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GLOBAL ACADEMIC EXCELLENCE

GLOBAL RESEARCH TRENDS AND EMERGING FRONTIERS IN DAMAGE CONTROL RESUSCITATION

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Abstract:

Damage Control Resuscitation (DCR) has emerged as a pivotal paradigm in modern trauma care, integrating hemorrhage control, hemostatic resuscitation, and rapid surgical intervention to improve survival outcomes. Despite its growing clinical importance, the evolution of research trends, collaborative patterns, and emerging thematic frontiers within this domain remains insufficiently characterized. This study aims to systematically evaluate the global research landscape of DCR through a comprehensive bibliometric analysis. Data were retrieved from the Scopus database using an advanced search strategy based on the keywords “damage control resuscitation” and “trauma,” covering publications from 2000 to May 2026. A total of 868 peer-reviewed articles were identified and analyzed. Bibliometric tools, including Scopus Analyzer, OpenRefine, and VOSviewer, were employed to examine publication trends, citation patterns, keyword co-occurrence, and international collaboration networks. The findings demonstrate a marked increase in publication output over time, with a significant surge observed after 2015, reflecting heightened academic and clinical interest in DCR. The United States and the United Kingdom emerged as leading contributors, both in

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productivity and collaborative influence. Highly cited articles predominantly focused on transfusion strategies, particularly balanced blood product ratios, underscoring their central role in advancing clinical practice. Keyword analysis revealed dominant themes centered on trauma, hemorrhage, and resuscitation, alongside emerging areas such as Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA), whole blood transfusion, and prehospital care. In conclusion, the field of DCR is characterized by rapid growth, strong international collaboration, and evolving research priorities driven by technological and clinical innovations. This study provides valuable insights into the intellectual structure and emerging directions of DCR, offering a foundation for future research and evidence-based advancements in trauma care.

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Keyword:

Damage Control Resuscitation, Trauma

Introduction

Damage Control Resuscitation (DCR) has evolved over the past two decades as a cornerstone of modern trauma care, aiming to address the high burden of preventable death from hemorrhage and trauma-induced coagulopathy. Early concepts centered on limiting crystalloid resuscitation, adopting permissive hypotension, and using balanced blood product transfusion instead of late, laboratory-driven protocols (Gruen et al., 2012; Sambasivan & Schreiber, 2009). As understanding of traumatic hemorrhage, coagulopathy, and the "lethal triad" (acidosis, hypothermia, coagulopathy) advanced, DCR expanded into an integrated, system-wide strategy spanning prehospital, in-hospital, and critical care phases (Baksaas-Aasen et al., 2020; Kenyon & Leighton, 2024; Latif et al., 2023).

A large body of work links DCR implementation to improved outcomes. Notably, a decade-long analysis of a major hemorrhage protocol presented mortality reductions from 45% to 27%, with massive transfusion rates and red cell use more than halved, and a greater proportion of patients discharged home (Cole et al., 2019). Following this, narrative and conceptual reviews describe parallel shifts toward early blood product use, higher plasma and platelet ratios, whole blood programs, tranexamic acid, and endovascular adjuncts such as Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) as defining elements of contemporary DCR (Muldowney et al., 2022; Schmitt et al., 2023). Military and civilian combat-related experience further underscores the significance of rapid hemorrhage control, "golden hour" response, and prehospital hemostatic resuscitation in survival gains (Manning et al., 2020; Remondelli et al., 2025).

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Emerging frontiers in DCR center on precision hemostatic management, novel technologies, and system redesign. Viscoelastic Hemostatic Assays (VHAs) such as Thromboelastography (TEG) and thromboelastometry allow real-time, whole-blood assessment of coagulation and are increasingly used to guide goal-directed transfusion algorithms across the continuum of care (Gonzalez et al., 2016; Meizoso et al., 2022; Volod et al., 2022; Zhu et al., 2022). Meanwhile, a single-center randomized trial demonstrated improved 28-day survival and reduced plasma and platelet utilization with TEG-guided massive transfusion compared to conventional coagulation assays (Gonzalez et al., 2016). Other randomized and observational studies, including the multicenter ITACTIC trial and propensity-matched cohort analyses, indicate that VHA augmented protocols can reduce massive transfusion rates and costs. However, consistent mortality benefits remain unproven, and results are heterogeneous (David et al., 2023; Murali et al., 2025). Accordingly, meta-analyses across bleeding populations confirmed that VHA-guided strategies reduce red blood cell and plasma use, though not mortality. They highlighted the limited number and variable quality of trauma-specific trials (Fahrendorff et al., 2017).

