BJCMR Brazilian Journal of Clinical Medicine and Review

PCAA PUBLICAÇÕES CIENTÍFICAS DE ACESSO ABERTO

Perspective

Chain of Prevention versus Chain of Survival: Reframing Hospital Safety from Rescue to Anticipation

Esmael Tomás [1,2,3,*], Ndenga Tomás [2,3]

[1] NOVA National School of Public Health, Comprehensive Health Center (CHRC), NOVA University Lisbon, Lisbon, Portugal.
[2] Faculty of Medicine, University Agostinho Neto, Luanda, Angola.
[3] Sagrada Esperança Clinic, Luanda, Angola.

* Correspondence: ef.tomas@ensp.unl.pt.

Abstract: The "Chain of Survival" has become one of the most influential conceptual models in resuscitation medicine, emphasizing early recognition of cardiac arrest, rapid activation of emergency systems, immediate cardiopulmonary resuscitation, defibrillation and advanced post-resuscitation care. Although this approach has contributed substantially to improvements in cardiac arrest outcomes worldwide, evidence suggests that many in-hospital cardiac arrests are preceded by hours of detectable physiological deterioration. Consequently, increasing attention has shifted toward prevention-oriented models, particularly the "Chain of Prevention", which prioritizes early detection of deterioration before catastrophic events occur. This Perspective argues that the Chain of Prevention and the Chain of Survival should be viewed as complementary components of a unified continuum of care and examines the implications of this integrated perspective for patient safety, resuscitation science and healthcare system design. It further proposes that modern healthcare systems should evolve from predominantly reactive rescue-based paradigms toward integrated anticipatory systems capable of identifying, escalating and treating clinical deterioration at earlier stages. The article further examines the role of Early Warning Systems, rapid response teams, implementation science and health-system organization in operationalizing prevention-based models, particularly in low- and middle-income countries. Finally, the article proposes that the future of resuscitation science depends not only on improving survival after cardiac arrest but increasingly on reducing the incidence of preventable cardiac arrest itself.

Keywords: Chain of Prevention; Chain of Survival; Early Warning Systems; Rapid Response Systems; Clinical Deterioration; Patient Safety; Cardiac Arrest.

Citation: Tomás E, Tomás Ndenga. Chain of Prevention versus Chain of Survival: Reframing Hos-pital Safety from Rescue to Anticipation. Brazilian Journal of Clinical Medicine and Review. 2026:Jan-Dec;4(1):bjcmr67.

https://doi.org/10.52600/2763-583X.bjcmr.2026.4.1.bjcmr67

Received: 30 May 2026
Accepted: 25 June 2026
Published: 29 June 2026

Copyright: This work is licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0).

1. Introduction

Few conceptual models in medicine have achieved the global recognition and practical influence of the Chain of Survival [1]. Initially developed to improve outcomes after sudden cardiac arrest, the model emphasized the importance of sequential and time-sensitive interventions including early recognition, rapid activation of emergency response systems, immediate cardiopulmonary resuscitation (CPR), defibrillation and advanced life support [1,2]. Since its introduction by the American Heart Association (AHA), the model has transformed resuscitation training, public health initiatives and emergency cardiovascular care systems worldwide, becoming a foundational element of resuscitation practice and guideline development [3,4].

The Chain of Survival emerged during a period when resuscitation science focused predominantly on improving outcomes after cardiac arrest had already occurred [1,2].

The central question was how to optimize rescue after cardiac arrest in order to improve survival and neurological outcomes [1,5]. However, over the past three decades, accumulating evidence has demonstrated that many in-hospital cardiac arrests are not sudden unpredictable events but rather the final stage of progressive physiological deterioration that often remains unrecognized or inadequately managed [6–9].

Studies consistently show that abnormalities in respiration rate, oxygen saturation, blood pressure, heart rate and level of consciousness are frequently present hours before catastrophic deterioration [6,8,9]. These findings fundamentally changed the understanding of hospital cardiac arrest by reframing it not merely as an isolated emergency event but as the consequence of failures in surveillance, recognition, communication and timely escalation of care within healthcare systems [5,10,11]. In this context, the concept of the Chain of Prevention emerged as a complementary paradigm emphasizing the identification and management of clinical deterioration before cardiac arrest occurs, thereby reframing the focus from rescue after collapse to prevention of deterioration through surveillance, recognition and timely response [5,10]. While the Chain of Survival seeks to optimize rescue after collapse, the Chain of Prevention seeks to prevent collapse itself [5]. This conceptual evolution reflects a broader transformation in patient safety and healthcare quality [12,13]. Modern healthcare systems are increasingly judged not only by their capacity to rescue critically ill patients but also by their ability to anticipate deterioration, prevent avoidable harm and reduce Failure-to-Rescue events [14,15].

