Diagnostic Safety Across Transitions of Care Throughout the Healthcare System: Current State and a Call to Action

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Diagnostic Safety Across Transitions of Care Throughout the Healthcare System: Current State and a Call to Action

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Introduction

Diagnostic error can be a blind spot in the patient safety field, according to the National Academy of Medicine.[1] An underrecognized and high-risk moment in patients' diagnostic journeys can occur at key intra- and perihospital transitions of care:

- From the emergency department (ED) to the ward,
- From the operating room (OR) to the postoperative area,
- From the intensive care unit (ICU) to the ward, and
- From the inpatient to the outpatient context (**Figure 1**).

Figure 1. Transitions of care with potential for diagnostic error
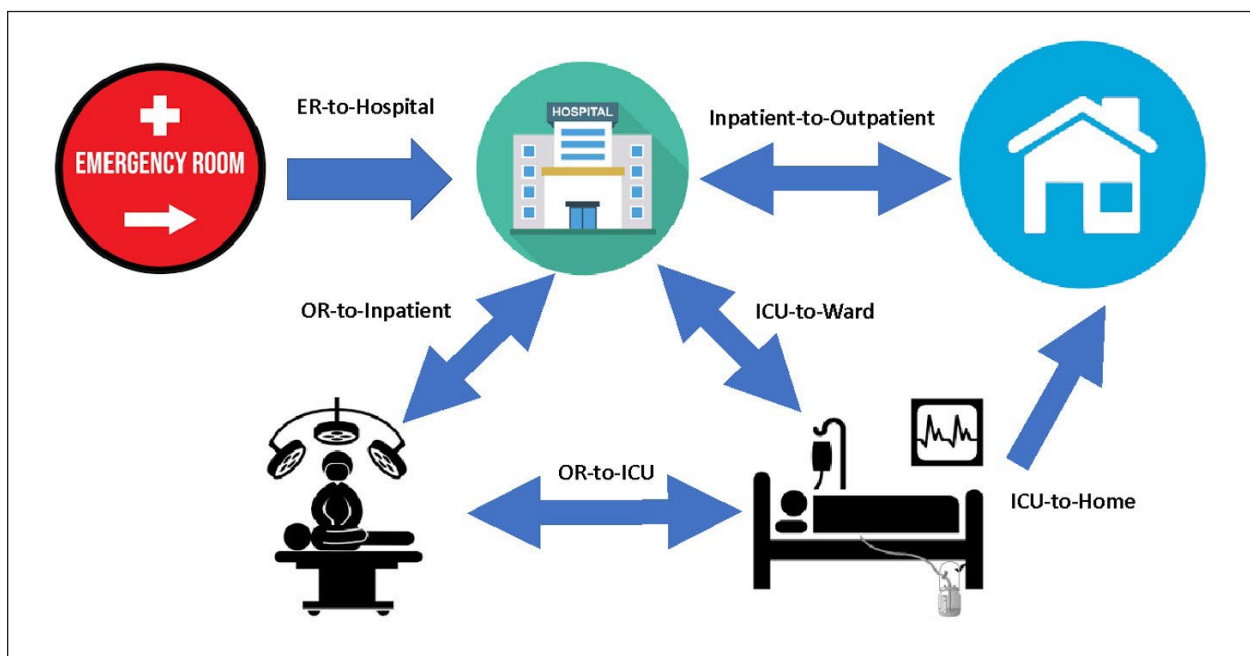
In healthcare and other industries, transitions of responsibility and handoffs are widely recognized as high-risk times when the potential for cognitive errors is high.[2] Not only do patients and families experience a transition of their multidisciplinary care team of physicians, nurses, and other providers, but also these providers may be at high risk for anchoring bias and other cognitive errors in these moments.

Each transition of care has certain underlying context-specific factors contributing to diagnostic errors. For instance, the high volume of encounters in the ED, the high acuity of encounters in the ED and ICU, and the changing of team members across contexts may each contribute to errors differently in these settings. Cognitive errors can include:

- Faulty hypothesis generation (such as failing to consider rare diseases or atypical presentations of common diseases),
- Faulty context formation (seeking rarer diagnoses),

- Faulty information gathering,
- Anchoring bias (the tendency to rely too much on the first piece of information received), and
- Faulty verification of hypotheses.