Concurrently, novel hemorrhage control and resuscitative technologies are reshaping what constitutes DCR. Reviews described endovascular and extracorporeal approaches, such as REBOA, selective aortic arch perfusion, extracorporeal life support, and emergency preservation and resuscitation as potential options for profound hemorrhagic shock and traumatic cardiac arrest. This offers temporizing circulatory support while definitive hemostasis is achieved (Manning et al., 2020). Advances in prehospital and en-route care now include field whole blood transfusion, freeze-dried plasma, hemostatic dressings, expanded tourniquet use, and en-route resuscitation teams, integrated within a trauma “chain of survival.” It emphasizes early recognition, rapid transport, and coordinated protocols for major hemorrhage (Muldowney et al., 2022; Remondelli et al., 2025). At the anesthetic and perioperative levels, damage control anesthesia aligns with DCR principles by combining rapid antifibrinolytic and fibrinogen therapy, temperature and calcium control, and cartridge-based VHA monitoring to reduce preventable bleeding deaths (Kwon & Ji, 2024).

Despite substantial progress, key controversies and gaps define the current research frontier in DCR. Evidence for fixed-ratio-based versus VHA-guided resuscitation remains mixed, with some trials demonstrating a survival benefit and others presenting no difference, and concerns that VHA-guided strategies may increase product use without clear mortality gains in some settings (Gonzalez et al., 2016; Murali et al., 2025). At the same time, the optimal role of whole blood, factor concentrates, desmopressin, and calcium, as well as the significance of evolving phenotypes of trauma-induced coagulopathy and endotheliopathy, is still being clarified (Kwon & Ji, 2024). Moreover, late deaths from organ failure and brain injury persist even as early exsanguination declines (Cole et al., 2019; Schmitt et al., 2023). Emerging frontiers, therefore, involve integrating precision diagnostics (VHA, endothelial, and microcirculatory markers), innovative hemorrhage control and perfusion techniques, and system-level optimization across prehospital, en-route, and in-hospital care. In this context, mapping the evolving DCR literature’s thematic clusters, technologies, and outcome data helps define where consensus is strong. Nonetheless, evidence is conflicting, and it is unclear which targeted research and implementation strategies are most likely to further reduce preventable deaths from traumatic hemorrhage.

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Research Question

1. How has the volume and temporal trajectory of scholarly publications on emerging frontiers in DCR evolved between 2000 and 2026?
2. Which publications have achieved the highest citation impact within the domain of emerging frontiers in DCR, and what are their defining characteristics?
3. Which keywords are most frequently utilized in the literature, and how do they reflect the core focus and thematic priorities of the study domain?
4. What are the patterns and structural dynamics of international research collaboration in emerging frontiers of DCR, as evidenced by country-level co-authorship networks?

Methodology

Bibliometric analysis involves the systematic identification, organization, and quantitative evaluation of bibliographic data derived from scholarly publications (Alves et al., 2021; Assyakur & Rosa, 2022; Verbeek et al., 2002). Beyond conventional descriptive metrics such as publication sources, the temporal distribution of outputs, and leading contributors (Wu & Wu, 2017), bibliometric approaches incorporate advanced analytical methods. This includes document co-citation analysis to elucidate intellectual structures within a research domain. Nonetheless, the integrity of a comprehensive literature review relies on a rigorous, iterative methodology that encompasses precise keyword selection, exhaustive database retrieval, and in-depth analytical assessment. Such a structured approach facilitates the construction of a robust and reliable bibliographic dataset, thereby enhancing the validity of the findings (Fahimnia et al., 2015) .