The present Perspective discusses the conceptual relationship between the Chain of Survival and the Chain of Prevention, explores their implications for contemporary healthcare systems and argues that prevention-oriented approaches may represent the next major frontier in resuscitation science. More importantly, we propose an Integrated Continuum of Rescue and Prevention (ICRP), a unified operational framework that links surveillance, recognition, escalation, rescue and recovery into a single patient-safety pathway. This framework seeks to move beyond the conceptual separation of prevention and resuscitation by explicitly identifying the organizational interfaces through which failures in anticipation evolve into failures of rescue.

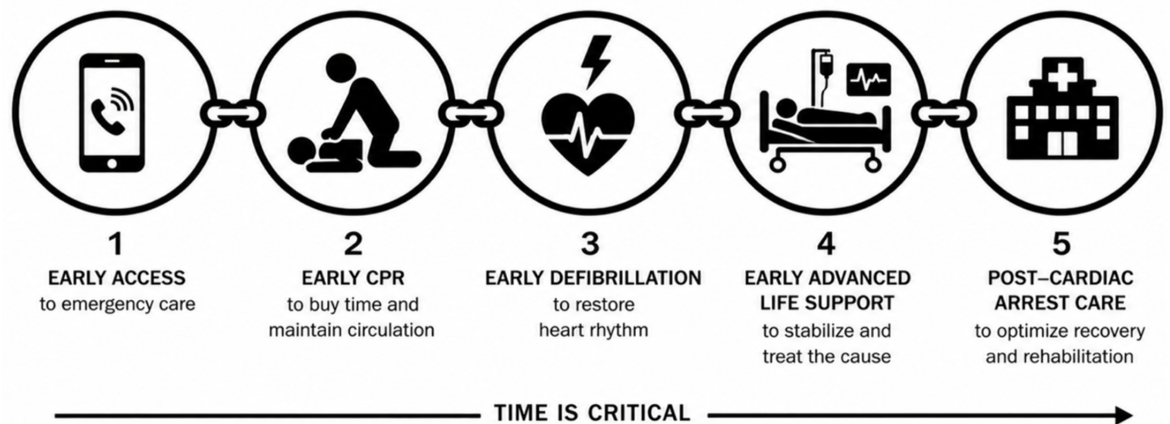
2. The Chain of Survival: A Revolutionary Rescue Framework

The Chain of Survival represented one of the most important advances in emergency cardiovascular care during the late twentieth century (Figure 1), providing a structured framework for improving outcomes after cardiac arrest through coordinated, time-sensitive interventions [1,2]. The original model incorporated four essential components: early access to emergency care, early CPR, early defibrillation and early advanced cardiac life support [1].

Subsequent iterations expanded the approach to include post-cardiac arrest care, targeted temperature management, rehabilitation and systems-level implementation strategies [16,17]. The impact of the Chain of Survival extended far beyond clinical practice, informing public CPR training programs, the widespread deployment of automated external defibrillators (AEDs) and the development of coordinated emergency medical systems [2,18].

Importantly, the Chain of Survival established several principles that remain central to modern emergency medicine: time-critical intervention improves outcomes, systems organization matters, standardized protocols improve reliability and education, and implementation are as important as technology [1,3,4]. Despite its enormous contribution to resuscitation science, the Chain of Survival remains fundamentally reactive, as it is activated only after cardiac arrest has occurred [5,9]. Consequently, even optimal execution of its individual links may be insufficient when progressive physiological deterioration has advanced beyond a reversible stage [5,9]. This limitation became increasingly apparent within hospital environments, where many arrests were found to be potentially preventable [8].

Figure 1. The Chain of Survival.



Adapted from Cummins et al. [1] and contemporary resuscitation guidelines [16,17].

3. Clinical Deterioration and the Emergence of the Chain of Prevention

Research during the 1990s and early 2000s demonstrated that most patients experiencing in-hospital cardiac arrest exhibit abnormal physiological signs before collapse [6,8,9]. Schein et al. showed that significant abnormalities in vital signs frequently precede cardiac arrest by several hours [9]. Similar observations were reported across multiple healthcare systems and patient populations, consistently demonstrating that physiological deterioration frequently precedes in-hospital cardiac arrest, unplanned intensive care unit admission and death [6–8]. These findings challenged the traditional view of cardiac arrest as a sudden, unpredictable event, revealing that it is frequently preceded by a recognizable pattern of physiological deterioration.

Smith subsequently proposed the concept of the Chain of Prevention as a conceptual extension of the Chain of Survival [5]. The model emphasized five interconnected elements: staff education, monitoring, recognition of deterioration, calling for help and appropriate clinical response [5]. These independent components are illustrated in Figure 2.

