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The Silent Epidemic of Iatrogenic Harm: A Review of Systemic Vulnerabilities Across the Medication and Medical Imaging Chain

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Abstract

Background: Iatrogenic harm, originating from healthcare processes themselves, constitutes a pervasive and often silent epidemic. Medication and diagnostic imaging errors represent two major, frequently siloed categories of preventable patient harm, embedded within complex, interdependent clinical systems. A systems safety perspective is essential to understand their interconnected nature.

Aim: This narrative review aims to synthesize evidence on the systemic vulnerabilities linking medication and medical imaging safety chains. It examines points of failure across professions—Pharmacy, Nursing, Diagnostic Radiology, Laboratory, Medical Devices Technology, Medical Secretaries, and Hospital Administration—to identify shared root causes and integrated solutions.

Methods: A comprehensive search of PubMed, CINAHL, Scopus, and Web of Science (2010-2024) was conducted using keywords related to medication errors, diagnostic errors, systems safety, and interprofessional collaboration. Literature was analyzed thematically to map the error pathways and systemic interdependencies.

Results: The review identifies recurrent, cross-cutting vulnerabilities: flawed communication handoffs, human-device interfaces prone to misuse, conflicting administrative priorities, and inadequate interprofessional checkpoints. Errors in one domain (e.g., a radiology contrast protocol) directly propagate to another (e.g., pharmacy-dispensed pre-medication). Latent system failures often precede active errors by frontline staff.

Conclusion: Medication and imaging safety are inextricably linked. Mitigating harm requires transcending professional silos through integrated, system-wide protocols that address shared root causes, foster a culture of collective accountability, and redesign workflows with inherent safety.

Keywords: Iatrogenic Harm, Systems Safety, Medication Errors, Diagnostic Errors, Interprofessional Collaboration

Introduction

Modern healthcare delivers remarkable therapeutic and diagnostic capabilities, yet within its intricate systems lies a persistent and damaging counterpoint: iatrogenic harm, the injury or illness inadvertently caused by medical care. Termed a "silent epidemic," its full scope is often obscured by underreporting, fragmentation, and a historical focus on individual blame rather than system flaws (Panagioti et al., 2019). Two of the most significant and costly manifestations of this epidemic are medication errors and diagnostic imaging errors. Medication errors, spanning prescribing, transcribing, dispensing, and administration, are a leading cause of patient morbidity, with landmark studies indicating they affect nearly 5% of hospital admissions (Assiri et al., 2018; Marznaki et al., 2023). Concurrently, errors in the diagnostic imaging chain—encompassing incorrect test selection, misinterpretation, miscommunication of results, or procedural complications—contribute substantially to diagnostic delay and misdiagnosis, implicated in an estimated 40-

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80,000 annual deaths in the United States alone (Newman-Toker et al., 2021).

Traditionally, these error domains have been managed within professional silos: pharmacy and nursing committees address medication safety, while radiology quality assurance programs focus on imaging. This fragmented approach is fundamentally misaligned with reality, where patient pathways weave seamlessly across these boundaries. A systems safety approach, pioneered in high-reliability industries like aviation, posits that errors are seldom the result of individual recklessness but rather the predictable outcome of latent conditions within the system—poor design, inadequate equipment, unrealistic workloads, or flawed communication protocols (Reason, 2016). Applying this lens reveals that the medication and imaging safety chains are not parallel tracks but a deeply interconnected network, where a failure in one node can catastrophically propagate to another.

This narrative review, therefore, aims to dissect these systemic interdependencies. It moves beyond cataloging errors within professions to examine the vulnerable interfaces between them: how a medical secretary's transcription task, a device technologist's calibration check, a radiologist's protocol choice, a pharmacist's verification, a nurse's administration act, and an administrator's resource allocation collectively create—or prevent—paths to patient harm. By synthesizing evidence from 2010-2024, this review will map the shared vulnerabilities and propose integrated defense strategies that acknowledge healthcare as a complex socio-technical system, where safety is a collective property emerging from the interaction of all its parts.