In this context, the present study prioritizes high-impact publications, given their critical role in shaping the field's conceptual and theoretical underpinnings. To ensure data accuracy and consistency, the Scopus database was employed as the primary source of literature retrieval (Al-Khoury et al., 2022; di Stefano et al., 2010; Khiste & Paithankar, 2017). Furthermore, to maintain methodological rigor and scholarly quality, only peer-reviewed journal articles were included, while other forms of publications, such as books and lecture notes, were deliberately excluded (Gu et al., 2019). Drawing on Elsevier's Scopus database, renowned for its coverage of academic literature, publications published between 2000 and May 2026 were systematically collected and subjected to subsequent analysis.

Data Search Strategy

The literature retrieval strategy was systematically developed using the Scopus database to ensure comprehensive and high-quality data acquisition. The search string was constructed using the TITLE-ABS-KEY field to maximize sensitivity while maintaining relevance. It incorporates key terms such as "damage control," "damage control resuscitation," and "DCR," along with core concepts in resuscitation, including "fluid resuscitation," "hemorrhage control," and "trauma resuscitation." At the same time, Boolean operators (AND, OR) were applied to refine the search logic and capture publications situated at the intersection of these domains. Note that additional filters were applied to enhance specificity, restricting the subject area to medicine, the document type to peer-reviewed articles, and the language to English. A temporal boundary was also applied (PUBYEAR > 2000 and PUBYEAR < 2026) to capture contemporary developments while excluding earlier literature with limited relevance to current

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clinical practices. Ultimately, this structured search strategy yielded 868 records, forming the initial dataset for further analysis.

Subsequently, a rigorous screening process was conducted using predefined inclusion and exclusion criteria outlined in Table 2 to ensure methodological consistency and data quality. Only publications written in English and classified under the medical subject area were retained, thereby ensuring disciplinary relevance and interpretability. The study period was confined to publications from 2000 to 2026 to align with the evolution of modern damage-control resuscitation practices. In addition, only original research articles were included to maintain a high level of scientific rigor, while other document types, such as reviews, conference papers, books, and notes, were excluded to minimize heterogeneity and potential bias. This systematic filtering process ensured that the final dataset comprised robust, peer-reviewed evidence suitable for subsequent bibliometric mapping and trend analysis.

Table 1: The Search String

Scopus	TITLE-ABS-KEY ((“damage control” OR “damage control resuscitation” OR “DCR”) AND (“resuscitation” OR “fluid resuscitation” OR “hemorrhage control” OR “trauma resuscitation”)) AND (LIMIT-TO (SUBJAREA , “MEDI”)) AND (LIMIT-TO (DOCTYPE , “ar”)) AND (LIMIT-TO (LANGUAGE , “English”)) AND PUBYEAR > 2000 AND PUBYEAR < 2026

Table 2: The Search Selection Criteria

Criterion	Inclusion	Exclusion
Language	English	Non-English
Subject	Medicine	Others
Timeline	2000 – 2026	<2000
Document type	Article	Others

Data Analysis

VOSviewer is a widely adopted and user-friendly tool for bibliometric analysis developed by Nees Jan van Eck and Ludo Waltman at Leiden University (van Eck & Waltman, 2010, 2017). The software is specifically designed to facilitate the visualization and quantitative analysis of scientific literature, offering advanced functionalities for constructing network maps, clustering related entities, and generating density visualizations. Moreover, its versatility supports the examination of diverse bibliometric relationships, including co-authorship, co-citation, and keyword co-occurrence networks. This, in turn, enables a comprehensive interrogation of research landscapes. Supported by an interactive interface and continuous development, VOSviewer enables efficient, scalable analysis of large bibliometric datasets. On a similar note, its capacity to compute bibliometric indicators, customize visual representations, and integrate heterogeneous data sources underscores its utility as a robust analytical platform for scholarly research.

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A principal strength of VOSviewer lies in its ability to transform complex bibliometric data into intuitive and interpretable visual structures. The software is particularly effective in network-based analyses, including the identification of thematic clusters, mapping of keyword co-occurrence patterns, and generation of density-based representations. Additionally, its intuitive design facilitates accessibility for both novice and experienced researchers, enabling efficient exploration and interpretation of evolving research trends. Likewise, continuous updates ensure that VOSviewer remains methodologically current, with adaptable functionalities applicable across multiple data types. This includes authorship, citation, and collaboration networks.