Moreover, transitions of care are high-risk times that often involve medical complexity and diagnostic uncertainty,[3] both of which must be explicitly managed by clinicians[4] and communicated to patients and families. In addition to cognitive errors of omission and commission, communication errors may follow similar patterns and are particularly relevant to diagnostic error.

Improving transitions of care has been well studied and prioritized at a national level. In fact, in 2013, the Joint Commission identified seven foundations critical for ensuring safe and effective transitions from one healthcare setting to another, including:

1. Leadership support,
2. Multidisciplinary collaboration,
3. Early identification of patients and clients at risk,
4. Transitional planning,
5. Medication management,
6. Patient and family action and engagement, and
7. Transfer of information.[5]

However, few strategies focus specifically on reducing diagnostic error during transitions of care.

To improve diagnostic safety at transitions of care, this issue brief examines the existing evidence base on how to improve diagnostic safety at intrahospital care transitions, from using data analysis tools to using structured communication frameworks. For each care transition, we will examine (1) context-specific contributors, (2) handoff or transition-specific contributors, and (3) recommended strategies to prevent and mitigate diagnostic errors and uncertainty.

ED-to-Hospital Transitions

Diagnostic uncertainty is common when patients are admitted from the ED to the hospital. Multiple studies have identified large discrepancies between patients' presenting symptoms and final diagnoses, between admission and discharge diagnoses, and between clinical diagnoses and autopsy findings among patients admitted through the ED.[6–8] The extent to which these discrepancies represent true diagnostic errors is less clear in the emergency setting than in other hospital settings.

The available measures in the ED (e.g., preliminary diagnoses) do not quantify uncertainty that may be clinically acknowledged. They also do not recognize the imperative for emergency care to focus on clinical stabilization and triage as much as, if not more so, than diagnostic specificity. Conceptually, then, diagnostic uncertainty at ED-to-hospital transitions may be inherent to emergency care or may relate to factors connected with the ED itself, the ED-to-hospital transfer communication, the receiving hospital clinicians, or some combination thereof. This section will review each of these in turn.

ED-Specific Contributors to Diagnostic Challenges and to Diagnostic Errors and Uncertainty

EDs are among the most common settings in which diagnostic error may occur,[9–13] for many reasons, including encounter brevity, high patient acuity and volumes, staffing issues, and undifferentiated presentations with fewer available data points.[14–16] These challenges produce second-order issues that further complicate the diagnostic process. Such issues include narrative uncertainty (i.e., unclear patient history) from patients who are incapacitated, experiencing impaired mentation or cognition, or lacking relevant cognitive (e.g., medication lists) or sensory aids.[17]

Further confounding the diagnostic processes are nonlinear emergency care pathways (e.g., departing the ED for imaging or procedures) and the frequent task switching in which clinicians must engage to process these dynamic streams of information.[12,18] Finally, some diagnostic investigations may have outstanding results at the time of admission, while others may have yielded "incidentalomas" of unclear urgency or importance; each possibility augments the potential for uncertainty and error.[12] Unsurprisingly, then, diagnostic errors in the ED are generally considered multifactorial.[19]

In addition to being common, diagnostic errors and uncertainty at the time of ED-hospital admission are high risk: approximately 3 in 20 occur in patients who ultimately experience severe harm or death,[20] for several reasons.[21] First, diagnostic error recognition in the ED is especially difficult: no clear standards for delays have been defined, and clinician perceptions of delays may differ from those of patients and families.[15] Furthermore, complexity and acuity correlate with both uncertainty and risk. Thus, those patients ill enough to require hospitalization and to have worse outcomes are also most likely to experience diagnostic uncertainty.

Second, and relatedly, early diagnostic errors can propagate other types of medical errors such as admission decisions (e.g., triage to an inappropriate level of care) or inappropriate medication choices. Finally, admission occurs early in a patient's hospital course, when patients may be medically unstable or undifferentiated and therefore most vulnerable to cascading errors.[12,15]

ED-to-Ward Handoff-Specific Contributors to Diagnostic Errors and Uncertainty

Because of these issues and because the language and goals of emergency care (i.e., triage and safe disposition) often differ from clinical goals in other settings (e.g., diagnostic accuracy), ED clinicians may have different cognitive and clinical reasoning processes than other clinicians.[16,22] Specifically, while hypothetico-deductive cognitive models are predominant in many clinical settings, Kovacs and Croskerry describe how ED clinicians often appropriately rely on other models. They use hypothesis elimination (i.e., ruling out high-risk "can't miss," or "worst case" diagnoses) rather than hypothesis verification (i.e., Bayesian "ruling in" of the most likely diagnosis) for most diagnostic decisions.[16]

