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Centering Reliability and Evidence: Integrating Site Reliability Engineering Error Budget Governance with Evidence Based Practice Implementation Frameworks in Large Scale Digital Health Systems

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ABSTRACT

The accelerating digitization of health care delivery, research, and administration has produced a paradoxical condition in which clinical systems are more information rich than at any point in history while simultaneously becoming more operationally fragile. Digital infrastructures that support electronic health records, clinical decision support, telemedicine platforms, and population health analytics are now mission critical to patient safety, institutional credibility, and regulatory compliance. Yet these infrastructures are routinely exposed to downtime, performance degradation, security incidents, and data integrity failures that threaten the very epistemic foundations of evidence based medicine. Within this context, site reliability engineering has emerged as a dominant paradigm for governing large scale software systems through quantifiable objectives, error budgets, and continuous improvement. At the same time, the health sciences have spent more than three decades refining evidence based practice frameworks to guide decision making, professional education, and organizational change. These two traditions have evolved largely in parallel, despite sharing a core concern with how knowledge, uncertainty, and risk are managed under real world conditions.

Using a qualitative meta analytic methodology grounded in the interpretive synthesis of existing empirical and theoretical studies, the paper identifies recurring patterns that link error budget governance to professional behavior, organizational learning, and patient outcomes. The results demonstrate that reliability oriented metrics can function as powerful boundary objects that align clinical, managerial, and technical communities, while also revealing tensions when quantitative reliability targets conflict with qualitative judgments of care quality. The discussion elaborates these tensions in light of debates within evidence based practice about standardization, professional autonomy, and contextualization of knowledge. It further examines how error budgets can be misused as instruments of control or cost containment if detached from clinical values, echoing long standing critiques of technocratic implementations of evidence based medicine.

By situating site reliability engineering within the broader epistemological and organizational debates of evidence based practice, this study provides a novel framework for understanding how digital health systems can be governed in a way that is both technically robust and clinically meaningful. The conclusion outlines implications for health care leaders, educators, and researchers, arguing that future progress in digital health will depend on the deliberate co design of reliability engineering practices and evidence based implementation strategies.

INTRODUCTION

The contemporary health care landscape is increasingly defined by the ubiquity of digital infrastructures that mediate nearly every aspect of clinical and organizational life. Electronic health records, computerized physician order entry, telemedicine platforms, clinical decision support systems, and large scale data analytics have become indispensable tools for modern medicine. These technologies promise unprecedented opportunities for standardization, transparency, and the systematic application of scientific evidence to patient care, which has been a central aspiration of evidence based medicine since its formal articulation in the late twentieth century (Sackett et al., 1996; Straus et al., 2018). Yet, the very systems that are intended to enhance evidence based practice also introduce new forms of risk and uncertainty. System outages, latency, data corruption, and software errors can undermine clinical workflows, distort information, and in extreme cases contribute directly to patient harm. This tension between the epistemic ideals of evidence based practice and the operational realities of digital systems has become one of the defining challenges of contemporary health care (Claridge & Fabian, 2005; Meakins, 2006).

Within the field of software engineering, a parallel response to the growing complexity and criticality of digital infrastructures has emerged in the form of site reliability engineering. Originating in large scale internet companies, site reliability engineering seeks to treat operations as a software problem, using automation, monitoring, and quantitative objectives to ensure that systems meet agreed levels of service (Dasari, 2025). A central concept in this paradigm is the error budget, which represents the allowable amount of unreliability that a system can experience while still meeting its service level objectives. Rather than striving for absolute perfection, organizations allocate a finite budget of errors that can be “spent” on innovation, experimentation, and change. This approach recognizes that reliability and innovation are inherently in tension, and that managing this tension requires explicit, data driven governance rather than ad hoc decision making (Dasari, 2025).

Although site reliability engineering has been widely adopted in technology intensive industries, its relevance to health care has only recently begun to attract scholarly attention. Health care organizations operate some of the most complex and safety critical information systems in the world, yet they have historically lacked a coherent framework for integrating reliability engineering with clinical governance and evidence based practice (Grol & Grimshaw, 2003; Williams et al., 2015). Instead, digital systems are often implemented as technical projects, while evidence based practice is treated as a professional or educational initiative, with limited integration between the two. This separation is increasingly untenable as clinical evidence is generated, stored, and applied through digital platforms whose reliability directly shapes the quality and credibility of care (Haynes et al., 2002; Montori & Guyatt, 2008).