In the present study, bibliographic data encompassing publication year, article title, authorship, source journals, citation metrics, and keywords were extracted in Plain Text format from the Scopus database, covering the period from 2000 to May 2026. The dataset was subsequently analyzed using VOSviewer (version 1.6.20). Using VOS mapping and clustering techniques, bibliometric networks were constructed and systematically examined. Unlike the Multidimensional Scaling (MDS) approach, VOSviewer employs a mapping technique that positions items in a low-dimensional space such that the inter-item distance reflects their relatedness (van Eck & Waltman, 2010). Although conceptually analogous to MDS (Appio et al., 2014), the VOS approach differs methodologically by incorporating normalization procedures optimized for co-occurrence data, notably the Association Strength (AS_{ij}), presented as (Van Eck & Waltman, 2007):

$$AS_{ij} = \frac{C_{ij}}{W_i W_j},$$

which is defined as being proportional to the ratio between the observed frequency of co-occurrence of items i and j and the expected frequency of their co-occurrence under the assumption of statistical independence (Van Eck & Waltman, 2007).

Result and Discussion

RQ1: How Has The Volume And Temporal Trajectory Of Scholarly Publications On Emerging Frontiers In Damage Control Resuscitation Evolved Between 2000 And 2026?

The temporal distribution of publications indicates a clear, progressive expansion of scholarly output in DCR over the past two decades, reflecting the field's maturation within trauma care. In the early phase (2000-2008), publication activity remained relatively low and sporadic, with annual outputs generally below 20 articles and percentages under 3%. This pattern likely corresponds to the nascent stage of DCR as a conceptual framework, during which clinical practices were still evolving from traditional resuscitation approaches toward more targeted strategies addressing coagulopathy, hypothermia, and acidosis. A gradual increase is then observed from 2009 to 2016, suggesting growing academic interest and early consolidation of DCR principles. This rise can be attributed to increasing recognition of trauma-induced coagulopathy and the adoption of balanced transfusion strategies. Interestingly, this is supported by emerging clinical evidence and military experience, significantly influencing civilian trauma systems.

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A more pronounced escalation is evident from 2017 onwards, culminating in peak productivity in 2021 (73 publications, 8.41%), followed by sustained high output through 2025. This surge reflects the transition of DCR into a well-established and highly researched domain. It is driven by advancements in trauma systems, widespread implementation of massive transfusion protocols, and increasing integration of viscoelastic testing and goal-directed resuscitation. The elevated publication rates during this period may also be linked to global collaborative research efforts and heightened attention to critical care practices during the COVID-19 era. This indirectly reinforced interest in resuscitation science. Meanwhile, the slight decline observed in 2024-2026 should be interpreted cautiously, as it may represent incomplete indexing for recent years rather than a true reduction in research activity. Overall, the upward trajectory and sustained productivity underscore the emergence of DCR as a critical frontier in trauma research, with ongoing innovations shaping its clinical and scientific landscape.

