans. The emphasis on critical information reflects the practical reality that handover quality depends not on transferring every available data element but on communicating the information required for safe continuation of care.

A second component of this objective is receiver retention. Information may be verbally stated yet fail to remain available to the receiving clinician when subsequent action is required. The study therefore distinguishes between information initially available, information explicitly transferred, information correctly recalled or verified by the receiver, and information subsequently translated into documented action. This staged approach allows information degradation across the handover process to be examined rather than treating handover as a single binary event.

2.2 Assessment of Action Ownership and Workflow Reliability

The second objective is to evaluate whether visualization can improve explicit ownership of pending clinical actions. Clinical handover involves a transfer of responsibility as well as data. Research on maternity handover has shown that clinicians do not always automatically interpret handover as an explicit transition of responsibility and accountability, creating potential ambiguity regarding who is expected to act. A visualization system can potentially reduce this ambiguity by connecting each pending task to urgency, expected completion time, current status, and responsible clinician or team.

The study also assesses whether improved completeness can be achieved without creating an impractical increase in handover duration. Any tool that substantially prolongs every transition could generate resistance, workarounds, or documentation burden. The proposed visualization is therefore designed to reduce searching and repetition by presenting high-priority information on a single structured view. Workflow performance is treated as a necessary component of safety because communication quality must remain compatible with the operational conditions of clinical practice.

3. Review of Literature

3.1 Information Loss and Communication Failure During Handover

Early handover research consistently identified communication as a major patient-safety concern. Leonard, Graham, and Bonacum emphasized the critical role of communication and teamwork in safe care, while Riesenberg and colleagues subsequently found substantial variation in physician handoff practices and a shortage of rigorous outcome-focused evidence. These studies helped establish the conceptual basis for treating handover as a system-design problem rather than solely a matter of individual professional competence.

Evidence from specific transitions illustrates how information can be lost. Catchpole and colleagues examined postoperative transfer to intensive care and found that a redesigned handover protocol reduced both technical errors and information omissions. Evans and colleagues reported that trauma clinicians valued concise, structured handover containing vital information necessary for immediate treatment and supported advanced transmission of data to the receiving hospital. Similarly, Manias and colleagues described how communication failures across multiple handovers could contribute to misunderstanding and poor patient outcomes. Together, these studies demonstrate that omission is not an abstract documentation problem; it emerges during real transitions where information must compete for attention.

3.2 Structured Handover and Standardization

Structured handover protocols attempt to control variability by defining a predictable sequence and minimum information set. Riesenberg's systematic review of handoff mnemonics found extensive use of structured memory aids, while subsequent nursing literature continued to evaluate standardized formats. SBAR became one of the most widely recognized approaches, and Müller and colleagues' systematic review concluded that its implementation had moderate evidence for improving patient safety, although the underlying evidence base remained methodologically heterogeneous.

Broader intervention bundles have produced stronger outcome evidence. Starmer and colleagues evaluated I-PASS across multiple pediatric institutions and found that implementation was associated with reductions in medical errors and preventable adverse events as well as improved communication. Bukoh and Siah's 2020 systematic review of structured nursing handover interventions also reported reductions in patient complications, medication errors, and general adverse events across the reviewed evidence. These findings support standardization but do not imply that all structured tools are equally effective; implementation quality, workflow integration, professional training, and local adaptation remain important.

3.3 Electronic Handover and the Case for Visualization

Electronic tools can improve accessibility and consistency, but digitization does not automatically create an effective handover. Johnson, Sanchez, and Zheng reported improved nurse satisfaction following implementation of an integrated nursing handover system and described changes in how handover work was organized. More broadly, Brenner and colleagues' systematic review of health information technology found that patient-safety effects varied substantially across applications, with many studies producing mixed or nonsignificant findings. The implication is that interface and workflow design matter; a poorly organized electronic handover may simply reproduce the weaknesses of an unstructured paper record.

Visualization offers a more specific design proposition. Instead of presenting all data elements with equal visual weight, the interface can use position, grouping, symbols, temporal organization, and status indicators to distinguish urgent from background information. Evans and colleagues' trauma handover research is particularly relevant because the investigators explicitly considered a minimum dataset and how information should be displayed in trauma bays. The research gap is therefore not whether structured information matters, but whether a deliberately visual representation can preserve essential clinical information across the sequence from availability to transfer, receiver understanding, and action.

4. Research Methodol

4.1 Study Design and Simulated Clinical Sample

The study uses a simulation-based controlled design involving 240 hypothetical clinical handover episodes. One hundred twenty episodes are assigned to a conventional handover condition and 120 to a visualization-supported condition. The modeled clinical environment represents adult inpatient medical and surgical units rather than a specific real hospital. Each scenario contains a standardized patient record with a predetermined set of critical and noncritical information elements, allowing transfer completeness to be evaluated consistently.