Although the Chain of Prevention represented a major conceptual advance, it remained primarily a descriptive framework. While it identified the critical stages preceding cardiac arrest, it did not explicitly define how prevention systems interact with rescue systems once deterioration progresses beyond reversible thresholds. Consequently, an important conceptual gap remains regarding the operational interface between prevention-oriented and rescue-oriented care pathways. Unlike the Chain of Survival, which focuses on rescue after collapse, the Chain of Prevention focuses on preventing collapse through earlier intervention [5].

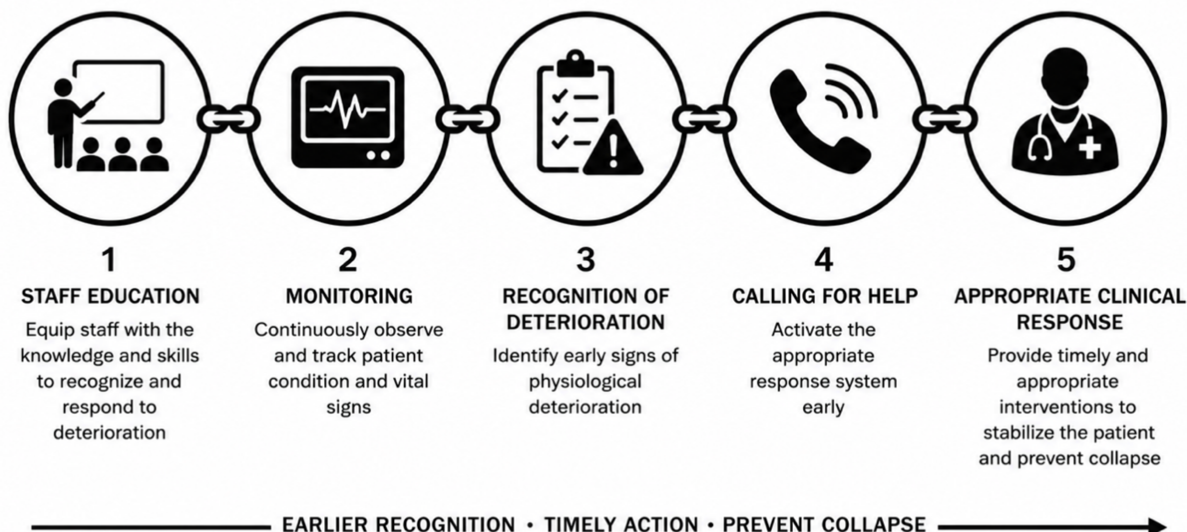
The conceptual distinction is highly significant: the Chain of Survival focuses on rescue after cardiac arrest, whereas the Chain of Prevention focuses on preventing cardiac arrest through the early recognition and management of clinical deterioration. This shift parallels broader developments in public health and patient safety, where prevention is increasingly prioritized over late-stage rescue.

4. Early Warning Systems as Operational Tools of the Chain of Prevention

The operationalization of the Chain of Prevention became possible largely through the development of Early Warning Systems (EWS), which aggregate routinely measured physiological variables into structured scores linked to predefined escalation pathways [19,20]. Among the most influential models is the National Early Warning Score 2 (NEWS2), developed by the Royal College of Physicians in the United Kingdom, which combines measured physiological parameters, including respiration rate, oxygen satura-

tion, systolic blood pressure, pulse, temperature and level of consciousness, into a standardized risk score linked to predefined clinical escalation pathways [20,21].

Figure 2. The Chain of Prevention.



Adapted from Smith [5].

Early Warning Systems function primarily within the afferent arm of Rapid Response Systems, facilitating physiological surveillance, risk recognition, standardized communication and escalation of care [10,11]. The effectiveness of these systems depends not only on predictive accuracy but also on organizational capacity to respond appropriately and in a timely manner to signs of clinical deterioration [11,22,23]. Accurate detection without timely intervention provides limited clinical benefit.

Consequently, modern resuscitation science increasingly recognizes that preventing hospital cardiac arrest requires integrated socio-technical systems involving monitoring infrastructure, workforce training, escalation protocols, rapid response teams, safety and leadership support [10,11]. The transition from rescue-oriented models toward prevention-oriented systems therefore reflects a broader system-based understanding of patient deterioration.

5. Human Factors and Implementation Challenges

Despite widespread adoption, Early Warning Systems frequently fail to achieve their anticipated clinical impact because physiological detection alone does not guarantee effective action. Implementation studies have identified several recurring barriers, including alarm fatigue, clinical inertia, professional hierarchy, communication failures and excessive cognitive workload. Alarm fatigue may occur when repeated alerts desensitize healthcare professionals, increasing the risk that genuine deterioration signals are ignored [24]. Similarly, clinical inertia arises when deterioration is recognized but escalation is delayed because staff underestimate risk or assume that another team member will intervene.

Professional hierarchy may further impede escalation, particularly when junior nurses identify deterioration but feel reluctant to challenge senior clinicians. These behavioral and organizational barriers illustrate that patient deterioration is not merely a physiological phenomenon but a socio-technical challenge requiring both technological and cultural solutions [25,26].