The literature on evidence based practice has long emphasized that evidence alone does not determine decisions; rather, it must be interpreted and applied by people within specific organizational and cultural contexts (Haynes et al., 2002; Trinder, 2000). Studies of physicians, nurses, and students have consistently identified barriers to the implementation of evidence based practice, including lack of time, limited access to resources, inadequate training, and unsupportive organizational cultures (Sadeghi-Bazargani et al., 2014; Camargo et al., 2018; Hamaideh, 2017). These barriers are not merely individual but systemic, reflecting the ways in which institutions allocate attention, authority, and resources. Digital systems can either exacerbate or mitigate these barriers depending on how they are designed and governed (Brown et al., 2009; Linton & Prasun, 2013). For example, a well designed clinical decision support system can make evidence more accessible at the point of care, while a poorly performing or unreliable system can create frustration and distrust that discourages clinicians from engaging with evidence based tools (Chiu et al., 2010; Gerrish et al., 2008).

In this sense, the reliability of digital health systems is not a purely technical concern but a foundational condition for the practice of evidence based medicine. If clinicians cannot rely on their systems to be available, accurate, and responsive, the epistemic authority of the evidence embedded within those systems is weakened. Conversely, investments in reliability that are not aligned with clinical priorities may divert resources from more meaningful improvements in care. Dasari (2025) explicitly frames error budget management as a governance mechanism that balances competing organizational objectives in large scale systems, making it a particularly fertile concept for bridging technical and clinical domains. By translating reliability into a quantifiable and negotiable resource, error budgets create a common language through which engineers, managers, and other stakeholders can deliberate about risk, performance, and change (Dasari, 2025).

Despite these apparent synergies, there has been little systematic effort to integrate site reliability engineering with evidence based practice theory. The two literatures have developed largely in isolation, using different vocabularies, methodologies, and assumptions about what constitutes valid knowledge. Evidence based practice is rooted in the traditions of clinical epidemiology and health services research, emphasizing randomized trials, observational studies, and systematic reviews as the gold standard of evidence (Sackett et al., 1996; Straus et al., 2018). Site reliability engineering, by contrast, draws on computer science and operations research, privileging metrics such as uptime, latency, and error rates as indicators of system performance (Dasari, 2025). Yet both fields grapple with the same fundamental problem: how to make rational decisions under conditions of uncertainty in complex systems where failures can have serious consequences.

The present study addresses this gap by developing an integrative framework that situates site reliability engineering error budget management within the broader discourse of evidence based practice. It does so by synthesizing insights from Dasari (2025) with a wide range of empirical and theoretical studies on evidence based medicine, nursing, and organizational change. The central argument is that error budgets can be understood as a form of evidence in their own right, providing actionable information about system performance that can and should inform clinical and managerial decisions. At the same time, the values and norms of evidence based practice provide essential guidance for how error budgets should be interpreted and used in health care settings, preventing them from becoming purely technocratic tools divorced from patient centered outcomes (Grol & Grimshaw, 2003; Williams et al., 2015).

The literature on barriers to evidence based practice is particularly instructive in this regard. Studies across multiple countries and professional groups have shown that clinicians often perceive evidence based initiatives as externally imposed and misaligned with the realities of practice (Kajermo et al., 2010; Al Omari et al., 2009; Van Dijk et al., 2010). Similar dynamics can be observed in the implementation of reliability engineering, where metrics and service level objectives may be experienced as managerial controls rather than supports for professional work. By explicitly linking error budgets to evidence based goals, organizations may be able to reframe reliability targets as enablers of high quality care rather than constraints (Dasari, 2025; Gale & Schaffer, 2009).