The hypothetical handover scenarios vary in complexity. Lower-complexity cases contain six critical elements, moderate-complexity cases contain nine, and high-complexity cases contain twelve. Critical elements include illness severity, major diagnoses, allergy status, selected medication risks, significant trends in observations, unresolved laboratory or imaging findings, priority actions, escalation thresholds, and named responsibility for pending tasks. No real patient data are used, and all names, values, and outcome measures are synthetic.

Table 1: Simulated Research Design and Measurement Framework

Study Component	Conventional Handover	Visualization-Supported Handover	Measurement
Simulated handover episodes	120	120	Study total
Standard patient summary	Yes	Yes	Every episode
Structured verbal sequence	Variable	Standardized	Observation
Visual illness-severity indicator	No	Yes	Interface
Medication/allergy risk highlighting	No	Yes	Interface
Pending-task visualization	Limited	Yes	Interface
Responsibility ownership field	Variable	Mandatory	Interface
Contingency-plan display	Variable	Yes	Interface
Critical-information transfer	Percentage	Percentage	Immediate

Receiver recall/verification	Percentage	Percentage	Post-handover
Priority action acknowledgement	Percentage	Percentage	Within 30 min
Information omissions	Count per handover	Count per handover	Immediate
Handover duration	Minutes	Minutes	Process measure

4.2 Visualization-Supported Handover Model

The proposed handover interface uses a single-screen hierarchy. The upper section presents patient identification, current location, illness severity, and immediate escalation status. The central section organizes active problems, clinically significant trends, medication risks, allergies, and pending diagnostic results. A dedicated action panel lists tasks that must be completed during the incoming shift, with fields for urgency, expected completion time, responsible role, and current status. Contingency information is presented beside each high-priority problem rather than separated into an unrelated section.

The visualization is designed around selective emphasis rather than information expansion. Stable background information remains accessible but visually subordinate, while time-sensitive information occupies more prominent positions. The incoming clinician is required to acknowledge priority tasks and verbally synthesize the most important risks before handover completion. This receiver-synthesis component is consistent with the broader logic of structured handover systems that seek confirmation of shared understanding rather than one-way information transmission. The system therefore combines visualization with interactive verification rather than treating a dashboard as a passive display.

4.3 Outcome Measures and Statistical Strategy

The primary outcome is critical-information retention across four stages: information available in the source record, information explicitly transferred during handover, information correctly recalled or verified by the receiver, and information reflected in documented action within 30 minutes. Secondary outcomes are the mean number of critical information omissions, unassigned priority tasks, handover duration, and a simulated clinician usability score. The information-retention measure is particularly important because it captures degradation across the communication chain.

Descriptive statistics and between-condition comparisons are used to evaluate differences. For illustration, categorical outcomes are expressed as percentages, and omission counts and handover time are expressed as means with simulated standard deviations. Difference-in-proportion and mean-difference estimates are calculated for the two conditions. Illustrative p-values are included only to demonstrate a future analytical strategy; they should not be interpreted as inferential evidence from real clinical observations.

