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Review Article

POWER AND DISCLOSURE IN HEALTHCARE: A SCOPING REVIEW OF MEDICAL ERROR RESPONSE ACROSS SYSTEMS

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Abstract:
Background: *Medical errors remain as a troubling cause of preventable harm within healthcare systems. In response, error disclosure has emerged as both an ethical imperative and a quality improvement priority. Despite increasing institutional and legal support for transparency, disclosure practices are often hindered by emotional, organizational, and systemic barriers.*
Objective: *This scoping review consolidates evidence on medical error disclosure and response, with particular attention to strategies that address power dynamics, communication practices, legal protections, organizational culture, and community engagement.*
Methods: A curated body of peer-reviewed literature from 2000 to 2025 was analyzed using an integrative and interpretive approach. Sources were drawn from medicine, public health, ethics, law, and education, and categorized across ten thematic domains: disclosure and communication; support for healthcare professionals; systematic learning; safety culture; legal and ethical considerations; restorative approaches; surveillance; education; interdisciplinary insights; and community-led models.
Results: *Findings highlight that effective disclosure is supported by structured frameworks (e.g., CANDOR), legal protections (e.g., apology laws), and organizational policies that promote psychological safety. Emerging innovations include patient-partnered education, virtual training modules, interdisciplinary root cause analysis, and community-informed participatory models. However, gaps remain in sustainability, long-term outcomes, and integration of equity and power-sensitive approaches.*
Conclusions: *Medical error response is evolving from isolated clinician responsibility to an integrated, systems-based practice. Sustainable progress requires alignment of institutional culture, legal reform, emotional support, and patient engagement. By embracing relational, transparent, and justice-oriented frameworks, healthcare systems can transform error disclosure into a meaningful catalyst for healing, accountability, and trust.*

Keywords*: Medical error disclosure, patient safety, systems-based response, organizational culture, healthcare quality improvement*

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1. Introduction

Medical errors are a major cause of preventable harm worldwide. In response, transparency and accountability have become central to patient safety and quality improvement. Disclosure of medical errors is not only an ethical obligation but is now embedded in many institutional policies and legal frameworks. However, disclosure practices are often shaped, and hindered, by power dynamics, emotional distress, organizational culture, and systemic barriers.

Efforts to improve disclosure have included communication training, structured programs, clinician support services, and culture change initiatives. For example, the American Academy of Pediatrics (AAP) promotes early and accurate disclosure through frameworks such as the Communication and Optimal Resolution (CANDOR) program, which provides structured guidance for clinicians [1]. Open communication after an error can reduce emotional harm, rebuild trust, and improve patient engagement [2].

Despite this progress, significant challenges persist: notably, fear of litigation, inadequate training, and limited institutional support for clinicians involved in errors [3]. Broader systemic issues such as hierarchical structures and hidden curricula in medical education further constrain transparent and restorative responses [4,5].

While previous studies have examined specific disclosure interventions, few have synthesized strategies across disciplines addressing power, communication, legal, cultural, and community dimensions. This gap limits the translation of evidence into practice and policy.

This scoping review consolidates current evidence and frameworks on medical error response and communication, examining structured disclosure practices, clinician and patient support systems, legal and ethical protections, and restorative and community-led approaches. Findings aim to inform institutional policies and training programs that foster transparency, accountability, and healing after medical harm.

2. Methods

This scoping review was conducted in accordance with the JBI Manual for Evidence Synthesis and the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) guidelines [6,7]. The objective was to map existing approaches to medical error disclosure and response, with a focus on how power, transparency, and communication influence outcomes for patients, healthcare providers, and systems.

