

Medical Surprise Anticipation and Recognition Capability: A New Concept for Better Health Care

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Abstract

Predicting and preparing for the unforeseen is challenging. Medicine and health care are continuously changing based on science, technology, and regulation. This very process of change creates pathways for surprise and leaves us vulnerable to its impact. The armed forces have established strategies to identify and address surprising events, a framework that can be adapted to benefit the medical community. We introduce Medical Surprise Anticipation and Recognition Capability (SARC), adapted from an established military strategy. SARC is the process of addressing surprising events before they emerge. We explore the framework for mitigating surprise as developed by the Committee on Capability Surprise on U.S. Naval Forces. We recommend further exploration of this concept in health care as a potential asset in our quest towards high reliability.

A Changing Landscape

The journey towards high reliability and quality in medicine has a new station to consider along its road—the capability to recognize and anticipate surprise. It is a necessary change outside of our current strategy to hardwire consistency. We currently function in a system where potential problems are already known, and we establish policies to avoid the known mistakes and tackle the known challenges. Nonetheless, the practice of medicine and the delivery of care is an ever-changing landscape. Society bears witness to an ongoing transition from anecdotal approaches at the bedside to evidenced-based practice supported by science and guidance from regulatory agencies and professional

organizations [1]. This system is vastly complex. Numerous entities regulate health care on the state and federal level, and policy is subject to change based on competing interests [2]. Furthermore, the traditional view of the physician as the primary provider has changed in recent years as increasing demand has called for further involvement of the advanced practitioner in primary care [3]. Even technological advancements, such as regenerative approaches to cure defects and disease [4], have altered the landscape. Nevertheless, there are challenges inherent to progress, the acquisition of new obstacles not yet seen or imagined.

Hopeful Change to Heartbreak

A story of hopeful change turned into a heartbreaking nightmare that reached headlines in late 2018 [5]. The story recounted the experience of multiple families whose children suffered life-altering disability and even death following cardiac surgery at a Florida-based children's hospital. Just a few years prior, many anticipated the program would advance with the new and incoming leadership. The transition period also included subsequent changes to the surgical and management teams. The heartbreak was evident when an investigation conducted by journalists exposed an unprecedented number of deaths. Within 18 months, there were at least eleven deaths, and within a matter of 2 years, the program's death rate tripled. The investigation revealed there were medical staff concerns, from whispers to outright reporting to leadership. Operations continued, albeit less complex, despite vocalization of staff.

Following the publication, top leadership resigned [6], and a federal inspection revealed management issues and shortcomings in quality assurance and infection control [7]. Within months, a state bill was signed into law granting increased oversight of pediatric cardiac surgery programs that would allow the state's advisory panel of physicians to inspect and incorporate quality control measures for programs in need [8, 9]. A tale of heartbreak it was indeed, and questions regarding the circumstances of this tragedy were insurmountable. We are left to ponder, could a program slated to endure numerous changes could have applied strategies to anticipate and recognize potential crises before they occurred?

Medical Error and High Reliability

Making mistakes is a part of the flawed human experience. This viewpoint is essential in medicine where devastating consequences of medical errors can evoke a strong emotional response that seeks to only blame human error at the cost of identifying the dysfunctional system where the mistake occurred [10]. In 1999, the landmark report *To Err is Human* was published by the National Academy of Medicine (NAM) to establish a national agenda for decreasing medical error and improving patient safety [11]. James Reason's Swiss cheese model of system accidents further explains how errors reach patients [10]. It requires a breakdown in each layer of defense, causing the holes in a system to directly align in one instance to create a direct pathway for mistakes to reach victims and cause harm.

Thus, if error is inherent to the human condition, are safe systems achievable? The answer to this question is an emphatic yes as human failures are likely the consequence of a condition, rather than the primary cause [12]. Furthermore, high stakes industries, such as nuclear power and commercial air travel, have managed to establish high reliability organizations (HROs) [13]. Researchers have studied how organizations that are inherently complex and hazardous manage to conduct safe operations that are highly reliable, a system where operations continue for long periods avoiding failures and catastrophes [14, 15]. According to Weick and Sutcliffe, HROs have five core principles. They include monitoring minor failures, avoiding oversimplification, remaining focused and sensitive to operations, commitment to resilience, and deference to expertise [16]. The establishment of an HRO within hospitals and health care remains a tall order, and according to the Joint Commission, has yet to be achieved [13].