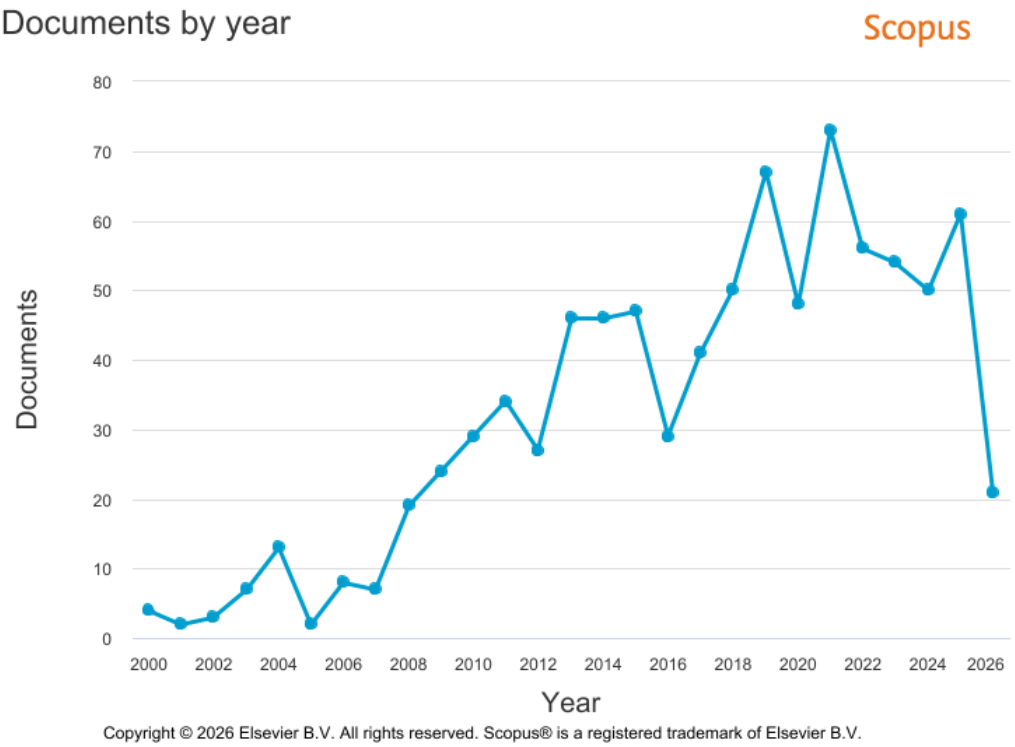

Figure 1: Temporal Trajectory Of Scholarly Publications On Emerging Frontiers In Damage Control Resuscitation Evolved Between 2000 And 2026

Table 3 The Volume And Temporal Trajectory Of Scholarly Publications On Emerging Frontiers In Damage Control Resuscitation Evolved Between 2000 And 2026

YEAR	Number of Publications	Percentage %
2026	21	2.42
2025	61	7.03
2024	50	5.76
2023	54	6.22
2022	56	6.45

2021	73	8.41
2020	48	5.53
2019	67	7.72
2018	50	5.76
2017	41	4.72
2016	29	3.34
2015	47	5.41
2014	46	5.30
2013	46	5.30
2012	27	3.11
2011	34	3.92
2010	29	3.34
2009	24	2.76
2008	19	2.19
2007	7	0.81
2006	8	0.92
2005	2	0.23
2004	13	1.50
2003	7	0.81
2002	3	0.35
2001	2	0.23
2000	4	0.46

RQ2: Which publications have achieved the highest citation impact within the domain of Emerging Frontiers in Damage Control Resuscitation, and what are their defining characteristics?

The citation profile presented in Table 4 highlights a strong concentration of highly influential studies that have fundamentally shaped the evolution of DCR, particularly in transfusion strategies and hemorrhage management. The most cited article by (Holcomb et al., 2015), published in the Journal of the American Medical Association (JAMA), dominates with 2,240 citations. This underscores its pivotal role in establishing evidence-based transfusion ratios (1:1:1 vs 1:1:2) through the Pragmatic, Randomized Optimal Platelet and Plasma Ratios (PROPPR) randomized clinical trial. This landmark study provided high-level clinical evidence that directly influenced massive transfusion protocols worldwide, explaining its exceptional citation impact. Similarly, other highly cited works in Table 4, such as those by Bryan A. Cotton and colleagues, emphasized optimizing blood product utilization and survival outcomes. This reflects the central importance of hemostatic resuscitation in DCR research. The prominence of journals such as the Journal of Trauma and JAMA further highlights the influence of leading medical journals. Studies published in these high-impact journals are more likely to achieve substantial citation counts due to their broad dissemination and clinical applicability.

In addition, Table 4 reveals that many of the top-cited articles originate from the early to mid-2000s, indicating a “foundational effect” where earlier seminal works accumulate citations over time and continue to inform subsequent research. Studies addressing core concepts such as abdominal compartment syndrome, trauma system performance, and the evolution of

damage control surgery remain relevant, as these topics underpin modern DCR principles. For instance, early contributions to damage control surgery and orthopedics laid the conceptual groundwork for later resuscitation-focused strategies. Furthermore, the presence of multidisciplinary themes suggests that DCR is inherently integrative, drawing on surgery, critical care, hematology, and emergency medicine. This includes coagulation management, mass casualty response, and trauma system optimization. The high citation counts can therefore be justified by the scientific rigor of these studies and their translational impact, as they address critical clinical challenges with direct implications for patient survival and healthcare system performance.