A comprehensive literature search was conducted between January and March 2025 using six databases: MEDLINE (via PubMed), Embase, CINAHL, PsycINFO, Scopus, and Web of Science. Grey literature sources were also reviewed, including the World Health Organization (WHO), Agency for Healthcare Research and Quality (AHRQ), and Canadian Patient Safety Institute repositories. The search strategy combined keywords and controlled vocabulary related to medical error, disclosure, communication, apology, transparency, candor, and patient safety. The core search string for PubMed was (“medical error” OR “adverse event” OR “patient safety incident”) AND (“disclosure” OR “communication” OR “apology” OR “transparency” OR “candor” OR “open disclosure”) AND (“framework” OR “training” OR “program” OR “policy” OR “restorative justice” OR “support”). The search terms were adapted for each database, and reference lists of included articles were screened to identify additional relevant studies through backward and forward citation tracking.

Articles were eligible for inclusion if they discussed disclosure or communication following medical errors or adverse events in healthcare settings and described or evaluated frameworks, interventions, policies, or educational strategies related to error response. Studies were included if they were published in English between 2000 and 2025 and reported empirical findings, conceptual models, or structured policy analyses. Studies were excluded if they did not address disclosure or post-error communication, if they focused exclusively on unrelated safety metrics, or if they consisted only of opinion pieces, commentaries, or editorials without substantive analysis.

All citations retrieved through the database searches were imported into Covidence for screening. Two reviewers independently screened titles, abstracts, and full texts to determine eligibility, with discrepancies resolved through discussion and consensus. Data were extracted from the included studies

on publication type, methodology, study setting, stakeholders involved, interventions or frameworks described, and reported barriers, facilitators, and outcomes.

The analysis followed an inductive-deductive thematic approach informed by eight domains commonly identified in patient safety and disclosure literature: disclosure and communication; support for healthcare professionals; systematic analysis and learning; organizational policies and safety culture; legal and ethical considerations; restorative and relational approaches; community-led or participatory models; and education and training. Each included article was reviewed and categorized based on its primary area of contribution within these domains, and findings were synthesized narratively to identify interconnections, gaps, and trends across disciplines.

While this review was not exhaustive, significant efforts were made to ensure transparency and reproducibility through clear reporting of databases, search terms, and inclusion criteria. The multidisciplinary nature of the review allowed inclusion of relevant literature from medicine, public health, ethics, law, and education, providing a broad and integrated understanding of current practices. The findings aim to guide policy development, institutional practice, and future research toward more ethical, transparent, and restorative systems of care in response to medical harm.

3. Results

This scoping review identified ten key thematic domains that describe current approaches to responding to medical errors within healthcare systems (Figure 1). These themes emerged from a diverse body of literature that spans empirical research, policy documents, ethics guidelines, legal scholarship, and education-focused studies. Together, they reflect the multifaceted nature of medical error disclosure and response, integrating organizational, interpersonal, legal, and cultural considerations. The thematic categories include: (1) disclosure and communication, (2) support for healthcare professionals, (3) systematic analysis and learning, (4) organizational policies and safety culture, (5) legal and ethical considerations, (6) restorative approaches, (7) monitoring and surveillance, (8) education and training, (9) interdisciplinary and psychological insights, and (10) community-led and participatory approaches. The following sections outline the core strategies, barriers, and innovations identified across each domain, highlighting patterns in current practices and opportunities for systemic improvement.