A Reactive Paradigm

Medical practice has a history rooted in establishing change after adverse outcomes—a reactive paradigm [1]. This strategy has its merits; it is an impetus for change. Furthermore, the adoption of this system underscores the complexity inherent to medical practice; the challenges are so numerous that we deal with them as they occur. In our constant pursuit for advancement, we are witnessing a continual shift towards proactive measures. In response, we have sought strategies from various industries, even the seemingly unrelated, to help us adapt [17]. The conventional wisdom is only relevant to the time in which it exists, and the field demands constant analysis and scrutiny of our current practice. However, we do not need to reinvent the wheel and we can directly borrow from an established industry. The candidate field should be rigorous, require strategic planning, and necessitate rapid decision making while burdened with life or death circumstances. An important and perhaps undervalued source of wisdom is our armed forces. They practice strategies that foster resilience in the face of unpredictability. Resilient institutions possess intrinsic factors and coping mechanisms that render resistance to adverse events [18]. We stand to learn from their approach to the changing times.

A New Concept in Health Care

We believe that for our learning health care system to move to next levels, we must not only react to information provided to us, not only anticipate new and obvious developments, but analyze, assess, and prepare for incidents and circumstances that may come from nowhere and, in effect, surprise. We introduce Medical Surprise Anticipation and Recognition Capability (SARC), a term we first describe here, merging concepts found in military strategy to predict and prepare for surprising events before they emerge. It is a new strategy for the medical community to begin to consider, and a likely asset for our long journey to high reliability.

A “capability surprise” occurs when an opponent obtains a new capability or strategy that catches the victim off guard [19, 20]. Surprise has the potential to cripple entire institutions and result in the loss of life. Similar to the military, the medical community is vulnerable to the impact of surprise.

An important distinction is we do not suggest that there are nefarious entities in medicine seeking to in-

flict surprise. Instead, we consider that the very process of change and advancement in medicine creates pathways for surprise. The goal is to create a new paradigm of thinking where challenges, particularly challenges that would not immediately come to mind, are predicted and managed before coming to light. This capability for identifying surprise represents the next frontier along the journey to more reliable health care with improved outcomes.

Defining Surprise

In 2008, the Defense Science Board convened to study capability surprise—an adversarial advantage obtained through exploiting developments in science, technology, and operations with the intent to inflict surprise on a victim who is not prepared. Inherent to surprise is unpredictability. Technological innovation and globalization further complicate predicting the unforeseen—historical examples of surprise include Pearl Harbor and 9/11 [19].

Surprise is unavoidable and appears even with improved data collection, better analysis, and advanced decision-making [21]. Importantly, at the heart of SARC is to:

1. Reduce the number of surprising events through planning.
2. Develop strategies that establish resilience when confronted with surprise.
3. Improve capabilities to coordinate a timely and effective response when unimagined circumstances occur [22].

Surprise is inevitable in medicine and related fields. It can be an unexpected outbreak of a disease (Infection Surprise), a rapidly evolving new climate pattern (Climate Surprise), or a mass casualty incident (Trauma Surprise). The primary objective is to adopt strategies to mitigate, not eliminate, surprise [22].

The nomenclature of surprise further elucidates how surprise manifests. From the military experience, there are two types of surprise [19]. A “known” surprise emerges, even when there are indications of an impending event, as a result of inadequate preparation. In our experience, most medical systems do not take the time to work to forward predict known surprise. A “surprising” surprise is genuine. However, the Defense Science Board has acknowledged that surprising events are rare. Someone usually anticipates a potential surprise, but there is a failure to intervene when

there is system burden, and the potential impact is ambiguous.