A key implication of this difference is that at hospital admission, these clinicians may have different expectations regarding diagnostic certainty than their handoff receivers.[12,23] For example, ED clinicians might feel comfortable—and diagnostically "certain" that immediately life-threatening pathologies are absent—admitting a patient with acute abdominal pain after "ruling out" perforated viscus and ruptured aortic aneurysm.[16]

In contrast, an admitting hospitalist might ideally view such a patient as undifferentiated and thus having a large degree of diagnostic uncertainty. However, common phenomena such as diagnostic momentum and anchoring bias could instead yield diagnostic error if, for example, the hospitalist were to interpret ED "certainty" as synonymous with a final diagnosis (such as considering an acute abdomen fully "ruled out").[24] Poor communication, both about the diagnostic process and these overall expectations, may yield diagnostic uncertainty, error, and conflict, which can again perpetuate diagnostic error.[22,25,26]

Receiving Hospital Contributors to Diagnostic Error and Uncertainty

Receiver-specific issues may also influence diagnostic error and uncertainty. As above, diagnostic momentum, anchoring bias, and early closure can result from poor handoff communication, lack of shared mental models, and lack of shared understanding between handoff senders and receivers. Handoff receivers may perpetuate these challenges through passive communication,[27] including not asking questions to clarify or check understanding, not seeking help from consultants or other clinicians, and not challenging unclear or potentially incorrect diagnoses when recognized.[26]

Strategies To Mitigate Diagnostic Errors and Uncertainty at ED-Hospital Transitions

Each of these factors might be targeted for preventing or mitigating diagnostic errors and uncertainty at the ED-hospital interface. In the ED and inpatient settings, computational approaches such as machine learning and natural language processing might in the future be able to analyze written notes and identify potential diagnostic uncertainty.[28] Automation and standardization may also add clarity to diagnostic test ordering and interpretation (e.g., standard content and formatting of imaging results).[29]

Diagnostic feedback to clinicians, such as through autopsies, both standardized and ad hoc, is important for individual diagnostic calibration.[15] For example, to promote clinician feedback and reflective practice on diagnostic performance, AHRQ developed the Calibrate Dx resource to help clinicians evaluate and calibrate their own diagnostic performance.[30] ED and inpatient clinicians and trainees can use this resource to reflect on recently discharged or admitted patients. Both emergency and inpatient settings may also benefit from universal availability of timely expert consultation,[15] including radiology double-reads.[20]

Although these setting-specific interventions may decrease diagnostic uncertainty and errors, these challenges will not be completely resolved without improved communication around diagnostic uncertainty at patient handoffs. Expert consensus recommends that ED-hospital admission handoffs explicitly mention the certainty of the provisional/working diagnosis,[12,22] and recent literature indicates that hospital-based clinicians want better skills with which to communicate uncertainty.[31,32] Educational products, such as the uncertainty communication checklist, may be useful in teaching these skills.[31]

Importantly, despite the theoretical benefits of explicitly calling out uncertainty (less diagnostic anchoring, more appropriate and targeted diagnostic testing, and potentially fewer diagnostic delays and errors), patients may perceive clinicians who discuss diagnostic uncertainty as less confident and competent than those who do not.[33–35] Thus, thoughtful communication strategies should be used in these situations.

In 2012, Beach, et. al., published best practice recommendations for ED-to-inpatient handoff communication, including style, form, and content.[22] These authors suggest synchronous, two-way, closed-

loop communication, with the goal of constructing a shared mental model of patient care between ED and admitting clinicians. These recommendations are consistent with best practices from other handoff contexts,[36–42] including a focus on clinical judgment and the patient's clinical trajectory, diagnostic uncertainty, and outstanding tasks.[22]

However, although synchronous, two-way, closed-loop bedside communication is often considered the preferred gold standard, asynchronous ED-hospital handoffs remain common.[26,43–47] Interestingly, in one before and after study, asynchronous voicemail-based signout did not change patient outcomes such as intensive care unit (ICU) transfers or perceived adverse events; this study did not measure diagnostic errors or uncertainty in either period.[48]

Structured handoff tools have been studied at the ED-hospital interface. Notable examples include DE-PASS:

- Decisive reason for admission,
- Evaluation time,
- Patient summary,
- Acute issues/action list,
- Situation awareness, and
- Signed out to whom.