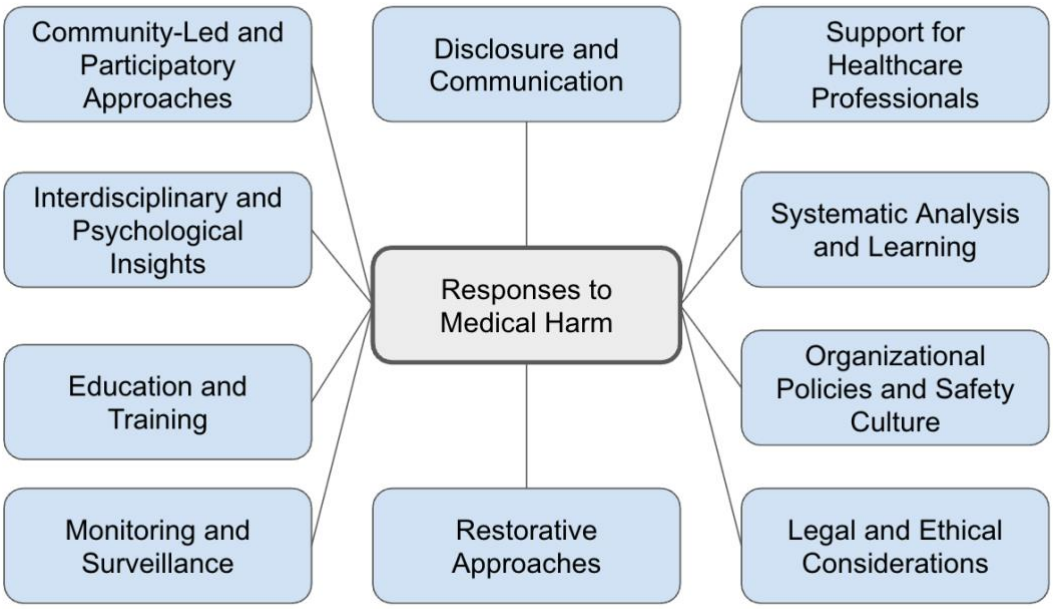

Figure 1. Conceptual map of medical error response across systems.

3.1. Disclosure and Communication

Effective disclosure is foundational to patient safety, patient trust, and healthcare system transparency. The literature consistently underscores the importance of prompt, accurate, and compassionate communication following adverse events. The American Academy of Pediatrics (AAP) emphasizes a structured approach to disclosure through initiatives like the Communication and Optimal Resolution (CANDOR) program, which includes predisclosure huddles and checklists to ensure consistency, empathy, and multidisciplinary involvement [1]. Disclosure should ideally include an honest explanation of what occurred, acknowledgment of harm, and a commitment to preventing future incidents. Such practices are associated with reduced emotional trauma and improved trust between patients and healthcare providers [2].

Involving appropriate personnel such as risk managers, attorneys, and unit leaders is recommended to support both clinicians and patients through the process [1]. Emotional support for patients is also critical, with literature suggesting that sincere apologies—when framed carefully to avoid legal pitfalls—can promote healing and reduce the adversarial nature of post-error communication [4].

Systemic support structures within institutions also play a critical role in enabling effective disclosure. This includes providing clinicians with training in communication skills, implementing standardized response protocols, and fostering a nonpunitive culture that encourages openness rather than fear [1], [2]. Ongoing follow-up communication is equally important. Initial disclosure may acknowledge that an error occurred, while follow-up conversations—once more information is available—demonstrate continued accountability and transparency [8]. Collectively, these strategies underscore a comprehensive model for disclosure that incorporates timeliness, empathy, multidisciplinary support, and patient-centered follow-up communication [1,2,8].

3.2. Support for Healthcare Professionals

Healthcare professionals involved in medical errors—often referred to as "second victims"—frequently experience intense emotional distress, including guilt, anxiety, burnout, and symptoms of post-traumatic stress. The literature emphasizes that support for these individuals is critical not only for their well-being but also for maintaining high standards of patient care and preventing workforce attrition [9,10].

Support structures for clinicians should begin with clear institutional protocols that promote prompt and accurate disclosure. The AAP advises that clinicians be guided by legal advisors and risk management staff to ensure their communication with patients is comprehensive and legally protected [1]. Emotional support through peer mentoring, debriefing sessions, and access to mental health services can alleviate the psychological burden clinicians carry after an error [9].

Furthermore, a systems-level commitment to a just culture is critical. Organizations must foster environments where clinicians feel safe disclosing errors without fear of punishment. Training in effective communication skills and resilience strategies can help clinicians engage constructively with both patients and colleagues following an adverse event [1]. Educational programs like Bell et al.'s (2010) *When Things Go Wrong* curriculum highlight the importance of integrating these supports into both faculty and trainee development.

Ongoing dialogue within the organization, including regular updates on investigations and outcomes, helps reinforce that clinicians are supported throughout the resolution process. This continuity is essential for long-term emotional recovery and professional development [9,10].