From the military experience, there are two classes of surprise [22]. Intelligence-inferred surprise develops over a long period, such as years. The organization is aware of the projected threat, continuously monitors, and yet there is an insufficient response. Disruptive technology and tactical surprise can develop within hours to months and establishing timely countermeasures may not be feasible. In medicine, disruptive technologies can include new clinical treatment paradigms, new equipment, and even the introduction of new staff. In the military, there are two variants of disruptive technology and tactical surprise. A “pop-up” event occurs when an adversary exploits new technology or applies known technology in a new way to create surprise. A “black swan” event occurs due to weaknesses within your system and is self-induced. The parallels with the medical profession and clinical care are clear.

Surprise impacts at all levels, from the individual to the institution. At the military operations level, soldiers are trained to encounter and manage surprise [19]. Inasmuch, bedside practice is fraught with surprise; disease management is unpredictable and obviates adapting accordingly. In professions where risk is the essence of the field, there is great reliance on individual resilience [23], and the ability to maintain “equanimity under duress” [24].

Moreover, the Board acknowledged that the military has struggled to deal with surprise at the strategic and institutional level. Personal actions in everyday practice can mitigate surprise, but effective planning and execution of strategies must come from higher planning agencies as surprise can emerge from “operational, social, natural, and political factors” [22]. There is an emphasis on leadership to understand surprise and to ensure organizational preparedness [19].

There are multiple reasons for surprise. Most importantly, it is merely the nature of the job both in the military and in medicine. Unforeseen events manifest under all conditions and organizational dysfunction further exacerbates. The internal conditions include a failure to adapt and think critically, inability to predict the impact, lack of attention to issues concealed, consensus-seeking behavior or groupthink, denial of facts that are not politically convenient, optimizing plans without regard for long-term outcomes, and organizational hubris [19, 20]. Furthermore, the Board acknowledges that a failure to imagine surprising events is only part of the story. Instead, it is the failure to decide

which surprising events to act on and to what extent. “There is no systematic mechanism in place...to help decide which events to act on aggressively, which to treat to a lesser degree, and which to ignore, for the time being” [19].

Six Phases for Surprise Mitigation

The Committee on Capability Surprise on U.S. Naval Forces outlines six phases for surprise mitigation that include (1) scanning and awareness, (2) assessing surprise, (3) prioritization, option development, and decision formulation, (4) resource and transition planning, (5) implementation and fielding, and (6) force response. This framework functions as a continuum, and each phase is necessary to anticipate and react to surprise. The defined strategies are useful throughout several stages [22].

The first phase—scanning and awareness—mandates continuous surveillance for a potential surprise. It requires a multi-disciplinary approach. One organization does not possess every method needed to detect surprise, and involving several disciplines engages versatile strategies to gather intelligence. The outputs obtained from this phase are passed along. Phase two—assessing surprise—prioritizes the potential surprises. This phase exploits strategies such as modeling and simulation, analysis, and red teaming. Modeling and simulation are tools used for detecting system vulnerabilities and capabilities. Within the naval forces, this method involves the coordination of several disciplines such as basic physics, engineering design, mission planning, training, and intelligence gathering [22].

Red teaming has not been explicitly described in medicine. Industries such as finance and business have already exploited the practice to their benefit [25]. Traditionally, red teaming is the process of assuming the mindset of the enemy to identify weaknesses in the blue team or current strategy as a way to construct countermeasures before potential defeat. Red teaming has played a role in military strategy that dates back to the Cold War. Recent adaptations of red teaming have accepted a broader definition of the practice as “a methodology that enables organizations to view their own vulnerabilities and challenge assumptions” [25]. Red teams are not established to deem current wisdom wrong. After all, most strategies are vetted before implementation. Instead, the goal is to consider other possibilities [21]. The red team should have independence to assess vulnerabilities and access to experts in academia and industry to brainstorm solutions [22].

Phase three—prioritization, option development, and decision formulation—requires conceptualizing and exhausting numerous solutions for the potential surprise. The organization should consider how surprise will manifest, and how surprise will affect their functionality. After obtaining solutions, phase four—resource and transition planning—identifies the sectors tasked with delivering the new strategy. This phase also considers the budget and resources necessary to execute the plan. The first four phases identify potential surprise and assign priority [22].