This tool was associated with improved clinician satisfaction and statistically fewer ICU transfers from the wards in a pre-post study at a tertiary cancer center.[49] While the DE-PASS study did not measure diagnostic errors or quantify uncertainty, the similarly designed SBAR-DR tool includes the presence of both a working diagnosis and the certainty around it.[50] (SBAR-DR stands for Situation, Background, Assessment, Responsibilities/Risk, Discussion/ Disposition, Readback/Record.) SBAR-DR was perceived positively by clinicians and yielded improved handoff quality after implementation but did not lessen perceived diagnostic uncertainty.

Research on diagnostic uncertainty and error at the ED-hospital interface should move forward in two parallel tracks. First, standardized approaches for handoff communication based on existing tools (e.g., DE-PASS, SBAR-DR) or newly developed tools can be implemented and evaluated now to improve the transfer of information when patients are admitted from the ED to the hospital. Methods from design, human factors, and implementation science can inform the tailoring of these interventions and the assessment of communication quality.[51,52]

Second, improved operational measurements of diagnostic error and diagnostic uncertainty are needed in order to research these concepts more effectively at the ED-hospital interface. Promising approaches toward this end (e.g., Symptom-Disease Pair Analysis of Diagnostic Error)[53] must be accompanied by methods to quantify uncertainty and to contextualize existing outcome measures with counterfactual information when possible.[54] Future work might use these measures to examine the extent to which diagnostic errors can be further reduced.

In conclusion, the ED-to-hospital transition is a high-risk time for diagnostic errors. Specific communication strategies focusing on explicitly acknowledging diagnostic uncertainty and creating shared mental models can help debias receiving clinicians, promote broader differential diagnoses, and prevent premature closure.

ICU-to-Ward Transitions

Similar to the ED-to-inpatient transition, patients transferred from the ICU to the general ward face numerous obstacles, placing them at significant risk for diagnostic error. At this transition, patients with complex life-threatening problems transition from the care of a critical care medicine physician to a medical, surgical, or primary care physician. Furthermore, determining who is ready for ICU discharge is a daily cognitive challenge for critical care physicians. Standardized ICU discharge criteria are lacking, and the transition to a lower resourced setting with multiple clinician handoffs makes patients vulnerable to harm.[55–57] Across academic medical centers, one survey[57] showed that 87 percent of residents recalled at least one adverse event specifically related to communication failures in the ICU-to-ward transition.

ICU-Specific Contributors to Diagnostic Errors and Uncertainty

Due to the high complexity and acuity of patients, the ICU is a busy and distracting setting for both seasoned clinicians and learners alike.[58] Despite the large volumes of physiologic data frequently available, the ICU context highlights the marked role of uncertainty in the diagnostic process.[59]

Dunlop and Schwartzstein suggest that the ICU context should be one where diagnostic uncertainty is clinically accepted and explicitly recognized, thereby countering some of the most common cognitive biases, such as anchoring, premature closure, and availability bias. The authors note that frontline ICU clinicians need a shared mental model to define what clinical uncertainty truly means.[59]

Just as in the ED, ICU clinicians grapple with high patient acuity, frequent task switching while processing large volumes of dynamic clinical information, and both cognitive failures and system-based failures, all of which can lead to diagnostic errors.[60] Although substantial efforts have focused on improving communication during end-of-shift and end-of-service handoffs,[61,62] the ICU-to-ward transition of care has been less studied.

ICU-to-Ward Handoff-Specific Contributors to Diagnostic Errors and Uncertainty

When transitioning from the ICU to the ward, the most critically ill patients in the hospital are often moved to a new care team from a resource-intensive environment to a less resource-intensive environment. Not surprisingly, at least 20 percent of patients discharged from the ICU experience an adverse event, with more than one-third of these adverse events deemed preventable.[63] These adverse events are associated with ICU readmission, increased length of stay, and death but are not accurately predicted by ICU or ward physicians.[63,64]

Ineffective verbal and written handoffs have been estimated to lead to approximately 10 percent of adverse events in the ICU.[65] However, few evidence-based approaches are available to structure written or verbal handoffs in the transition from the ICU to the ward despite it being a high-risk transition of care.