3.3. Systematic Analysis and Learning

Systematic analysis following medical error plays a critical role in transforming adverse events into learning opportunities. Root cause analyses (RCA) and apparent cause analysis (ACA) are widely

adopted frameworks for dissecting the system-level factors that contribute to medical harm [1,11]. The process typically begins with accurate reporting and documentation of the event, which serves as the foundation for a structured investigation [12].

RCA involves a multidisciplinary team conducting a thorough timeline review, identification of contributing factors, and mapping of latent and active errors [13,14]. This analysis shifts the focus from individual blame to systemic improvement, enabling organizations to identify vulnerabilities in workflows, communication channels, and training programs.

Patient and family engagement in the investigative process is increasingly recognized as a best practice. Including them in interviews and discussions fosters transparency, enhances trust, and can provide additional insights into system breakdowns [15]. Disclosure of the error, accompanied by a sincere apology and a discussion of steps taken to prevent recurrence, is now a recognized part of ethical and professional standards [13].

Corrective action plans developed from RCA findings should be specific, actionable, and monitored for long-term impact [13]. Concurrently, support for healthcare professionals involved in the event remains integral throughout the process to mitigate emotional harm and reinforce institutional trust [13]. Ultimately, a systems-oriented approach to analysis and learning includes timely reporting, collaborative RCA, stakeholder engagement, corrective action implementation, and sustained clinician support—each essential to improving care quality and safety culture [9,13,15].

3.4. Organizational Policies and Safety Culture

Institutional culture plays a pivotal role in shaping how medical errors are disclosed, analyzed, and used for system improvement. A strong culture of safety emphasizes transparency, systemic learning, and non punitive accountability. Across the literature, a recurring theme is the importance of cultivating a "just culture -one in which clinicians feel psychologically safe to report errors, trusting that the focus will be on learning rather than blame [16-18]. Such an environment encourages the open reporting of incidents, leading to a more accurate understanding of system vulnerabilities and fostering opportunities for quality improvement.

Key organizational policies that support a just culture include structured disclosure protocols, psychological support systems, and clearly defined mechanisms for feedback and learning. The American Academy of Pediatrics (AAP) emphasizes the adoption of a systems approach, recognizing that the majority of medical errors stem from flawed processes rather than individual failings [1]. This approach shifts the emphasis from individual culpability to system-level root cause identification and correction.

Transparency with patients and families is another cornerstone of a safety-oriented culture. Prompt disclosure, coupled with an honest explanation and expression of regret, reinforces institutional accountability and maintains patient trust [4,9]. Simultaneously, the organization must ensure that healthcare providers involved in adverse events receive meaningful emotional support. Second victim programs, including peer support and confidential counseling, are critical to help clinicians recover and remain engaged in quality care delivery [9].

Moreover, institutional leadership plays a crucial role in modeling safety values. Commitment from senior management to safety improvement, continuous education, and non punitive policies signals to staff that learning from error is a protected and supported process [18-20].

3.5. Legal and Ethical Considerations

Legal and ethical considerations are central to shaping institutional responses to medical error. The ethical imperative of veracity—truth-telling in clinical encounters—serves as the foundation for disclosure frameworks. The AAP policy on adverse events recommends prompt and transparent

disclosure, including acknowledgment of harm, clear communication of the facts, and a sincere apology where appropriate [1]. This ethical standard aligns with evolving legal frameworks that increasingly protect open disclosure practices.

One of the most notable legal mechanisms is the implementation of "apology laws," which protect clinicians' statements of apology from being used against them in court. These laws aim to reduce the fear of litigation that has historically discouraged transparency and have been shown to facilitate earlier resolution and preserve the therapeutic alliance [21].

Support for healthcare providers is also addressed within legal and institutional frameworks. Medical errors can have profound psychological consequences for clinicians, and institutions have an ethical obligation to support these individuals. Peer support programs, emotional counseling, and guidance from legal advisors and risk managers are essential components of an ethically sound response to medical error [1].