Phase five—implementation and fielding—is variable and greatly influenced by the findings of the previous four. The deployment of a new capability should emerge from this phase. As a caution, the Committee advises against establishing partial or easily obtainable solutions and advocates exhaustive assessment before implementation. The final phase—force response—analyzes the organization’s readiness for surprise. There are two tiers of readiness at the individual and system level. Progression through each phase requires an awareness of common pitfalls. They include denial of a surprising event, misunderstanding of its impact, an embarrassment that the organization was surprised, and refusal to admit mistakes [22].

Equity in Health Care

Quality care is a prerequisite for equitable care and equitable care is a prerequisite for quality care. Persistent inequities in care naturally raises concerns about the overall quality [26]. Equitable health care is amongst the six aims for health care improvement identified by the NAM. At the population level, equity aims to reduce disparities amongst specific groups and provide universal access. At the individual level, equity implies fair treatment by health institutions with appropriately available services and quality services that are distributed based on personal need rather than individual characteristics [27]. However, the quality chasm previously described by the NAM can be considered a gulf for specific groups within our population [26]. We anticipate that overall advancement in the care we deliver will translate to benefit all patients, especially racial and ethnic minorities who face unique challenges.

Future Perspectives

This military framework offers solutions and concurrently raises questions. How can we adopt this strategy in medicine and health care? We have already learned that the very practice of this model should come from the top, but to be truly effective, there must be buy-in

by all. That includes regulatory agencies, professional organizations, and hospital systems. Numerous advancements within our progressive field have left us vulnerable to surprise. We believe that the implementation of this framework can provide tools to mitigate even the extreme and low probability phenomenon, and thus provide a new paradigm for achieving improved health care.