Santhosh, et al., conducted a study at three academic medical centers to evaluate the structure, perceptions, and processes of ICU-ward transfers.[11,57] The authors found that despite significant process variation across sites, almost all resident physicians recalled an adverse event related to the ICU-ward handoff, and most of these adverse events were rooted in communication issues.[57,66]

In addition to communication between providers at the ICU-to-ward transition, communication between patients and providers is also an important facilitator for a successful ICU discharge.[67] Patients and families valued summaries about the patient's stay in the ICU and information about the transfer to the ward.[67,68] Patients and families also appreciated being actively engaged in the decision making regarding whether the patient was ready to transfer out of the ICU.[67] Plotnikoff, et al., found that patients and families felt that consistent communication from the healthcare team helped facilitate a successful transition from an ICU to a hospital ward.[69]

Strategies To Mitigate Diagnostic Errors and Uncertainty at ICU-to-Ward Transitions

Stelfox, et al., conducted a scoping review to systematically review the literature reporting patient discharge from ICUs, identify facilitators and barriers to high-quality care, and describe tools developed to improve care.[68] They found that ICU discharge is complex and a single universal tool is probably insufficient to address the challenges. However, the literature notes numerous elements to inform an ICU discharge strategy, including:

- Structures to facilitate patient discharge,

- Education programs to train providers,

- Risk stratification models to evaluate readiness for ICU discharge,

- Patient and family involvement in the ICU handoff process,

- Communication with the receiving team,

- Detailed medication reconciliation, and

- Deliberate tracking of postdischarge outcomes.

Plotnikoff, et al., found that the most common facilitator for a successful ICU discharge was the explicit education of patients and families regarding this process.[69]

While many ICU-to-ward transition tools focus on clinical criteria such as ICU readmissions, few focus explicitly on preventing diagnostic error. The ICU-PAUSE is one such tool that explicitly embeds a diagnostic pause with an acknowledgment and ranking of diagnostic uncertainty when clinicians communicate about a patient transitioning from the ICU to a ward.[70,71]

Further research should examine how diagnostic errors can be reduced with more widespread and standardized implementation of structured communication tools such as ICU-PAUSE. Once again, tools such as Calibrate Dx could also be useful for both individual clinicians and health systems alike to evaluate and calibrate diagnostic performance at the time of transitions of care.[30]

In conclusion, the ICU-to-ward transition is a high-risk time for diagnostic errors. Specific strategies such as educating providers and family on readiness for ICU discharge, explicitly embedding diagnostic pauses, and measuring postdischarge diagnostic outcomes can mitigate diagnostic error at this transition.

OR-to-ICU Transitions

OR-to-ICU Handoff-Specific Contributors to Diagnostic Errors and Uncertainty

The transition from the OR to the ICU involves coordinating teams from multiple disciplines in the movement and management of critically ill patients and complex equipment. This transition is prone to technical and diagnostic error due to not only the high patient acuity and time pressure common across many care transitions, but also the competing prioritization of information among team members from different disciplines, including anesthesia, surgery, and critical care.[72] Communication failures during perioperative care transitions are well recognized to contribute to medical error,[73,74] including loss of important patient information, exposure to unnecessary interventions, and preventable harm.[62]

During the OR-to-ICU handoff, time pressure inherent in a critical care setting can shift individual clinician decision-making processes toward naturalistic decision making over deliberative thought.[75,76] This type of thinking is more prone to cognitive bias and increases the likelihood of diagnostic error.

Studies examining the incidence of cognitive bias among surgeons[10,77] and anesthesiologists,[78] key participants in the OR to ICU handoff, have identified several common biases, including:

- Anchoring,
- Confirmation,
- Omission,
- Commission,
- Premature closure, and
- Framing effect (whether the option is presented as a loss or a gain).

These studies also aimed to quantify the number of cases affected by common cognitive biases, ranging from 32.7 percent of all cases[77] to more than half of emergencies.[78] These cognitive biases contribute to diagnostic error, which in turn has real consequences for patients, including death. One study by Antonacci, et al., found that death after surgery related to communication, system, diagnostic, and judgment error— all errors in which these cognitive biases are implicated—was significantly higher than death related to technical error.[79]

Strategies To Mitigate Diagnostic Errors and Uncertainty at OR-to-ICU Transitions

A large body of evidence shows the benefits of standardizing the perioperative handoff process for patient outcomes, information exchange, and medical error.[73,75,80,81] In a systematic review and meta-analysis, Abraham, et al., identified 32 studies since 2007, the majority of which were published after 2010, that examined the impact of OR-to-ICU handoff interventions.[80] Most interventions studied were process-based protocols and communication checklists to support information processing and social interactions. These interventions resulted in fewer information omissions and errors, but the statistical quality of many of the studies was low.