In addition to responding to individual incidents, healthcare organizations are increasingly expected to use error data to drive systemic improvements. Root cause analysis, quality assurance reviews, and ethical reflection contribute to learning and prevention [2]. These practices represent a broader shift toward ethical systems thinking, wherein individual responsibility is contextualized within structural contributors to harm.

In summary, a legally and ethically grounded response to medical error supports transparency through protected disclosure, reduces adversarial consequences, and ensures psychological safety for both patients and providers.

3.6. Restorative Approaches

Restorative approaches to medical error offer a paradigm focused not just on investigation or litigation, but on healing. These strategies recognize the emotional toll that adverse events have on patients, families, and healthcare providers, and emphasize relational accountability, emotional repair, and systems learning.

Communication-and-resolution programs (CRPs) are a central restorative model. CRPs promote early, honest communication with patients about adverse events, provide a thorough investigation of what happened, and—where appropriate—offer compensation for harm caused by substandard care [22,23]. When done sincerely and respectfully, these conversations can restore trust and mitigate the emotional burden of harm.

Disclosure and apology remain critical elements of restorative practice. The literature supports the importance of culturally sensitive and emotionally intelligent communication, including clear explanations and genuine expressions of regret [9,24]. These approaches help patients feel acknowledged and support emotional healing.

Restorative strategies also highlight the importance of supporting clinicians. Medical errors can be traumatizing for those involved, often leading to guilt, isolation, or long-term psychological distress. Peer support systems and institutional acknowledgement of emotional harm are essential to address the needs of second victims and foster resilience [9,25].

Importantly, restorative approaches extend beyond interpersonal healing to system-wide reform. Following adverse events, institutions must implement meaningful changes to prevent recurrence. These can include protocol redesigns, increased team training, and improved safety practices. Engaging patients and families in these conversations—by asking what outcomes or changes they would like to see—can enhance the credibility and relevance of institutional responses [22,26].

Finally, education and training are central to restorative frameworks. Programs such as *When Things Go Wrong* equip healthcare professionals with the communication and relational tools needed to participate in disclosure and healing processes effectively [2]. Taken together, restorative approaches

reframe medical error response as an opportunity for both healing and growth—grounded in empathy, transparency, and collaborative reform [27,28].

3.7. Monitoring and Surveillance

Monitoring and surveillance are essential components of a responsive safety system that not only identifies harm but facilitates early intervention and prevention. Surveillance systems—such as those that track sentinel events and near misses—help institutions recognize error patterns, assess system vulnerabilities, and implement timely corrective actions [11,29].

A comprehensive surveillance framework begins with transparent and immediate communication of the event to patients and their families. This disclosure fosters trust and sets the foundation for ethical accountability [14]. Internal reporting systems must be robust, accessible, and designed to capture a wide range of events, enabling meaningful data aggregation and trend analysis [2]. These systems function not only as tools for incident documentation but as drivers of organizational learning.

Root cause analysis (RCA) remains a cornerstone of post-event inquiry. Through systematic mapping of the timeline, contributing factors, and latent system failures, RCA promotes a nonpunitive learning environment and aids in the development of preventive strategies [14]. Outcomes of such analyses should be directly linked to institutional change efforts, including protocol redesign, staff training, and improved communication workflows [30].

In parallel, healthcare providers affected by the error require dedicated emotional and professional support. Second victim support services should be embedded into the monitoring infrastructure, ensuring clinicians are not retraumatized by the investigative process [2]. When implemented effectively, monitoring and surveillance serve not only as retrospective tools but as mechanisms for ongoing system refinement and harm prevention.

3.8. Education and Training

Education and training are vital to equipping healthcare professionals with the skills, confidence, and ethical orientation necessary to manage medical errors transparently and constructively. Across the literature, educational interventions emphasize communication, systems thinking, and resilience as foundational competencies for safe clinical practice [4,31].