6. Implementation Science and Organizational Readiness

The Consolidated Framework for Implementation Research (CFIR) provides a useful framework for understanding why Early Warning Systems succeed in some organizations and fail in others [27]. Factors such as leadership engagement, implementation of climate, organizational readiness, communication structures and workforce capability may influence outcomes as strongly as the predictive performance of the scoring system itself [27]. Consequently, successful implementation requires not only accurate monitoring tools but also institutional commitment to timely escalation and response.

Table 1. Common Barriers to Effective Chain of Prevention Implementation and Potential Mitigation Strategies.

Barrier	Operational Consequence	Potential Mitigation
Alarm fatigue	Missed deterioration signals	Tiered alert systems
Clinical inertia	Delayed escalation	Mandatory escalation protocols
Professional hierarchy	Suppressed communication	Structured escalation authority
Workforce shortages	Inadequate surveillance	Task-sharing and simplified workflows
Poor safety culture	Failure to activate response systems	Leadership engagement and training

As illustrated in Table 1, many of the challenges associated with clinical deterioration arise from interactions between human behaviour, organizational culture and system design rather than deficiencies in physiological monitoring alone. Consequently, successful implementation of the Chain of Prevention requires a broader systems perspective that integrates technological tools with workforce development, leadership engagement and institutional readiness.

7. Chain of Prevention and Failure-to-Rescue

The concept of Failure-to-Rescue (FTR) provides an important theoretical framework linking the Chain of Prevention to healthcare quality and is defined as death following a complication that was not recognized or managed effectively [15,28]. Importantly, FTR emphasizes organizational performance rather than disease severity alone, as hospitals with comparable complication rates may demonstrate substantially different mortality outcomes depending on their capacity to recognize and respond effectively to clinical deterioration [15,28].

The Chain of Prevention directly addresses the mechanisms underlying Failure-to-Rescue, including failures in monitoring, recognition of deterioration, communication, escalation of care and timely clinical intervention [5,25]. Thus, the Chain of Prevention should not be viewed merely as an extension of resuscitation science but as a broader patient-safety framework. This perspective aligns closely with Donabedian's Structure–Process–Outcome model, where organizational structures influence surveillance processes which ultimately determine patient outcomes [29,30].

8. Reframing Failure-to-Rescue Across the Continuum

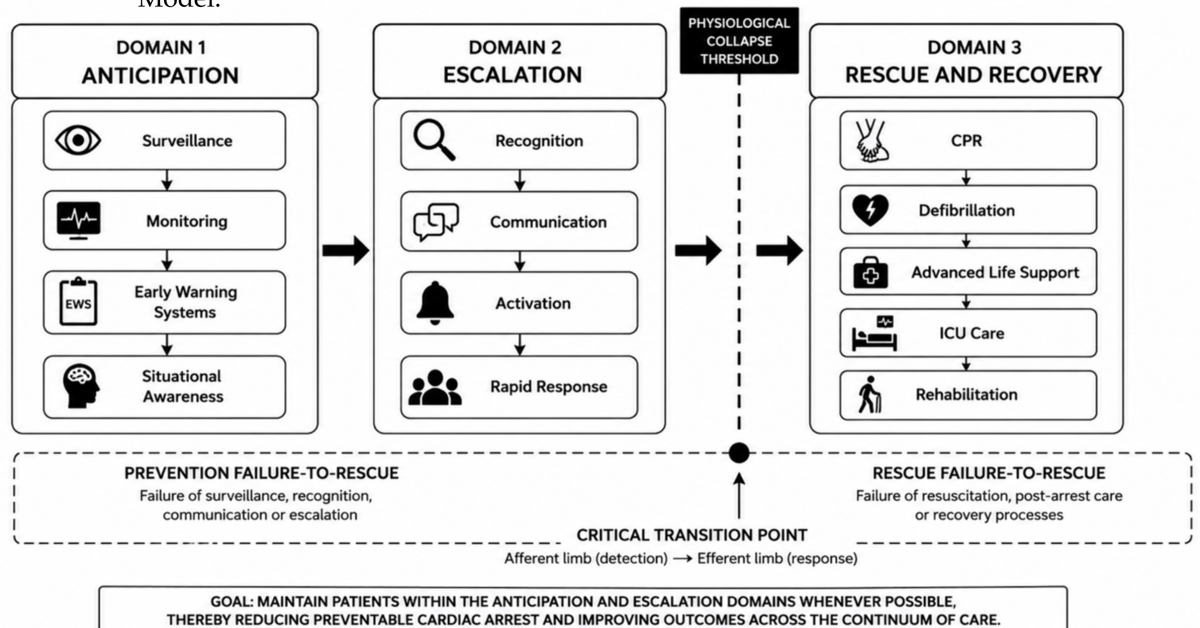
Failure-to-Rescue has traditionally been defined as death following a complication that was not recognized or managed effectively [15,28]. However, within the context of an integrated continuum, Failure-to-Rescue may arise through failures occurring either before or after physiological collapse. Prevention Failure-to-Rescue refers to failures occurring within the Chain of Prevention, including inadequate monitoring, failure to recognize deterioration, delayed communication and delayed escalation of care [15,28]. Rescue Failure-to-Rescue refers to failures occurring after collapse, including delays in cardiopulmonary resuscitation, defibrillation, advanced life support or post-cardiac arrest management [15,28].