Systematic reviews examining the OR-to-ICU handoff intervention literature among subsets of surgical populations, such as cardiothoracic surgery,[73] have reported similar findings. Most studies have been small, single center, and focused on the effectiveness of a handoff intervention rather than sustainability.

Lane-Fall, et al., have done extensive work examining both the effectiveness of a standardized OR-to-ICU handoff as well as strategies for implementation. In their initial study, Handoffs and Transitions in Critical Care (HATRICC),[82] they examined the implementation of a handoff protocol using an information template in two mixed ICUs, with the primary outcome of information omissions. Standardization of the handoff practice was associated with decreased information omissions, but no change was found for ICU mortality or length of stay. The study did not explicitly look at medical error.

Subsequent work by Lane-Fall, et al., expands on these findings in an ongoing larger hybrid effectiveness-implementation trial in 12 ICUs across 5 academic medical centers (HATRICC-US).[75] This is the only large multicenter prospective study to date examining the implementation and effectiveness of a standardized OR-to-ICU handoff process. The primary implementation outcome of this study will be fidelity to the handoff protocol and the primary effectiveness outcome will be a composite measure of new-onset multiorgan failure. Secondary outcomes will include information omissions and adverse events.

The ongoing HATRICC-US study aims to address many of the gaps in existing literature regarding the OR-to-ICU handoff process, although several remain. Within this growing body of literature, established consensus is limited regarding the most effective way to standardize the OR-to-ICU information exchange and the content that is most important to include in a structured handoff tool.[83] Ascertaining which elements to include in a handoff tool is vital to preventing cognitive overload, reducing the risk of communication failure,[83] and mitigating diagnostic error.

Many of the proposed tools prioritize specific operative details over anticipatory guidance and tend to focus on important details such as blood products given, allergy list, and neuromuscular blockade given. However, they sometimes have less information synthesizing the patient's clinical course to date, proposed diagnosis, or anticipated clinical trajectory.

Most tools were developed by experts and adapted to suit the institution in which the handoff process was studied. No studies used a design method that explicitly focused on the mitigation of cognitive bias. Further work should focus on the development and standardization of handoff tools designed to address the specific cognitive biases that lead to diagnostic error.

Another area in need of more study is how to sustain implementation of an OR-to-ICU handoff tool. Critical care settings are underrepresented in implementation science literature,[84] due in part to time pressure inherent in caring for critically ill patients.75 Yet it is that time pressure that makes a sustainable and standardized handoff tool even more necessary.

Zjwadecz, et al., found that only 23 percent of reviewed articles mentioned sustainability of an OR-to-ICU handoff intervention and none mentioned such interventions in the context of outcome measures.[85] In practice, uptake of these handoff strategies is limited and no studies besides the HATRICC-US trial have examined how to sustain implementation on a large scale. Hopefully, the ongoing HATRICC-US trial will provide some insight into effective protocols for and barriers to implementation and will establish the groundwork for future implementation efforts in different settings (community, specialty ICU).

It is challenging to explicitly evaluate diagnostic error as an outcome in the postoperative period: for example, was the patient's postoperative shock hemorrhagic due to high estimated blood loss, or was it actually cardiogenic due to aggressive fluid and blood product resuscitation? Although medical error and information omission are common outcomes in many studies, none isolate the effect of handoff standardization on diagnostic error in the postoperative period.

To prevent a patient from deteriorating after surgery, one must have accurate and complete information to reduce the risk of diagnostic error during rapid clinical change. The transmission of this information occurs during the OR-to-ICU handoff. Thus, an evaluation of diagnostic safety is inherent within the composite outcome measure of new-onset multiorgan failure proposed by HATRICC-US, although it is difficult to isolate.