Disclosure training is a central component. Programs such as *When Things Go Wrong* provide interactive frameworks for teaching disclosure principles, apology delivery, and emotional support strategies, particularly for trainees and early-career clinicians [10]. Simulation and role-play exercises further enhance these skills, offering low-stakes environments in which to practice difficult conversations [4,32].

Root cause analysis (RCA) training introduces learners to the principles of system-based error analysis. This skillset helps clinicians move beyond individual blame toward recognizing systemic contributors to harm, facilitating a culture of learning and prevention [33]. The emotional dimensions of error are also addressed through peer discussion forums and mentorship. Structured opportunities for reflection, combined with institutional support, allow clinicians to process distress, learn from failure, and reengage with patient care [9,34,35].

Formal curricula are increasingly integrating these competencies into medical education. Content includes the ethical and professional implications of error, techniques for error recognition and reporting, and systems-level safety strategies [33,36]. Additionally, the modeling of transparent and reflective practice by senior clinicians plays a crucial role in shaping learners' attitudes toward disclosure and accountability [34,37]. Taken together, these educational strategies contribute to a generative learning environment where medical error becomes an opportunity for growth, reflection, and improved patient safety.

3.9. Interdisciplinary and Psychological Insights

Addressing medical error through an interdisciplinary lens ensures that both clinical and emotional dimensions of harm are acknowledged. This approach draws on fields such as ethics, law, psychology, communication, and patient advocacy to inform more holistic models of disclosure and response.

Transparent communication remains a central tenet. Literature emphasizes that open, honest, and timely disclosure—paired with an explanation and apology—can reinforce trust and mitigate long-term psychological harm [2,9]. Reporting mechanisms also play a critical role, enabling the identification of recurring challenges and systemic patterns [2].

Psychological support for clinicians is especially important. Research highlights the profound distress experienced by providers following medical errors, including feelings of guilt, isolation, and burnout [9,25,38]. Interventions such as peer support, counseling, and reflective practice can significantly reduce emotional fallout.

Root cause analysis conducted by interdisciplinary teams allows for comprehensive understanding and more nuanced corrective action [9]. These teams often include not only physicians and nurses, but also social workers, risk managers, and mental health professionals, enhancing both the rigor and relational quality of institutional responses [1,8].

Cognitive and behavioral insights from psychology further deepen understanding of barriers to disclosure. For instance, Han et al. (2017) [24] identify cognitive biases—such as fundamental attribution error—that may impede clinicians from acknowledging their own mistakes. Virtual reality and simulation training are proposed as tools to address these biases and support reflective, compassionate behavior. Ultimately, integrating psychological and interdisciplinary knowledge enhances the emotional, ethical, and structural resilience of healthcare systems after adverse events.

3.10. Community-Led and Participatory Approaches

Community-led and participatory approaches challenge the traditional top-down model of error response by centering patients, families, and communities as partners in disclosure and harm prevention. These models emphasize transparency, accountability, and shared ownership of safety improvement.

One compelling model involves patients and families serving as co-educators in error disclosure training. Through hospital advisory councils and collaborative learning initiatives, patients and families share their lived experiences with clinicians and trainees, fostering empathy, enhancing communication skills, and reframing power dynamics in healthcare interactions [39].

Structured involvement of patients and families in adverse event analysis is also gaining recognition. Institutions have begun to incorporate interviews and conferences with affected individuals as part of their formal incident review processes. These participatory efforts provide critical insights into patient perceptions and can lead to more responsive and effective system redesigns [40].

Open disclosure policies that mandate transparency and apology following harm are central to this participatory ethos. Rathnayake et al. (2025) [8] emphasize that patients and families value continued, honest communication and active participation in post-incident evaluations—factors that are strongly correlated with improved satisfaction and resolution.

In addition, broader community-based health strategies contribute to safer care delivery. Initiatives such as the clinical community model [41], community health worker (CHW) programs [42], and participatory research frameworks [43,44] demonstrate how community engagement can address systemic inequities and co-create culturally grounded safety solutions. These models highlight the importance of relational accountability and offer a powerful counterpoint to hierarchical models of safety, reimagining harm prevention as a collaborative and community-rooted practice.