Failure-to-Rescue definitions and performance metrics vary substantially across surgical, medical and oncological populations owing to differences in complication profiles and deterioration trajectories. Consequently, specialty-specific calibration may be required when applying continuum-based Failure-to-Rescue metrics. Distinguishing between these two domains may allow healthcare organizations to better identify where patient-safety vulnerabilities occur and design more targeted quality-improvement interventions.

9. The Integrated Continuum of Rescue and Prevention

Rather than representing independent frameworks, the Chain of Prevention and the Chain of Survival can be conceptualized as sequential components of a single Integrated Continuum of Rescue and Prevention (ICRP). The Integrated Continuum of Rescue and Prevention is illustrated in Figure 3 and conceptualizes hospital safety as a continuous pathway extending from anticipation of clinical deterioration through escalation of care, rescue interventions and recovery.

Figure 3. Integrated Continuum of Rescue and Prevention (ICRP): A Three-Domain Model.



Unlike previous frameworks, the ICRP explicitly identifies the transition between the afferent limb of deterioration detection and the efferent limb of clinical response as a distinct operational domain. By framing Failure-to-Rescue as a continuum phenomenon rather than an isolated outcome, the model provides a practical structure for quality improvement, implementation assessment and resource allocation across the entire patient-safety pathway.

- Domain 1 (Anticipation) encompasses surveillance, monitoring, Early Warning Systems and situational awareness.
- Domain 2 (Escalation) includes recognition of deterioration, communication, activation of support systems and rapid clinical response.
- Domain 3 (Rescue and Recovery) comprises cardiopulmonary resuscitation, defibrillation, advanced life support, intensive care and rehabilitation.

The interface between the afferent limb of deterioration recognition and the efferent limb of clinical response represents a critical transition point within the continuum and a common source of Failure-to-Rescue events. The model proposes that the Chain of Prevention and the Chain of Survival should be understood as interconnected components of a unified operational framework rather than separate paradigms. The transition between Domains 2 and 3 may represent the most important target for future quality-improvement initiatives because failures at this interface frequently determine whether deterioration remains reversible or progresses to cardiac arrest.

10. Implications for Low- and Middle-Income Countries

The relevance of the Chain of Prevention may be especially pronounced in resource-limited healthcare systems. Resource-constrained hospitals cannot realistically implement all components of the Chain of Prevention simultaneously. Consequently, implementation should prioritize interventions according to local resource availability:

- In severely constrained environments, the initial priorities should include routine physiological monitoring, standardized observation charts, paper-based Early Warning Scores and basic escalation protocols.
- Intermediate-resource settings may subsequently develop structured rapid-response mechanisms, escalation teams and digital surveillance tools.
- Highly resourced systems may further incorporate continuous monitoring technologies and predictive analytics.

LMICs face major structural constraints including workforce shortages, limited monitoring equipment, delayed escalation pathways and restricted ICU capacity [31,32]. Under these conditions, preventable deterioration frequently progresses unnoticed until advanced organ failure or cardiac arrest occurs. Recent evidence from Angola and other sub-Saharan African settings suggests that adaptation and implementation of Early Warning Systems are feasible even in constrained environments [31–33]. Contextual adaptation, however, is essential because scores developed in high-income countries may not perform identically across different epidemiological and organizational settings [31–33].

Findings from Angolan adaptation and Delphi studies demonstrated that successful implementation required linguistic adaptation, simplification of escalation algorithms, alignment with local staffing models and incorporation of locally relevant clinical workflows. These findings highlight the importance of contextual adaptation rather than direct transplantation of Early Warning Systems developed in high-income healthcare systems. The future of prevention-oriented systems in LMICs will depend heavily on implementation science, workforce education, simplified escalation models, digital surveillance tools and locally validated scoring systems [31,34,35].

Importantly, prevention-based models may offer greater scalability and sustainability than highly specialized rescue technologies. The operational requirements for implementing the Chain of Prevention vary substantially according to resource availability. While high-income healthcare systems may rely on continuous electronic monitoring, automated escalation pathways and predictive analytics, resource-limited hospitals often depend on manual observations, simplified escalation mechanisms and workforce-driven surveillance. These differences do not invalidate prevention-oriented approaches; rather, they require adaptation to local contexts. Key operational differences across resource settings are summarised in Table 2.