References

1. Federation of Medical Regulatory Authorities of Canada. *Federation of State Medical Boards. Medical Regulatory Authorities and the Quality of Medical Services in Canada and the United States* [Internet]. New York, NY: Milbank Memorial Fund; 2008 [cited 2019 Apr 2]. Available from: <https://www.milbank.org/wp-content/files/documents/0806MedServiceCanada/0806MedServicesCanada.pdf>
2. Field, R. I. *Why is health care regulation so complex?* P T. 2008 Oct;33(10):607–8.
3. Institute of Medicine. *The Future of Nursing: Leading Change, Advancing Health* [Internet]. Washington, DC: The National Academies Press; 2011. Available from: <https://doi.org/10.17226/12956>.
4. Laurencin, C., and L. Nair. *Next Generation Devices and Technologies Through Regenerative Engineering*. In: Shorey R, Purnendu G, editors. *Healthcare Engineering: Proceedings of CAETS 2015 Convocation on Pathways to Sustainability*. Singapore: Springer Nature; 2017. p. 21–8.
5. McGrory, K., and N. Bedi. *HeartBroken* [Internet]. Tampa Bay Times. 2018 [cited 2019 Jul 17]. Available from: <https://www.tampabay.com/projects/2018/investigations/heartbroken/all-childrens-heartinstitute/>
6. McGrory, K., and N. Bedi. *Top All Children's executives resign following Times report on heart surgeries* [Internet]. Tampa Bay Times. 2018 [cited 2019 Jul 17]. Available from: <https://www.tampabay.com/investigations/2018/12/11/top-all-childrens-executivesresign-following-times-report/>
7. Bedi, N., and K. McGrory. *Regulators still not satisfied with All Children's progress* [Internet]. Tampa Bay Times. 2019 [cited 2019 Jul 17]. Available from: <https://www.tampabay.com/investigations/2019/05/01/regulators-still-not-satisfied-with-allchildrens-progress/>
8. McGrory, K. and E. Koh. *Lawmakers approve measure to catch pediatric heart surgery problems* [Internet]. Tampa Bay Times. 2019 [cited 2019 Jul 17]. Available from: <https://www.tampabay.com/floridapolitics/buzz/2019/04/29/lawmakers-approve-measure-to-catchpediatric-heart-surgery-problems/>
9. McGrory, K. and N. Bedi. *Extra oversight for children's heart surgery signed into law* [Internet]. Tampa Bay Times. 2019 [cited 2019 Jul 17]. Available from: <https://www.tampabay.com/investigations/2019/06/26/extra-oversight-for-childrens-heart-surgery-signedinto-law/>
10. Reason, J. Human error: models and management. *BMJ*. 2000;320: 768–70.
11. Institute of Medicine. *To Err is Human: Building a Safer Health System* [Internet]. Washington: The National Academies Press; 2000. Available from: <https://doi.org/10.17226/9728>.
12. Reason, J. *Managing the Risk of Organizational Accidents*. Burlington: Ashgate; 1997.
13. Chassin, M. R., and J. M. Loeb. *High-Reliability Health Care: Getting There from Here*. MilBank Q. 2013;91(3):459–90.
14. Rochlin, G. I. Reliable Organizations: Present Research and Future Directions. *Journal of Contingencies and Crisis Management*. 1996;4(2):55–9.
15. Roberts, K. H. New challenges in organizational research: high reliability organizations. *Industrial Crisis Quarterly*. 1989;3:111–25.
16. Weick, K. and K. Sutcliffe. *Managing the Unexpected*. 2nd ed. San Francisco: Josey-Bass; 2007.
17. Hughes, R. G. *Tools and Strategies for Quality Improvement and Patient Safety* [Internet]. Hughes R, editor. *Patient Safety and Quality: An Evidence-Based Handbook for Nurses*. Rockville (MD): Agency for Healthcare Research and Quality (US); 2008 [cited 2019 Apr 2]. p. ch. 44. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK2682/>
18. Carthey, J., M. R. De Leval, and J. T. Reason. Institutional resilience in healthcare systems. *Quality in Health Care*. 2001;10:29–32.
19. Defense Science Board. *Report of the Defense Science Board 2008 Summer Study on Capability Surprise Volume I: Main Report* [Internet]. Washington, DC; 2009 [cited 2019 Mar 7]. Available from: <https://www.acq.osd.mil/dsb/reports/2000s/ADA506396.pdf>
20. Mills, C. and P. Goon. *PAK-FA, F-35, F-22, and Capa-*

- bility Surprise* [Internet]. 2010 [cited 2019 Apr 10]. Available from: <http://www.ausairpower.net/APA-NOTAM-230210-1.html>
21. Cancian, M. F. *Coping with Surprise in Great Power Conflicts*. Lanham: Rowman Littlefield; 2018.
 22. National Research Council. *Responding to Capability Surprise: A Strategy for U.S. Naval Forces* [Internet]. Washington: The National Academies Press; 2013. Available from: <https://doi.org/10.17226/14672>.
 23. Vincent, C., and R. Amalberti. *Safer healthcare: Strategies for the real world*. Cham: Springer; 2016.
 24. Harris, H. R. *Howard's legendary LaSalle Leffall still going strong at 85* [Internet]. The Washington Post. 2015 [cited 2019 Jul 24]. Available from: <https://www.washingtonpost.com/news/local/wp/2015/05/19/howards-legendary-dr-lasalle-leffall-stillgoing-strong-at-85/>
 25. Kardos, M. and P. Dexter. *A Simple Handbook for Non-Traditional Red Teaming* [Internet]. Joint and Operations Analysis Division; 2017 [cited 2019 Mar 7]. Available from: <https://apps.dtic.mil/dtic/tr/fulltext/u2/1027344.pdf>
 26. Mayberry, R. M., D. A. Nicewander, H. Qin, and D. J. Ballard. Improving quality and reducing inequities: a challenge in achieving best care. *Baylor University Medical Center Proceedings* 2006;19(2):103–18.
 27. Institute of Medicine. *Crossing the Quality Chasm: A New Health System for the 21st Century* [Internet]. Washington: The National Academies Press; 2001. Available from: <https://doi.org/10.17226/10027>.

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