4. Discussion

This review illustrates that effective medical error response requires a systems-level approach that integrates emotional, ethical, legal, and relational dimensions. Across multiple domains, transparency emerges as a core value—whether through structured disclosure frameworks [9], apology laws that protect clinicians from litigation, or community-informed participatory models [8,45]. The literature consistently affirms that timely and honest communication is critical to maintaining trust with patients and families, and that meaningful disclosure is often strengthened by organizational policies and legal protections.

Another important factor is the recognition of healthcare providers as second victims, with studies emphasizing the emotional toll of error and the need for institutional support [25,46]. Programs that provide peer debriefing, psychological counseling, and resilient learning environments are increasingly viewed as essential components of safe systems [10,37]. Furthermore, the inclusion of root cause analysis (RCA) and structured monitoring frameworks offers evidence-based mechanisms for learning from harm and guiding preventive action [13,29]. Innovations such as virtual reality training [47], interdisciplinary RCA teams [15], and patient-led education programs [39] demonstrate how cross-sector collaboration can enhance both accountability and system learning.

The novelty of this review lies in its integration of diverse frameworks—from legal, psychological, and restorative perspectives—into a unified analysis of how systems can respond ethically and relationally to medical harm. Whereas prior reviews have primarily focused on either communication training or institutional disclosure programs, this work extends the field by mapping intersections across eight domains, including restorative and community-led approaches that remain underexplored in existing literature. By synthesizing literature from medicine, law, ethics, and education, this review provides a broader interdisciplinary lens through which disclosure and response can be reimagined as collaborative, power-aware, and patient-centered processes.

Despite these advancements, barriers persist. Cognitive biases, fear of litigation, hierarchical cultures, and fragmented communication systems can impede disclosure efforts [4,47]. Moreover, the literature reveals gaps in long-term evaluation, with few studies assessing the sustainability or patient-reported outcomes of disclosure interventions. This review contributes uniquely by identifying these cross-cutting gaps and emphasizing the need for frameworks that operationalize transparency and emotional repair at both individual and organizational levels. Future research should prioritize the development of adaptable, equity-oriented models that address power dynamics and ensure the voices of patients, families, and frontline clinicians are meaningfully integrated into institutional responses.

5. Conclusion

This review demonstrates that medical error disclosure is no longer a matter of individual moral courage alone, but a collective, multidisciplinary effort embedded in organizational structures and cultural norms. From restorative justice models to participatory learning environments, the literature reveals a growing convergence on strategies that center transparency, emotional healing, and systemic accountability. Training clinicians in communication and RCA, building institutional cultures of psychological safety, and engaging patients in harm reduction strategies are not isolated interventions—they are mutually reinforcing components of a broader shift toward ethical and resilient systems of care.

While no single approach can fully resolve the complexity of medical error, the findings of this review suggest that integrated models—those that combine legal reform, emotional support, community collaboration, and systems learning—offer the most promise. To move forward, healthcare organizations must commit not only to improving clinical processes, but to reshaping the relationships

between providers, patients, and the systems that surround them. In doing so, they can transform moments of harm into opportunities for growth, trust-building, and institutional renewal.

Ethical statement:

This study did not involve the use of human participants, animals, or hazardous materials. As such, ethics approval was not required. All data used in this scoping review were obtained from publicly available published literature.

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Conflict of interest:

The authors declare that there are no conflicts of interest relevant to the content of this article.

Authors' Contributions:

S.Q. conceptualized and led the review, conducted the literature synthesis, and wrote the manuscript. S.L. and S.Z. contributed to data interpretation and critically reviewed and revised the manuscript. K.Z. supported literature search strategies, citation management, and contributed to editing and formatting. All authors read and approved the final manuscript.

Generative AI statement:

The authors declare that no Gen AI was used in the creation of this manuscript.

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