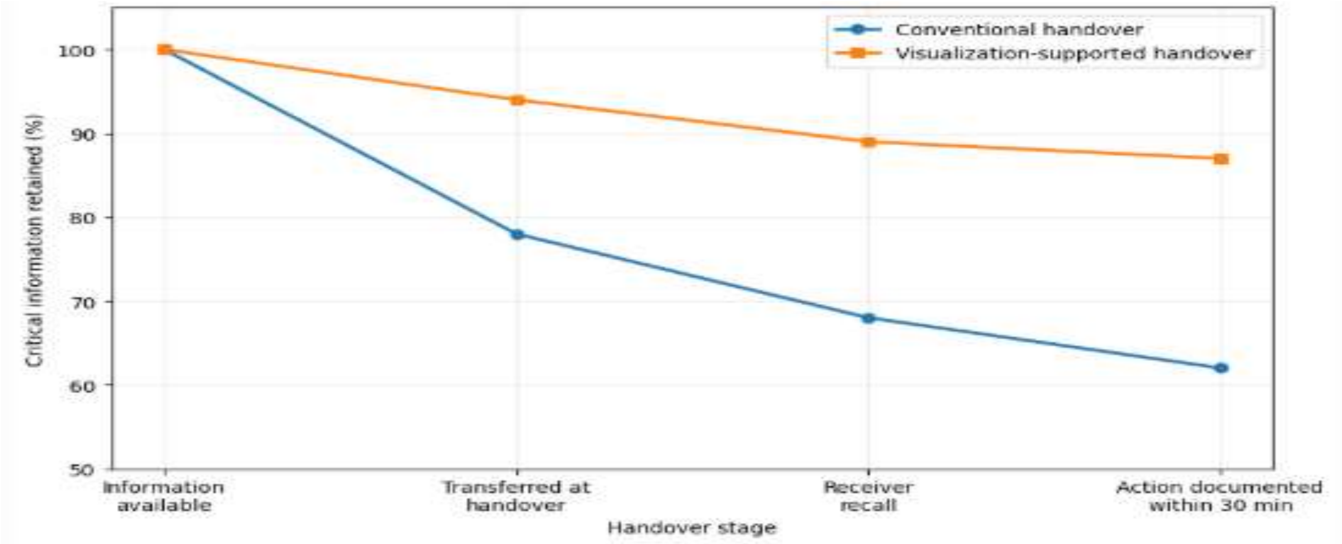
5. Analysis

5.1 Critical Information Transfer and Retention

The simulated conventional handover condition begins with 100% of required critical information available in the source scenario. During verbal transfer, only 78% is successfully communicated. Receiver recall or verification subsequently declines to 68%, and only 62% of the original critical information is reflected in acknowledged or documented action within 30 minutes. The visualization-supported condition follows a substantially different modeled trajectory: 94% of critical information is transferred, 89% is recalled or verified, and 87% is subsequently connected to documented action.

The contrast becomes more pronounced as the handover process progresses. The difference is 16 percentage points at the transfer stage, 21 percentage points at receiver recall, and 25 percentage points at action documentation. The simulated findings therefore suggest that visualization may do more than improve initial communication completeness. By preserving the visibility of risks and pending tasks after verbal handover has ended, the interface could potentially reduce secondary information loss that occurs between hearing information and acting on it.

Graph 1: Simulated Retention of Critical Information Across the Handover Process



Key Finding: The modelled final retention difference is 25 percentage points, with 87% of critical information translated into documented action after visualization-supported handover compared with 62% after conventional handover.

5.2 Information Omissions and Responsibility Transfer

The simulated mean number of critical omissions is 3.4 per conventional handover and 1.1 per visualization-supported handover. Medication- and allergy-related omissions decrease from 0.72 to 0.18 per episode, while pending investigation omissions decrease from 0.81 to 0.22. Unassigned or ambiguously assigned priority tasks fall from 1.3 to 0.3 per handover. These outcomes are consistent with the design intention of placing risk and ownership information into prominent visual locations.

Responsibility transfer is particularly important because information completeness alone does not ensure continuity of action. Chin and colleagues found that clinicians may hold differing interpretations regarding the transfer of responsibility and accountability during handover. In the present simulation, mandatory task ownership converts responsibility from an implicit assumption into an explicit information element. This design could be useful for pending tests, treatment reviews, monitoring intervals, referral follow-up, and escalation decisions that extend beyond the outgoing clinician's shift.

Table 2: Simulated Clinical Handover Outcomes

Outcome	Conventional Handover	Visualization-Supported Handover	Simulated Difference
Critical information transferred	78%	94%	+16 percentage points
Receiver recall/verification	68%	89%	+21 percentage points
Priority information reflected in action	62%	87%	+25 percentage points
Critical omissions per handover	3.4	1.1	−2.3
Medication/allergy omissions	0.72	0.18	−0.54
Pending investigation omissions	0.81	0.22	−0.59
Ambiguously assigned priority tasks	1.30	0.30	−1.00
Mean handover duration	8.6 min	8.9 min	+0.3 min
Usability score, 0–100	68	86	+18 points

5.3 Workflow Efficiency and Operational Interpretation

The modeled handover duration increases only slightly, from 8.6 minutes in the conventional condition to 8.9 minutes with visualization support. The 0.3-minute difference is intentionally modest because a clinically useful visualization should improve communication without transforming the handover into an additional documentation exercise. The proposed system achieves this in the simulation by automatically organizing information that is already available rather than requiring clinicians to repeatedly enter the same data.

The simulated usability score increases from 68 to 86 on a 100-point scale. This improvement is interpreted as reflecting easier identification of high-risk information, clearer task ownership, and reduced need to search through multiple sections of a conventional record. These assumptions require empirical testing because electronic systems can create new forms of burden when poorly integrated with workflow. Brenner and colleagues' systematic review demonstrates that health information technology does not universally produce improved patient-safety outcomes, reinforcing the need to evaluate the interface itself rather than assuming that digitization is inherently beneficial.