This article therefore seeks to answer three interrelated questions. First, how can the concept of error budgets from site reliability engineering be theoretically integrated with evidence based practice frameworks? Second, what does the existing empirical literature suggest about the ways in which reliability and evidence interact in health care organizations? Third, what are the implications of this integration for policy, leadership, and future research in digital health? By addressing these questions, the study aims to contribute not only to the technical literature on system reliability but also to the long standing debates within evidence based medicine about how best to translate knowledge into practice (Straus et al., 2018; Montori & Guyatt, 2008).

The remainder of the article develops this argument in a structured yet continuous manner. Following this introduction, the methodology section outlines the interpretive synthesis approach used to analyze the diverse body of literature. The results section presents the main patterns that emerge from this synthesis, focusing on how error budgets and evidence based practice intersect at the levels of individual professionals, organizational processes, and system governance. The discussion then situates these findings within broader theoretical debates, critically examining both the promises and the pitfalls of integrating reliability engineering with clinical evidence. The conclusion reflects on the implications of this work for the future of digital health and outlines directions for further inquiry.

METHODOLOGY

The methodological approach adopted in this study is a qualitative interpretive synthesis designed to integrate heterogeneous bodies of literature into a coherent analytical framework. Given that the objective of the research is not to test a specific hypothesis but to develop a theoretically grounded understanding of how site reliability engineering and evidence based practice intersect, a narrative and conceptual synthesis is more appropriate than a statistical meta analysis (Trinder, 2000; Kajermo et al., 2010). This approach aligns with established practices in health services research and implementation science, where complex interventions and organizational phenomena are often best understood through the systematic interpretation of multiple sources of evidence (Grol & Grimshaw, 2003; Funk et al., 1995).

The primary conceptual anchor for the synthesis is provided by Dasari (2025), whose analysis of site reliability engineering practices for error budget management in large scale systems offers a detailed account of how reliability is operationalized and governed in contemporary digital infrastructures. This work is treated not as a purely technical text but as a theoretical contribution to the understanding of how organizations negotiate risk, performance, and change. The principles articulated by Dasari (2025), including the use of service level objectives, error budgets, and blameless postmortems, are interpreted through the lens of organizational theory and epistemology to identify their relevance for health care contexts.

In parallel, the study draws on a broad range of literature on evidence based practice, including foundational texts that define its epistemic and methodological commitments (Sackett et al., 1996; Straus et al., 2018), historical analyses of its development (Claridge & Fabian, 2005; Montori & Guyatt, 2008), and empirical studies of its implementation across different professional and cultural settings (Brown et al., 2009; Al-Almaie & Al-Baghli, 2004; Labrague et al., 2019). Particular attention is given to research on barriers and facilitators of evidence based practice, as these studies illuminate the organizational and behavioral dynamics that are most likely to interact with reliability engineering initiatives (Sadeghi-Bazargani et al., 2014; Shifaza et al., 2014; Williams et al., 2015).

The synthesis proceeds in three iterative stages. First, key concepts and themes are identified within each body of literature. In the case of site reliability engineering, these include reliability, availability, error budgets, service level objectives, and continuous improvement (Dasari, 2025). In the evidence based practice literature, central themes include the hierarchy of evidence, professional autonomy, organizational culture, and knowledge translation (Sackett et al., 1996; Grol & Grimshaw, 2003). Second, these themes are compared and contrasted to identify points of convergence and divergence. For example, both literatures emphasize the importance of measurement and feedback, but they differ in their assumptions about what should be measured and why. Third, an integrative framework is developed that reinterprets error budgets as a form of evidence and situates them within the broader ecology of clinical and organizational decision making.

Throughout this process, the synthesis is guided by principles of transparency and reflexivity that are widely endorsed in evidence based research (Straus et al., 2018; STROBE, 2022). Rather than treating the included studies as objective facts to be aggregated, the analysis acknowledges that each piece of evidence is produced within a particular methodological and institutional context that shapes its meaning and limitations. For example, surveys of nurses' attitudes toward evidence based practice may reveal important patterns of perception but may not capture the full complexity of organizational dynamics (Melnyk et al., 2012; Hamaideh, 2017). Similarly, technical analyses of system reliability may abstract away from the social processes through which reliability is negotiated and maintained (Dasari, 2025).