As shown in Table 2, the fundamental principles of surveillance, recognition and escalation remain consistent across healthcare systems despite substantial differences in technological and organisational capacity. This observation suggests that the Chain of

Prevention should be adapted rather than transplanted across settings, with implementation strategies tailored to local resources, workforce capabilities and healthcare priorities.

Table 2. Common Barriers to Effective Chain of Prevention Implementation and Potential Mitigation Strategies.

Domain	High-income settings	Resource-limited settings
Monitoring	Continuous electronic monitoring	Intermittent manual observations
Early Warning Scores	Automated digital systems	Paper-based systems
Escalation	Electronic alerting	Telephone or direct communication
Response	Rapid response teams	Senior clinician review
Analytics	Predictive analytics and AI	Simplified audit systems

11. The Future of Resuscitation Science

The evolution from Chain of Survival toward Chain of Prevention reflects a deeper philosophical transition within medicine: the movement from episodic rescue toward anticipatory systems-based care. Although artificial intelligence and predictive analytics may substantially improve the early identification of deterioration, their implementation raises important concerns regarding equity, algorithmic bias, data governance and financial sustainability [36]. Many predictive models have been developed using datasets derived primarily from high-income healthcare systems [36]. Consequently, their performance may be reduced when applied to populations with different epidemiological profiles, resource constraints and clinical workflows.

Furthermore, excessive reliance on proprietary technologies risks widening existing disparities between highly resourced hospitals and underfunded healthcare facilities. Similar concerns have been raised within the digital health literature, where informatics interventions implemented without explicit attention to equity, context and local capacity may unintentionally exacerbate existing healthcare inequalities rather than reduce them [37].

Artificial intelligence should therefore be viewed as an additional layer within the prevention continuum rather than a substitute for fundamental prevention infrastructure (36). In resource-constrained healthcare systems, prioritizing advanced predictive analytics before establishing basic monitoring and escalation infrastructure may inadvertently widen existing safety inequities. Basic monitoring, structured escalation pathways and workforce capability remain prerequisites for effective prevention irrespective of technological sophistication. Future resuscitation science will likely depend increasingly on artificial intelligence-assisted deterioration detection, continuous remote physiological monitoring, predictive analytics, automated escalation systems and integrated patient-safety platforms [23,38]. These developments may fundamentally redefine the boundaries between critical care, patient safety and hospital medicine.

Importantly, the future challenge is not merely technological but organizational. Even highly accurate predictive systems will fail without effective implementation, staff engagement and institutional readiness. The most advanced Early Warning Score cannot compensate for dysfunctional escalation pathways, poor communication or inadequate staffing. Thus, the next frontier in resuscitation science may not be improving CPR itself but preventing the need for CPR whenever possible.

12. Prevention as a Health-System Investment Strategy

From a health-economic perspective, prevention-oriented systems may offer substantial value by reducing avoidable ICU admissions, hospital cardiac arrests and Fail-

ure-to-Rescue events [11,39]. While advanced rescue technologies such as extracorporeal cardiopulmonary resuscitation and highly specialized critical care programmers remain essential for selected patients, prevention infrastructure potentially influences a much larger population [11,39]. Although economic evidence remains limited, prevention-oriented systems may influence substantially larger patient populations than highly specialized rescue technologies, potentially generating greater population-level benefit per unit of investment.

Future research should evaluate the comparative cost-effectiveness of investments in surveillance systems, rapid-response programmers and advanced rescue technologies across different healthcare environments [11,39].

13. Conclusion

The Chain of Survival has profoundly shaped modern resuscitation practice by establishing a structured approach to improving outcomes after cardiac arrest. However, growing recognition that many in-hospital cardiac arrests are preceded by detectable physiological deterioration has highlighted the limitations of relying solely on rescue-oriented strategies. This Perspective argues that the Chain of Prevention and the Chain of Survival are best viewed as complementary components of a unified continuum of care, linking prevention, early recognition, escalation and resuscitation within a single patient-safety framework.

Rather than representing competing paradigms, the Chain of Prevention and the Chain of Survival should be viewed as complementary components of a unified continuum of care. While the Chain of Prevention seeks to reduce the incidence of preventable cardiac arrest through surveillance and early intervention, the Chain of Survival remains essential for optimizing outcomes when cardiac arrest occurs. Together, they provide a comprehensive framework for improving patient safety, reducing Failure-to-Rescue events and strengthening healthcare system performance.

We propose that hospital safety should be conceptualized as an integrated continuum extending from anticipation to rescue and recovery. Future evaluations of healthcare quality should move beyond measuring survival after critical events and increasingly assess how effectively organizations prevent avoidable deterioration from progressing to cardiac arrest. In this context, the ultimate achievement of modern resuscitation science may not be rescuing more patients after collapse but preventing collapse from occurring in the first place. The ICRP offers a practical framework through which healthcare organizations can align prevention, escalation and rescue strategies within a single patient-safety architecture.