Methodology

A search strategy was employed to identify relevant literature published between January 2010 and December 2024. Electronic databases searched included PubMed, CINAHL, Scopus, and Web of Science. The search strategy utilized a combination of keywords and MeSH terms within three conceptual clusters: (1) Error Types: ("medication errors" OR "drug-related side effects and adverse reactions" OR "diagnostic errors" OR "radiology errors" OR "contrast media adverse reactions"); (2) Systems Focus: ("systems theory" OR "root cause analysis" OR "human factors engineering" OR "safety management" OR "high reliability organization"); and (3) Professional Roles: ("interprofessional relations" OR "pharmacists" OR "radiology technologists" OR "nursing" OR "clinical laboratory personnel" OR "health information management" OR "healthcare administration"). Boolean operators (AND, OR) were used to combine clusters.

Inclusion criteria encompassed peer-reviewed empirical studies (qualitative, quantitative, mixed-methods), systematic and narrative reviews, case reports analyzing systemic causes, and theoretical commentaries published in English. Studies focusing solely on individual blame, those without a clear systems analysis, or those about non-acute or non-hospital settings without generalizable insights were excluded. Data were charted and synthesized to identify recurrent themes across the medication and imaging chains, with a particular focus on interprofessional interfaces and latent organizational factors.

The Intertwined Chains

The journey of a medication and the journey of a diagnostic image are, at first glance, distinct. However, a patient-centered process map reveals critical convergence points where system failures can amplify. The medication chain involves prescribing, order communication/transcription, pharmacy review and dispensing, storage, and finally administration and monitoring (Kuitunen et al., 2021). The imaging chain involves test indication and selection, scheduling and preparation, patient identification and procedure performance, image acquisition and processing, interpretation and reporting, and result communication and integration (Bruno et al., 2015). These chains intersect powerfully at several junctures.

The most direct intersection is pharmaco-imaging, where medications are integral to the imaging process. This includes the safe use of radiocontrast agents, sedatives for pediatric or anxious patients, beta-blockers for cardiac imaging, and antispasmodics for gastrointestinal studies. An error in prescribing, dispensing, or administering these adjunct medications can lead to a failed study, an adverse reaction, or a misinterpretation due to suboptimal patient preparation (Orlacchio et al., 2022). For instance, a pharmacy dispensing the wrong concentration of a sedative (a medication error) can lead to a respiratory event during an MRI scan, necessitating emergency intervention and aborting the diagnostic procedure (an imaging pathway failure).

Beyond pharmaco-imaging, the chains share common systemic "pinch points." Communication handoffs are ubiquitous: a physician's hand-written or verbal imaging order must be accurately transcribed by a medical secretary, entered into an information system, and understood by nursing for patient preparation. Ambiguity here—such as an unclear indication or missing allergy information—can lead to the wrong test, wrong protocol, or unprepared patient (Pierre et al., 2023). Patient identification is another shared, high-risk step. A misidentification event can result in a patient receiving another's medication *and* undergoing an unnecessary or contraindicated imaging study, compounding the harm exponentially (Härkänen et al., 2021). These overlapping nodes create a network where a single latent failure, like a poorly designed order entry screen, can generate error opportunities in both chains simultaneously (Table 1).

Table 1: Points of Intersection and Vulnerability Between Medication and Imaging Safety Chains

Intersection Point	Potential Failure Mode (Medication Chain)	Potential Failure Mode (Imaging Chain)	Resulting Systemic Harm
Patient Preparation	Incorrect pre-medication (dose, drug, timing) was dispensed/administered.	Patient not properly prepared (NPO, bowel prep, lab values), leading to a non-diagnostic study or cancellation.	Diagnostic delay, resource waste, patient discomfort, and potential for procedure-related complications.
Contrast Media Administration	Allergy not checked; pre-medication for allergy not given; renal dosing guidelines ignored.	Incorrect contrast protocol selected; extravasation during injection; acute kidney injury.	Life-threatening allergic reaction, contrast-induced nephropathy, tissue injury, and suboptimal imaging.
Procedural Sedation/Analgesia	Wrong drug/dose prepared; drug interaction overlooked; monitoring inadequate.	Procedure delayed or aborted due to over/under-sedation; respiratory compromise during scan.	Respiratory arrest, failed procedure, increased length of stay in recovery.
Order Communication/Transcription	An ambiguous medication order was transcribed incorrectly by the secretary or nurse.	Ambiguous imaging request leads to wrong body part, wrong protocol, or wrong test entirely.	Wrong drug administered AND wrong test performed (double error from one source).
Patient Identification	The wrong patient's medication profile was accessed.	The wrong patient's imaging order was scheduled/performed.	Patient receives wrong drug and undergoes unnecessary/contraindicated imaging.