A key methodological challenge in this study is the integration of literatures that use different forms of evidence and standards of rigor. Clinical research often privileges randomized controlled trials and systematic reviews, while organizational and engineering research may rely more heavily on case studies, observational data, and performance metrics (Sackett et al., 1996; Dasari, 2025). Rather than attempting to impose a single hierarchy of evidence across these domains, the synthesis adopts a pluralistic stance that recognizes the validity of multiple forms of knowledge for different purposes. This approach is consistent with critiques of overly rigid interpretations of evidence based practice, which argue that professional judgment and contextual understanding are essential complements to empirical data (Trinder, 2000; Haynes et al., 2002).

The limitations of this methodological approach must also be acknowledged. Because the synthesis is based on existing literature rather than new empirical data, its conclusions are necessarily constrained by the scope and quality of the available studies. There is relatively little direct research on the application of site reliability engineering in health care, which means that some inferences must be drawn by analogy from other industries (Dasari, 2025). Furthermore, the evidence based practice literature is itself heterogeneous, with variations in definitions, measures, and contexts that complicate straightforward comparisons (Kajermo et al., 2010; Van Dijk et al., 2010). These limitations do not invalidate the synthesis but underscore the need for caution in generalizing its findings and for further empirical research to test and refine the proposed framework.

Despite these challenges, the interpretive synthesis method offers a powerful means of generating new insights at the intersection of technology and health care. By systematically juxtaposing the logics of reliability engineering and evidence based practice, the study seeks to illuminate underlying assumptions, reveal hidden tensions, and identify opportunities for more coherent and effective governance of digital health systems (Grol & Grimshaw, 2003; Dasari, 2025). The following sections present the results of this synthesis and explore their implications in detail.

RESULTS

The interpretive synthesis of site reliability engineering and evidence based practice literature reveals several recurring patterns that illuminate how reliability, evidence, and organizational behavior are intertwined in digital health systems. These patterns do not emerge as simple causal relationships but as complex configurations of practices, beliefs, and institutional structures that shape how both technical and clinical knowledge is produced and used (Brown et al., 2009; Dasari, 2025).

One of the most salient findings is that error budgets function as a form of organizational evidence that mediates between competing priorities. In the framework articulated by Dasari (2025), error budgets quantify the permissible level of system failure, thereby creating a shared reference point for decisions about whether to prioritize stability or innovation. This mirrors the role of clinical evidence in evidence based practice, where research findings provide a basis for weighing the benefits and risks of different interventions (Sackett et al., 1996; Straus et al., 2018). In both cases, evidence does not dictate decisions but structures the conversation by making trade offs explicit (Haynes et al., 2002; Dasari, 2025).

In health care organizations, this parallel suggests that reliability metrics can be integrated into the same deliberative processes that clinicians use to interpret clinical evidence. For example, when considering the rollout of a new decision support tool, leaders can weigh the expected clinical benefits against the potential impact on system reliability as reflected in the remaining error budget. This aligns with findings from implementation research that emphasize the importance of organizational readiness and stakeholder engagement in adopting new practices (Gale & Schaffer, 2009; Linton & Prasun, 2013). When reliability data are presented as part of a broader evidence based rationale for change, they are more likely to be perceived as legitimate and relevant by clinicians (Gerrish et al., 2008; Dasari, 2025).

A second pattern concerns the role of transparency and feedback. Site reliability engineering places strong emphasis on continuous monitoring, incident reporting, and blameless postmortems as mechanisms for learning from failure (Dasari, 2025). Similarly, evidence based practice relies on audit and feedback, performance measurement, and reflective practice to promote adherence to best evidence (Grol & Grimshaw, 2003; Funk et al., 1995). Studies of nursing and medical practice have shown that when feedback is timely, specific, and framed constructively, it can support the adoption of evidence based behaviors (Brown et al., 2009; Al Omari et al., 2009). The synthesis suggests that integrating reliability feedback into these existing channels can enhance their effectiveness by providing a more comprehensive picture of how systems and practices interact.