Funding: None.

Research Ethics Committee Approval: Not applicable.

Acknowledgments: None.

Conflicts of Interest: The authors declare no conflict of interest.

Supplementary Materials: None.

References

1. Cummins RO, Ornato JP, Thies WH, Pepe PE. Improving survival from sudden cardiac arrest: the 'chain of survival' concept. A statement for health professionals from the Advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee, American Heart Association. Circulation. 1991 May;83(5):1832–47. doi:10.1161/01.CIR.83.5.1832.
2. Graham R, McCoy M, Schultz A. Emergency Medical Services Response to Cardiac Arrest. In: Strategies to Improve Cardiac Arrest Survival: A Time to Act [Internet]. Washington, D.C.: National Academies Press; 2015 [cited 2026 May 29]. p. 21723. Available from: https://www.nationalacademies.org/publications/21723 doi:10.17226/21723.
3. Schnaubelt S, Monsieurs KG, Fijacko N, Veigl C, Al-Hilali Z, Atiq H, et al. International facets of the 'chain of survival' for out-of-hospital and in-hospital cardiac arrest – A scoping review. Resusc Plus. 2024 Sep;19:100689. doi:10.1016/j.resplu.2024.100689.

4. Del Rios M, Bartos JA, Panchal AR, Atkins DL, Cabañas JG, Cao D, et al. Part 1: Executive Summary: 2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2025 Oct 21;152(16_suppl_2). doi:10.1161/CIR.0000000000001372.
5. Smith GB. In-hospital cardiac arrest: Is it time for an in-hospital 'chain of prevention'? Resuscitation. 2010;81(9):1209–11. doi:10.1016/j.resuscitation.2010.04.017.
6. Franklin C, Mathew J. Developing strategies to prevent inhospital cardiac arrest: analyzing responses of physicians and nurses in the hours before the event. Crit Care Med. 1994 Feb;22(2):244–7.
7. Goldhill DR, White SA, Sumner A. Physiological values and procedures in the 24 h before ICU admission from the ward. Anaesthesia. 1999 Jun;54(6):529–34. doi:10.1046/j.1365-2044.1999.00837.x
8. Buist MD, Burton PR, Bernard SA, Waxman BP, Anderson J. Recognising clinical instability in hospital patients before cardiac arrest or unplanned admission to intensive care: A pilot study in a tertiary-care hospital. Med J Aust. 1999 Jul;171(1):22–5. doi:10.5694/j.1326-5377.1999.tb123492.x.
9. Schein RMH, Hazday N, Pena M, Ruben BH, Sprung CL. Clinical antecedents to in-hospital cardiopulmonary arrest. Chest. 1990 Dec;98(6):1388–92. doi:10.1378/chest.98.6.1388.
10. DeVita MA, Bellomo R, Hillman K, Kellum J, Rotondi A, Teres D, et al. Findings of the first consensus conference on medical emergency teams. Crit Care Med. 2006 Sep;34(9):2463–78. doi:10.1097/01.CCM.0000235743.38172.6E.
11. Jones DA, DeVita MA, Bellomo R. Rapid-response teams. N Engl J Med. 2011 Jul 14;365(2):139–46. doi:10.1056/NEJMra0910926
12. World Health Organization. Global patient safety action plan 2021-2030: towards eliminating avoidable harm in health care. Geneva: World Health Organization; 2021.
13. Institute of Medicine (US) Committee on Quality of Health Care in America. To err Is human: building a safer health system [Internet]. Washington, D.C.: National Academies Press; 2000 [cited 2026 Mar 2].
14. World Health Organization. Global patient safety report 2024. Geneva: World Health Organization; 2024.
15. Silber JH, Williams SV, Krakauer H, Schwartz S. Hospital and Patient Characteristics Associated With Death After Surgery: A Study of Adverse Occurrence and Failure to Rescue. Med Care. 1992 Jul;30(7):615–29. doi:10.1097/00005650-199207000-00004.
16. Panchal AR, Bartos JA, Cabañas JG, Donnino MW, Drennan IR, Hirsch KG, et al. Part 3: Adult Basic and Advanced Life Support: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2020 Oct 20;142(16_suppl_2). doi:10.1161/CIR.0000000000000916.
17. Nolan JP, Soar J, Cariou A, Cronberg T, Moulaert VRM, Deakin CD, et al. European Resuscitation Council and European Society of Intensive Care Medicine 2015 guidelines for post-resuscitation care. Intensive Care Med. 2015 Dec;41(12):2039–56. doi:10.1007/s00134-015-4051-3.
18. Kaye W, Mancini ME, Richards N. Organizing and implementing a hospital-wide first-responder automated external defibrillation program: strengthening the in-hospital chain of survival. Resuscitation. 1995 Oct;30(2):151–6. doi:10.1016/0300-9572(95)00881-S.
19. Morgan R, Lloyd-Williams F, Wright M. An early warning scoring system for detecting developing critical illness. Clin Intensive Care. 1997;8(2):100.
20. Royal College of Physicians. National Early Warning Score (NEWS) 2: standardising the assessment of acute-illness severity in the NHS. Updated report of a working party. London: RCP; 2017.
21. Smith GB, Redfern OC, Pimentel MAF, Gerry S, Collins GS, Malycha J, et al. The National Early warning Score 2 (NEWS2). Clin Med J R Coll Physicians Lond. 2019;19(3):260. Located at: Scopus. doi:10.7861/clinmedicine.19-3-260.
22. Subbe CP, Duller B, Bellomo R. Effect of an automated notification system for deteriorating ward patients on clinical outcomes. Crit Care. 2017 Dec;21(1):52. doi:10.1186/s13054-017-1635-z.
23. Gerry S, Birks J, Bonnici T, Watkinson PJ, Kirtley S, Collins GS. Early warning scores for detecting deterioration in adult hospital patients: A systematic review protocol. BMJ Open. 2017;7(12). Located at: Scopus. doi:10.1136/bmjopen-2017-019268.
24. Sendelbach S, Funk M. Alarm Fatigue. AACN Adv Crit Care. 2013 Oct 1;24(4):378–86. doi:10.4037/NCI.0b013e3182a903f9.
25. Johnston M, Arora S, King D, Stroman L, Darzi A. Escalation of care and failure to rescue: A multicenter, multiprofessional qualitative study. Surgery. 2014 Jun;155(6):989–94. doi:10.1016/j.surg.2014.01.016.
26. Hogan H, Zipfel R, Neuburger J, Hutchings A, Darzi A, Black N. Avoidability of hospital deaths and association with hospital-wide mortality ratios: retrospective case record review and regression analysis. BMJ. 2015 Jul 14;h3239.
27. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. Implement Sci. 2009 Dec;4(1):50. doi:10.1186/1748-5908-4-50
28. Silber JH, Romano PS, Rosen AK, Wang Y, Even-Shoshan O, Volpp KG. Failure-to-rescue: comparing definitions to measure quality of care. Med Care. 2007 Oct;45(10):918–25. doi:10.1097/MLR.0b013e31812e01cc.
29. Donabedian A. The quality of care: how can It be assessed? JAMA. 1988 Sep 23;260(12):1743.
30. Donabedian A. Evaluating the quality of medical care. Milbank Q. 2005 Dec;83(4):691–729.
31. Tomás E, Escoval A, Antunes ML. Cross-cultural adaptation of National Early Warning Score 2 to Angolan Portuguese. Afr J Emerg Med. 2024;14(3):145–9. doi:10.1016/j.afjem.2024.06.006.
32. Tomás E, Escoval A, Antunes ML. Consensus for the development of a new Early Warning Score for predicting patients' clinical deterioration in Angola: a Delphi study. Crit Care Res Pract. 2024;2024:9070807. doi:10.1155/2024/9070807.