Further research could be directed at understanding the best way to evaluate diagnostic safety during the OR-to-ICU transition. This research could more explicitly explore how the HATRICC bundle could be used to reduce diagnostic errors. In establishing a standardized outcome measure, the evaluation and comparison of the effect of different handoff tools and protocols on diagnostic error will become more meaningful.

In conclusion, the OR-to-ICU transition is inherently high risk, and the growing body of evidence on this topic highlights the need for sustained implementation of standardized handoff tools to mitigate the impact of cognitive biases and reduce the risk of diagnostic error in the OR-to-ICU transition.

Inpatient-to-Outpatient Transitions

The hospital discharge, when patients transition from the inpatient to outpatient setting, is perhaps the setting where diagnostic error and diagnostic uncertainty have been most well recognized and well studied. In one study, 49 percent of patients experienced at least one medical error after discharge, related to a variety of causes, including medication, test results, and diagnostic workups.[86]

Medical students are taught from their early clinical foundation the importance of preparing for a high-quality and safe discharge to prevent readmissions, medication-related adverse events, and diagnostic error. The Joint Commission recognizes and codifies that discharge summaries are a required part of the medical record and must be completed within 30 days of discharge.[87] Interventions related to measuring and preventing postdischarge error have largely focused on communication and coordination of care.[88] This section will review inpatient-to-outpatient handoff-specific contributors to diagnostic errors and uncertainty and discuss strategies to mitigate diagnostic errors and uncertainty.

Inpatient-to-Outpatient Handoff-Specific Contributors to Diagnostic Errors and Uncertainty

Patients transitioning from the inpatient to the outpatient setting are also vulnerable to diagnostic error as the discharging teams' provisional or working diagnoses may evolve posthospitalization. Moreover, patients and families often have limited engagement in the decision to discharge. Communication between inpatient and outpatient providers is quite limited and often only consists of the written discharge summary. Lastly, discharge summaries are often unavailable, not timely, too brief or too long, unstandardized, or not informative enough, especially after high-acuity complex inpatient hospitalizations.

Deficits occur in both communication and information transfer at the inpatient-to-outpatient transition, with available discharge summaries often omitting critical information, such as diagnostic test results, test results pending at discharge, and discharge medications.[89] During ICU stays, when patients experience multiple care transitions described above (both ICU-to-ward and inpatient-to-outpatient), the potential for diagnostic error can be further magnified, and the standardized discharge summaries can be especially inadequate.[90]

Although the literature on the inpatient-to-outpatient transition in general is robust, the literature specifically focusing on diagnostic error at this transition is much more limited. One prospective cohort study of

unplanned 7-day and 30-day hospital readmissions found that diagnostic error may have contributed to 10.6 percent of 7-day readmissions in this high-risk cohort.[91]

One retrospective cohort study of unplanned 7-day readmissions specifically used a two-physician diagnostic error review and adjudication process to categorize diagnostic error. The incidence of diagnostic error was 5.6 percent, with the most common errors related to radiology/laboratory testing and clinicians' diagnostic reasoning.[92] The most common contributing factors to clinical reasoning errors were failure or delay in ordering needed diagnostic tests, erroneous interpretation of tests, and inappropriate consideration or prioritization of diagnoses.

Strategies To Mitigate Diagnostic Errors and Uncertainty at Inpatient-to-Outpatient Transitions

The inpatient-to-outpatient transition has been the most studied, and a variety of structured improvements have been made to standardize this process, including a focus on diagnostic error. Most of these interventions focus on improved discharge processes and documentation, improved verbal handoffs and including patients and families in the process, and improved awareness and education about diagnostic errors.

Several interventions have focused on standardizing and improving the complexities of the discharge process. AHRQ developed an evidence-based resource to improve the safety of the inpatient-to-outpatient transition and engage patients and families in discharge planning through a novel IDEAL Discharge Planning strategy.[93] This systematic framework focuses on:

- **I**ncluding patients and families as full partners in discharge planning,

- **D**iscussing with patients and families key areas to prevent problems at home,

- **E**ducating patients and families about the patient's condition and the discharge process,

- **A**ssessing how well doctors and nurses explain the diagnosis using teach-back, and

- **L**istening to and honoring the patient and family's goals and preferences.

These strategies empower the patient and family's involvement in the diagnostic journey as well as the discharge process, thus engaging patients and families as partners throughout.