For instance, a recurring barrier to evidence based practice is the perception that new guidelines or protocols are disconnected from the realities of workflow and resource constraints (Sadeghi-Bazargani et al., 2014; Shifaza et al., 2014). Reliability data can make these constraints visible, showing how system performance affects clinicians' ability to access and apply evidence. When clinicians see that slow response times or frequent outages are being systematically measured and addressed through error budget governance, they may be more willing to engage with digital tools that support evidence based care (Hamaideh, 2017; Dasari, 2025).

A third pattern involves the negotiation of professional autonomy. Evidence based practice has often been criticized for imposing standardized guidelines that may conflict with clinicians' experiential knowledge and judgment (Trinder, 2000; Montori & Guyatt, 2008). Site reliability engineering, with its emphasis on service level objectives and compliance with predefined targets, can evoke similar concerns about technocratic control (Dasari, 2025). However, both literatures also highlight the importance of professional discretion in interpreting and applying evidence. Error budgets, by allowing teams to decide how to "spend" their allotted unreliability, create space for localized decision making within a shared governance framework (Dasari, 2025). This resonates with findings that nurses and physicians are more likely to adopt evidence based practices when they perceive them as compatible with their professional values and autonomy (Kajermo et al., 2010; Andersson et al., 2007).

The synthesis also reveals tensions that arise when quantitative metrics are privileged over qualitative judgments. Reliability engineering depends on numerical indicators such as uptime and error rates, while evidence based practice often grapples with outcomes that are difficult to quantify, such as patient satisfaction, quality of life, and professional competence (Straus et al., 2018; Labrague et al., 2019). When reliability targets are pursued in isolation, there is a risk that systems will be optimized for technical performance at the expense of clinical usability or patient centeredness. This mirrors critiques of evidence based medicine that warn against reducing complex clinical decisions to algorithmic rules (Trinder, 2000; Meakins, 2006). The results suggest that a balanced integration of reliability and evidence requires ongoing dialogue between technical and clinical stakeholders to ensure that metrics remain aligned with meaningful outcomes (Dasari, 2025; Williams et al., 2015).

Finally, the synthesis highlights the importance of organizational culture in shaping how both reliability and evidence are enacted. Studies across diverse settings consistently show that supportive leadership, access to resources, and a culture of learning are critical for the successful implementation of evidence based practice (Melnyk et al., 2012; Al-Almaie & Al-Baghli, 2004; Van Dijk et al., 2010). Site reliability engineering similarly depends on a culture that encourages reporting of errors, experimentation within limits, and continuous improvement (Dasari, 2025). Where these cultural elements are present, reliability metrics and clinical evidence can reinforce each other, creating virtuous cycles of learning and improvement. Where they are absent, both forms of evidence may be ignored or resisted, leading to stagnation or crisis (Gerrish et al., 2008; Dasari, 2025).

Together, these findings suggest that the integration of error budget management and evidence based practice is not merely a technical challenge but a deeply organizational and epistemic one. The next section explores these implications in greater theoretical depth.

DISCUSSION

The synthesis of site reliability engineering and evidence based practice literatures invites a reexamination of some of the most enduring debates in health care governance and professional practice. At its core, both traditions grapple with the problem of how to act responsibly in complex systems characterized by uncertainty, interdependence, and high stakes (Sackett et al., 1996; Dasari, 2025). By placing error budgets and clinical evidence in dialogue, it becomes possible to articulate a more nuanced understanding of how knowledge, risk, and authority are negotiated in digital health environments.

One of the most significant theoretical implications of this integration is the reframing of reliability as an epistemic as well as a technical property. In the classical view of evidence based medicine, the reliability of knowledge refers primarily to the methodological rigor of research, such as the internal validity of randomized trials or the absence of bias in systematic reviews (Sackett et al., 1996; Straus et al., 2018). Yet in a digital age, the reliability of the systems that deliver and operationalize this knowledge becomes equally critical. A perfectly designed guideline is of little value if it cannot be accessed at the point of care due to system outages or performance issues. Dasari (2025) implicitly acknowledges this by treating system reliability as a resource that must be managed and allocated, rather than assumed.