33. Tomás E, Ulica E, Alves C, Pascoal C, Jeremias A, Escoval A, et al. Effectiveness of early warning scores in predicting in-hospital mortality and adverse events in adult general-ward patients in low- and middle-income countries: A systematic review. Afr J Emerg Med. 2026 Mar;16(1):100943. doi:10.1016/j.afjem.2026.100943.
34. Baker T. Critical care in low-income countries. Trop Med Int Health. 2009 Feb;14(2):143–8. doi:10.1111/j.1365-3156.2008.02202.x.
35. Greenhalgh T, Papoutsi C. Studying complexity in health services research: desperately seeking an overdue paradigm shift. BMC Med. 2018 Dec;16(1):95, s12916-018-1089–4. doi:10.1186/s12916-018-1089-4.
36. Obermeyer Z, Powers B, Vogeli C, Mullainathan S. Dissecting racial bias in an algorithm used to manage the health of populations. Science. 2019 Oct 25;366(6464):447–53. doi:10.1126/science.aax2342
37. Veinot TC, Mitchell H, Ancker JS. Good intentions are not enough: how informatics interventions can worsen inequality. J Am Med Inform Assoc. 2018 Aug 1;25(8):1080–8. doi:10.1093/jamia/ocy052
38. Escobar GJ, Gupta NR, Walsh EM, Soltesz L, Terry SM, Kipnis P. Automated early detection of obstetric complications: theoretic and methodologic considerations. Am J Obstet Gynecol. 2019;220(4):297–307. Located at: Scopus.
39. Winters BD. Rapid Response Systems. Crit Care Clin. 2024;40(3):583–98. Located at: Scopus. doi:10.1016/j.ccc.2024.03.008.