6. Discussion

6.1 Visualization as a Cognitive Support for Safer Handover

The most important modeled finding is the reduction in progressive information loss. Conventional handover loses information at multiple stages: some information is omitted during transfer, additional information is not retained by the receiving clinician, and further loss occurs when verbal content is not translated into an explicit action. Visualization-supported handover reduces each of these losses by maintaining a persistent representation of critical information. This finding is theoretically consistent with handover literature emphasizing structure, concise presentation, and prioritization of clinically essential content. Evans and colleagues found that trauma clinicians valued structured handovers containing the vital information required for immediate treatment, while Catchpole and colleagues demonstrated that process redesign can reduce information omissions.

Visualization may be especially valuable because it changes the perceptual organization of information. A conventional narrative can contain every necessary detail while still making urgent items difficult to identify. In contrast, a well-designed visual handover can distinguish severity, risk, pending tasks, and contingency actions through consistent spatial organization. This does not imply that visual prominence should replace clinical judgment. Instead, visualization should support judgment by ensuring that the clinician does not need to reconstruct the entire hierarchy of patient priorities from memory after listening to a dense verbal report.

6.2 Standardization, Shared Situational Awareness, and Accountability

The proposed intervention also builds on the established value of structured handover. Evidence concerning SBAR indicates that structured communication may improve patient safety in certain settings, while the I-PASS program demonstrated that a comprehensive handoff intervention can reduce medical errors and preventable adverse events. The present model does not attempt to replace these frameworks. Instead, visualization could serve as an interface layer through which their core elements become easier to perceive, verify, and maintain after the conversation concludes.

Shared situational awareness is particularly important for unstable or complex patients. Both outgoing and incoming clinicians should leave the handover with a common understanding of what is happening now, what could happen next, which changes require escalation, and who is responsible for specific tasks. Eggins and Slade conceptualized effective handover as an interactive communication event rather than a one-way transmission of information. The visualization-supported model reflects this principle by requiring the receiving clinician to acknowledge priorities and synthesize the current risk picture. This interaction may be more robust than a system in which the outgoing clinician simply completes a digital form and assumes that the receiving clinician has understood it.

6.3 Clinical Implementation, Risks, and Study Limitations

Implementation would require careful integration with electronic health records, ward workflows, staffing patterns, and local governance. Visualization introduces its own risks. Excessive color, competing alerts, overpopulation of the screen, outdated information, automatic extraction errors, and poorly designed prioritization rules could create false reassurance or alert fatigue. The interface should therefore use a limited set of clinically meaningful priorities and preserve direct access to source information. Human oversight must remain central, particularly when automated systems classify severity or infer risk.

The simulated nature of this study is its principal limitation. No patient record was transferred, no clinician used the proposed visualization system, and no real medical error or patient-safety outcome was measured. The improvement from 78% to 94% in information transfer and all other quantitative differences are hypothetical analytical values. The study also does not estimate development cost, interoperability challenges, training requirements, privacy implications, specialty-specific variation, or clinician resistance to interface changes. These factors may substantially affect real-world implementation.

A future empirical study should begin with usability and simulation testing before progressing to prospective clinical evaluation. Outcome assessment should include direct observation of handovers, predefined critical-information checklists, task-completion data, receiver comprehension, handover duration, usability, interruption frequency, and adverse-event indicators. Randomized or stepped-wedge designs may be appropriate where operationally feasible. Importantly, future evaluation should compare visualization-supported handover with a strong structured control condition rather than an artificially weak or unstandardized baseline, because existing evidence already supports the broader value of structured communication.

7. Conclusion

Clinical handover is a critical transition in which information, responsibility, and situational awareness must be transferred accurately despite time pressure, interruptions, clinical complexity, and limitations of human memory. Existing evidence supports structured approaches to handover and demonstrates that carefully implemented interventions can improve communication and patient-safety outcomes. However, standardization alone does not guarantee that clinicians can rapidly identify and retain the most important information within a complex patient record.

The present simulation proposes clinical handover visualization as a complementary strategy for reducing information loss. By organizing illness severity, major risks, abnormal trends, pending investigations, immediate tasks, contingency plans, and responsibility ownership within a persistent visual hierarchy, the system is designed to support both information transfer and subsequent action. Within the simulated dataset, visualization-supported handover produces higher critical-information transfer, stronger receiver retention, fewer omissions, clearer assignment of pending tasks, and greater conversion of information into documented action.

The small modeled difference in handover duration is also important. An effective clinical communication system should not achieve completeness by adding excessive procedural burden. The proposed approach instead attempts to make existing information easier to interpret and verify. Its potential value therefore lies not in displaying more data but in presenting the right data with sufficient hierarchy, persistence, and accountability to support clinical decision-making.

These findings remain hypothetical and should not be interpreted as evidence of clinical effectiveness. The next research step should involve human-factors testing followed by controlled clinical evaluation using real handover episodes and predefined patient-safety outcomes.

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