This perspective resonates with sociological critiques of evidence based medicine that emphasize the material and organizational conditions under which evidence is used (Trinder, 2000; Claridge & Fabian, 2005). From this standpoint, error budgets can be understood as a form of infrastructural evidence that shapes what kinds of clinical knowledge can be enacted in practice. When error budgets are generous and well managed, organizations can afford to experiment with new evidence based tools and workflows. When they are depleted, the organization must prioritize stability, potentially delaying the adoption of new evidence even if it promises clinical benefits (Dasari, 2025). This dynamic highlights a fundamental tension between the ideal of continuous improvement that animates evidence based practice and the pragmatic need to maintain reliable operations.

Another important theoretical issue concerns the politics of measurement. Both evidence based practice and site reliability engineering rely heavily on metrics, yet they differ in what they choose to measure and how those measurements are used. Clinical metrics often focus on outcomes such as mortality, morbidity, and adherence to guidelines, while reliability metrics focus on technical performance indicators (Brown et al., 2009; Dasari, 2025). The integration of these metrics raises questions about whose values are being prioritized and how trade offs are negotiated. For example, a system that achieves high uptime by restricting access to certain features may inadvertently limit clinicians' ability to apply the latest evidence, undermining the very goals of evidence based practice (Williams et al., 2015; Montori & Guyatt, 2008).

These tensions echo long standing debates about the standardization of care. Proponents of evidence based medicine have argued that standardized guidelines reduce unwarranted variation and improve quality, while critics warn that they can erode professional judgment and responsiveness to individual patient needs (Meakins, 2006; Trinder, 2000). Site reliability engineering introduces a similar dynamic by standardizing expectations of system performance through service level objectives and error budgets (Dasari, 2025). The challenge, in both cases, is to design standards that support rather than constrain meaningful practice. The synthesis suggests that this can be achieved by embedding metrics within participatory governance structures that allow clinicians and engineers to interpret and adjust them in light of evolving evidence and context (Gerrish et al., 2008; Dasari, 2025).

The discussion also illuminates the role of leadership and organizational learning. Evidence based practice research has repeatedly shown that top down mandates are insufficient to change behavior; instead, change is most effective when leaders foster environments that value inquiry, reflection, and collaboration (Grol & Grimshaw, 2003; Melnyk et al., 2012). Site reliability engineering similarly depends on leadership that supports blameless postmortems and continuous improvement rather than punitive responses to failure (Dasari, 2025). When these leadership styles converge, organizations are better positioned to integrate reliability data and clinical evidence into a coherent learning system that adapts over time.

At the same time, the integration of reliability engineering and evidence based practice raises ethical and practical concerns. There is a risk that error budgets could be used to justify tolerating levels of system failure that are unacceptable in a health care context, where even a single error can have grave consequences (Sadeghi-Bazargani et al., 2014; Hamaideh, 2017). Conversely, an overly cautious approach to reliability could stifle innovation and delay the implementation of new evidence based interventions that could improve patient outcomes. Navigating this balance requires not only technical expertise but also ethical deliberation and stakeholder engagement, reinforcing the need to situate reliability engineering within the broader normative framework of health care (Dasari, 2025; Haynes et al., 2002).

The limitations of the current synthesis also point to important directions for future research. Empirical studies are needed to examine how error budget practices are actually implemented in health care organizations and how they interact with existing evidence based initiatives. Comparative studies across different institutional and cultural contexts could shed light on how organizational culture mediates these interactions (Labrague et al., 2019; Van Dijk et al., 2010). There is also a need for methodological innovation to develop metrics that capture both technical reliability and clinical meaningfulness, bridging the gap between engineering and health services research (STROBE, 2022; Dasari, 2025).

CONCLUSION

The integration of site reliability engineering error budget management with evidence based practice frameworks offers a powerful lens for understanding and improving the governance of digital health systems. By recognizing reliability as a form of evidence and situating it within the epistemic and organizational traditions of evidence based medicine, health care leaders and researchers can move beyond simplistic dichotomies between technology and care. The analysis grounded in Dasari (2025) and the extensive evidence based practice literature demonstrates that reliability and evidence are mutually reinforcing when embedded in supportive cultures of learning, transparency, and professional engagement. As digital infrastructures continue to shape the future of health care, the deliberate co design of reliability engineering and evidence based implementation will be essential to realizing their full potential for patient centered, high quality care.

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