Similarly, the Warm Handoff Plus tool is a patient safety strategy that ensures that patients and family are present for a warm face-to-face verbal handoff between two members of the healthcare team.[94] It was originally designed to be conducted within the primary care practice but could also be applied at the inpatient-to-outpatient transition if applicable.

Unfortunately, a warm handoff is rarely possible between the inpatient and outpatient contexts, and written discharge summaries are often the only communication that occurs between inpatient and outpatient teams. Thus, improving and standardizing discharge summaries is an essential component of mitigating diagnostic error at the inpatient-to-outpatient transition.

In 2007, the Transitions of Care Consensus Conference recommended adoption of standardized discharge summary elements with specific factors included such as patients' goals of care and clear delineation of responsibilities for outpatient postdischarge patient care-related tasks.[95] Followup efforts have focused on designing and implementing enhanced discharge summary templates to focus on reducing redundant documentation and promoting clinician satisfaction.[96]

Various studies have shown that electronic discharge summary templates and other electronic tools were associated with improved timeliness of communication with outpatient physicians and improved communication of potential diagnostic errors, such as discussing test results pending at discharge.[97–100]

While many interventions focus on improving the discharge process and communication related to discharge, other interventions, which could be used in any healthcare setting, focus on educating clinicians about diagnostic error. A systematic review of cognitive interventions to reduce diagnostic error across healthcare settings found that different modalities all helped reduce cognitive errors in diagnosis. However, most interventions were not tested directly for error reduction in clinical practice. Interventions included simulation-based training, improved feedback and education, reflective practice, metacognitive review, and use of cognitive aids.[101]

One example of a real-life ambulatory cognitive intervention was the institution of a diagnostic pause in the ambulatory care setting, which was found to influence clinicians to modify initial working diagnoses without adding significant extra time burden.[102] The inpatient-to-outpatient care transition is another opportunity to use tools such as Calibrate Dx for both individual clinicians and health systems to evaluate and calibrate diagnostic performance.

In conclusion, while the inpatient-to-outpatient transition poses challenges when it comes to diagnostic error, structured tools have been developed to standardize communication, improve patient and family engagement, and improve education about diagnostic error at this key transition.

Next Steps and a Call to Action

Transitions of care represent a vulnerable moment for patients and families with high potential for diagnostic error, regardless of the care contexts between which the transition occurs. Although handoffs between shifts have been largely recognized as vulnerable moments for patient care, transitions between other contexts have not been as readily recognized as having such high potential for diagnostic error.

Each unique context carries its own risks for diagnostic error. **Table 1** highlights and summarizes specific strategies that can help mitigate diagnostic error at each transition.

Table 1. Care transitions, sources of error, and potential mitigating strategies

Care Transition	Latent Failures Contributing to Error	Potential Mitigating Strategies
ED to hospital	Encounter brevity	Standardization of processes
	High patient acuity	Artificial intelligence/machine learning (AI/ML) prediction tools
	High patient volumes	Availability of timely expert consultation
	Diagnostic uncertainty	Explicitly mentioning diagnostic uncertainty
	Nonlinear care pathways	Uncertainty communication checklists
	Lack of shared mental model	Standardized communication tools
ICU to ward	High patient acuity	Standardization of processes
	High patient complexity	AI/ML prediction tools
	Diagnostic uncertainty	Patient and family involvement
	Lack of structured handoffs	Standardized communication tools
	Lack of family engagement	Explicitly mentioning diagnostic uncertainty
OR to ICU	Encounter brevity	Standardization of processes
	High patient acuity	Standardized communication tools
	Lack of shared mental model	Standardized communication tools
	Coordination between multiple specialties	Standardized communication tools
Inpatient to outpatient	Evolving diagnoses	Standardization of processes
	Lack of shared mental model	Standardized communication tools
	Lack of structured handoffs	Patient and family involvement
	Inadequate or incomplete documentation	Education about diagnostic error
	Multiple care transitions	Personal and system diagnostic calibration

Although each transition has had some research focusing on improving the transition of care between contexts, the explicit goal of reducing diagnostic error has not been studied. Tools such as Calibrate Dx must be applied to help both individual clinicians and larger health systems evaluate and calibrate their own diagnostic performance. Moreover, interventions focused on mitigating diagnostic error at each transition have largely not scaled up implementation across multiple institutions nationally. Research is needed to more explicitly study the impact of these interventions on diagnostic error and to scale up and nationally implement effective tools to mitigate diagnostic error.

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