Latent Conditions and Active Failures

James Reason's Swiss Cheese Model illustrates how harm occurs when the holes in multiple layers of defense momentarily align (Reason, 2016). In our intertwined chains, the "cheese slices" represent the defensive layers contributed by different professions. Latent conditions are the resident pathogens within the system that create these holes.

Communication & Information Transfer

The transfer of critical information is a primary vulnerability. Medical secretaries, tasked with order entry and scheduling, operate under time pressure with potentially ambiguous source data. Studies show that unstructured verbal or handwritten orders significantly increase transcription error rates for both medications and imaging tests (Mijwil et al., 2023). Furthermore, critical information like patient allergies, renal function, or pregnancy status often resides in disparate parts of the electronic health record (EHR), requiring proactive synthesis by multiple professionals—a process prone to omission. Incomplete handoffs between nursing shifts regarding a patient's pre-imaging medication administration can lead to duplicate or missed doses (Starmer et al., 2017).

Technology & Human-Device Interface

Both chains rely heavily on technology that can introduce errors. Smart infusion pumps for contrast media or sedatives can be misprogrammed, or their safety software overridden. Pharmacy dispensing cabinets may have look-alike/sound-alike drugs placed in adjacent bins. In imaging, modality workstations may display default protocols that are inappropriate for the specific clinical question, or PACS (Picture Archiving and Communication System) interfaces may fail to display prior comparative studies prominently (Hussien et al., 2022). These are not user errors but design-induced errors, where the technology fails to support the cognitive work of the professional. The calibration and maintenance of this equipment, the domain of Medical Devices Technologists, is another latent condition; a poorly calibrated MRI machine can produce artifactual images leading to misdiagnosis, just as a malfunctioning automated dispensing cabinet can deliver an incorrect pill (Wang et al., 2022).

Workload, Environment & Administrative Pressures

Latent conditions are often rooted in organizational decisions. Chronic understaffing in nursing and pharmacy increases cognitive load, multitasking, and interruptions—all known precursors to error in medication administration and patient monitoring (Westbrook et al., 2018). Similarly, productivity pressures in radiology, measured by studies per hour, can shorten the time available for

image interpretation and consultation, increasing the risk of perceptual or cognitive error (Hegde et al., 2023). Administrators, balancing financial constraints, may defer investments in integrated IT systems, forcing staff to use workarounds that bypass safety features. These systemic pressures create an environment where even highly skilled professionals are set up to fail.

Knowledge Gaps & Interprofessional Checkpoints

Defensive layers depend on professional expertise (Table 2). A crucial checkpoint is the pharmacist's review of medication orders, including those for imaging-related drugs. However, if the indication is unclear (e.g., "metoprolol for scan"), the pharmacist may not recognize a dosing error for a specific cardiac protocol (de Laforcade et al., 2021). Conversely, a radiologist may be unaware of specific drug-induced conditions that mimic pathology. The laboratory's role is pivotal yet sometimes overlooked: timely reporting of renal function (creatinine) is essential for safe contrast use. A delay in lab reporting or an absence of a hard stop in the ordering system for patients with renal impairment is a systemic hole shared by both chains (McDonald et al., 2014).

Table 2: Systemic Root Causes and Their Manifestations Across Professional Domains

Systemic Root Cause	Manifestation in Medication Chain	Manifestation in Imaging Chain	Affected Professions
Fragmented Information Systems	EHR does not flag drug-drug interactions across outpatient/inpatient settings.	PACS does not automatically display relevant prior exams; the report is not linked to the order.	All: Secretaries, Pharmacists, Radiologists.
Normalization of Deviance	Overriding pump alarms becomes routine; not scanning barcodes due to time pressure.	Accepting suboptimal image quality to avoid re-scanning; skipping time-out protocols.	Nursing, Device Techs, Radiology Techs.
Inadequate Safety Culture	Fear of reporting near-misses; blame-oriented RCA.	Reluctance to seek second reads; hierarchical barriers to speaking up.	All, reinforced by the Administration.
Misaligned Incentives	Productivity metrics (orders processed/hour) trump safety checks.	RVU-based compensation discourages time-consuming consultations or protocol tailoring.	Secretaries, Pharmacists, Radiologists.
Gaps in Interprofessional Education	Nurses are unaware of specific contrast media risks. Pharmacists are not trained on imaging protocols.	Radiologists are unaware of medication effects on imaging findings.	Nursing, Pharmacy, Radiology, and Laboratory.

Towards Integrated Safeguards

Acknowledging the deeply interconnected nature of vulnerabilities within the medication and imaging chains compels a paradigm shift from isolated, profession-specific interventions toward integrated, system-wide defenses. The core objective is to engineer inherently safer processes—designing work systems that make errors difficult to commit and easy to detect—by harnessing the collective vigilance and complementary expertise of the interprofessional team (Reason, 2016). This necessitates moving beyond merely adding more checklist responsibilities onto overloaded staff, and instead fundamentally redesigning workflows and technological interfaces to support reliable performance and facilitate seamless collaboration across traditional professional boundaries.

A cornerstone of this integrated approach is the strategic hardwiring of critical intersections within the Electronic Health Record (EHR) using forcing functions and intelligent clinical decision support. The pharmaco-imaging interface presents a prime opportunity for such redesign. Rather than relying on the flawless recall and coordination of multiple individuals, the system itself can be configured to guide safe practice through "guided protocols" or "order sets" (Cashion & Weisbord et al., 2022). For instance, when a provider orders a contrast-enhanced computed tomography (CT) scan, the EHR can be programmed to execute a series of automated, interdependent safety checks. First, it would seamlessly interface with laboratory information systems to retrieve the patient's most recent serum creatinine level and estimated glomerular filtration rate (eGFR), applying a configurable hard stop or a mandatory override-with-justification prompt if the values fall outside established safe parameters for contrast administration (McDonald et al., 2014; Weinreb et al., 2021). This automates a crucial safety gate that otherwise depends on manual lookup and interpretation by the ordering clinician, radiologist, scheduler, or nurse.

Concurrently, the system would present a mandatory field requiring documentation of the patient's history of prior contrast reactions or other relevant allergies. Based on the inputs gathered—

procedure type, renal function, and allergy status—the EHR could then dynamically generate a standardized, pre-populated order set for any necessary pre-procedural medications. For a patient with a prior mild reaction, this might include a structured order for pre-medication with corticosteroids and antihistamines, sent directly to the pharmacy for verification and dispensing (Davenport et al., 2020). This functionality links the diagnostic and therapeutic pathways explicitly, transforming them from parallel processes into a single, unified patient journey visible to all team members. The radiologist sees that pre-medication is ordered, the pharmacist reviews the order in its specific imaging context, and the nursing team receives clear administration instructions tied to the scheduled procedure time (Marzal-Alfaro et al., 2021). This level of integration mitigates the risks of omitted orders, communication failures, and administration timing errors that are prevalent in manual coordination (Wack et al., 2015; Wilson et al., 2020). By embedding evidence-based guidelines directly into the workflow, these systemic safeguards reduce cognitive burden and variability, making the safe path the default and easiest path to follow (Sarkar et al., 2021).

Enhancing Interprofessional Checkpoints with Structured Communication

Replace ambiguous communication with standardization. Implement a "Diagnostic Time-Out" akin to the surgical safety checklist, to be conducted by the imaging team (technologist, nurse, radiologist) for complex or high-risk studies. This brief pause would verify patient identity, procedure, indicated protocol, relevant medications administered, and any patient-specific risks (Zhang et al., 2023). Furthermore, encourage structured consultation between pharmacists and radiologists on complex pharmaco-imaging cases, formalizing a currently ad-hoc process (Moyer et al., 2013).

Leveraging Technology for Cognitive Support

Deploy advanced decision-support tools that are context-aware. For pharmacists, alert fatigue can be reduced by making alerts more intelligent—flagging only critical, protocol-specific medication issues for imaging procedures. For radiologists, integrate AI-based algorithms that act as a "second set of eyes," not to replace judgment but to flag potential discrepancies (e.g., a missed pulmonary nodule or an inconsistency between the report and the clinical indication) (Waite et al., 2017; Alexander et al., 2022). For device technologists, implement predictive analytics on medical device logs to flag equipment trending towards failure before it causes a clinical error (Moll et al., 2022; Shamim, 2022).

Fostering a Culture of Collective Accountability and Continuous Learning

Ultimately, the sustainability and effectiveness of any technical or procedural safeguard are contingent upon the underlying organizational culture. Hospital Administration bears the critical responsibility for leading a deliberate shift from a culture of individual blame—which drives errors underground—to one of **"collective accountability"** (Frankel, Leonard, & Denham, 2017). This cultural transformation posits that safety is a shared property of the system, owned by the entire interprofessional team and the leadership that designs the work environment. It requires creating conditions where learning from failure is prioritized over assigning personal fault.

The foundation of this culture is a transparent, non-punitive reporting system designed to capture near-misses and minor events, which are invaluable precursors to major harm (Kellogg, Hettinger, & Shah, 2017). Such systems must be intentionally structured to bridge professional silos, allowing a nurse to report a confusing medication order related to an imaging protocol with the same ease as a radiologist reporting an ambiguous referral—and ensuring those reports are analyzed for systemic patterns, not individual performance (O'Donovan & McAuliffe, 2020). When adverse events do occur, the investigative process must itself be interprofessional. Conducting **Root Cause Analyses (RCAs)** with representatives from nursing, pharmacy, radiology, the laboratory, and medical secretarial staff is essential to fully map the cross-domain trajectory of a failure (Nicolini, Waring, & Mengis, 2019). This collaborative analysis moves beyond the immediate "sharp end" error to expose latent conditions in scheduling, device design, information flow, and policy, fostering a shared understanding of the system's complexity.

This shared understanding must then be translated into collective competence through **simulation-based interprofessional training**. High-fidelity scenarios that recreate high-risk intersections—such as managing a severe contrast media reaction during an MRI scan—train teams, not just individuals, to coordinate communication, role clarity, and technical response under pressure (Vanderzwan et al., 2023). These simulations reinforce shared mental models and build the psychological safety necessary for team members to speak up in real clinical situations.

Finally, culture is powerfully shaped by what is measured and rewarded. Hospital Administration must actively **align performance and financial incentives with safety outcomes**, moving beyond dominant volume-based metrics (e.g., studies per hour, patients seen). This involves integrating indicators of system reliability—such as near-miss reporting rates, adherence to safety protocols, and interprofessional collaboration metrics—into departmental and executive scorecards (Frankel et al., 2017). By rewarding behaviors that contribute to a learning culture and demonstrating that reliability is the paramount organizational value, leadership can solidify the shift from a focus on individual perfection to a commitment to collective, resilient performance. Figure 1 presents a systems-based model illustrating

how medication and diagnostic imaging safety chains are deeply interconnected within modern healthcare.

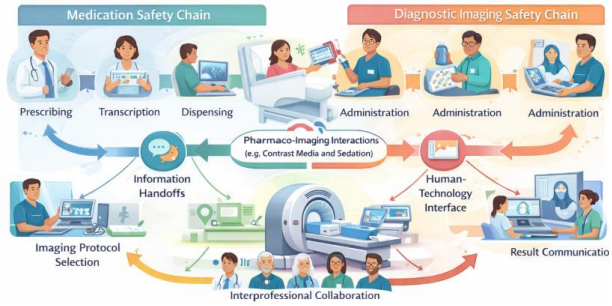

Figure 1: Interconnected Medication and Medical Imaging Safety Chains: A Systems Perspective on Iatrogenic Harm

Conclusion

The silent epidemic of iatrogenic harm stemming from medication and diagnostic imaging errors is not a collection of unrelated incidents but a symptom of systemic vulnerabilities within an interconnected healthcare network. This review has delineated how the safety chains for medication and imaging are interwoven, sharing critical points of failure in communication, technology, workload, and knowledge application across the domains of Pharmacy, Nursing, Diagnostic Radiology, Laboratory, Medical Devices Technology, Medical Secretaries, and Hospital Administration. Latent conditions created by organizational decisions and technological design set the stage for active failures by frontline professionals.

Acknowledging this interdependence is the first step toward meaningful mitigation. The path forward lies in deliberately integrating safety efforts. Defenses must be designed to span professional boundaries, using health information technology to create forcing functions, standardizing interprofessional communication, and leveraging the unique expertise of each profession to build mutual reinforcement. Ultimately, safety must be reconceptualized as a collective achievement, a property of the system as a whole, nurtured by leadership and embodied in daily practice by every member of the healthcare team. Only by dismantling the silos that confine our view of safety can we hope to mute the silent epidemic and build healthcare systems that are as safe as they are capable.

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