Table 4: Publications Have Achieved The Highest Citation Impact

No	Authors	Title	Year	Source title	Cited by
1	Holcomb et al. (2015)	Transfusion of plasma, platelets, and red blood cells in a 1:1:1 vs a 1:1:2 ratio and mortality in patients with severe trauma: The PROPPR randomized clinical trial	2015	Journal of the American Medical Association (JAMA)	2240
2	Cotton et al. (2008)	Damage control hematology: The impact of a trauma exsanguination protocol on survival and blood product utilization	2008	Journal of Trauma - Injury, Infection and Critical Care	421
3	Aylwin et al. (2006)	Reduction in critical mortality in urban mass casualty incidents: analysis of triage, surge, and resource use after the London bombings on July 7, 2005	2006	Lancet	361
4	Balogh et al. (2003)	Both primary and secondary abdominal compartment syndrome can be predicted early and are harbingers of multiple organ failure	2003	Journal of Trauma	352
5	Dutton et al. (2010)	Trauma mortality in mature trauma systems: Are we doing better? an analysis of trauma mortality patterns, 1997-2008	2010	Journal of Trauma - Injury, Infection and Critical Care	350
6	Gunter et al. (2008)	Optimizing outcomes in damage control resuscitation: Identifying blood product ratios associated with improved survival	2008	Journal of Trauma - Injury, Infection and Critical Care	326
7	Johnson et al. (2001)	Evolution in damage control for exsanguinating penetrating abdominal injury	2001	Journal of Trauma	322
8	Hauser et al. (2010)	Results of the control trial: Efficacy and safety of recombinant activated factor VII in the management of refractory traumatic hemorrhage	2010	Journal of Trauma - Injury, Infection and Critical Care	321

9	Spinella & Holcomb (2009)	Resuscitation and transfusion principles for traumatic hemorrhagic shock	2009	Blood Reviews	308
10	Giannoudis & Pape (2004)	Damage control orthopaedics in unstable pelvic ring injuries	2004	Injury	228

RQ3.Which Keywords Are Most Frequently Utilized In The Literature, And How Do They Reflect The Core Focus And Thematic Priorities Of The Study Domain?

The keyword co-occurrence network illustrated in Figure 2 reveals a highly centralized structure dominated by core concepts such as “damage control” (349 occurrences; Total Link Strength (TLS) 815), “trauma,” “resuscitation,” and “hemorrhage.” This indicates that the intellectual foundation of this research domain is strongly anchored in acute trauma care and bleeding management. Furthermore, the high TLS of these keywords reflects their extensive interconnectivity with other terms, suggesting they function as primary hubs within the knowledge network. Closely related terms such as “hemorrhagic shock,” “massive transfusion,” “coagulopathy,” and “shock” further reinforce the centrality of hemostatic resuscitation as a key thematic axis. Remarkably, this pattern is consistent with the clinical priority of addressing the “lethal triad” in trauma, where early control of bleeding and correction of coagulopathy are critical determinants of survival. The prominence of “emergency medicine” and “prehospital” keywords also highlights the expanding scope of DCR beyond the operating room. This reflects an increasing emphasis on early intervention and on integrating system-wide trauma care.

In addition, Figure 2 demonstrates the emergence of several specialized, evolving research clusters, indicating diversification within the field. Keywords such as “REBOA,” “whole blood,” “thromboelastography,” and “permissive hypotension” highlight advancing technologies and refined physiological strategies in resuscitation practice. On a similar note, the presence of terms related to military and combat settings (e.g., “military,” “combat,” “battlefield”) underscores the significant translational influence of military medicine on civilian trauma innovations. This is particularly true in hemorrhage control and transfusion strategies. In line with this, clusters involving “pediatric trauma,” “traumatic brain injury,” and “postpartum hemorrhage” suggest the extension of DCR principles into broader and more specialized patient populations. The relatively lower occurrence yet meaningful linkage strength of these emerging keywords indicates that, while still developing, these areas represent important frontiers of research. Collectively, the network structure supports the interpretation that the field is transitioning from foundational principles toward more targeted, technology-driven, and population-specific applications. This, in turn, reflects a dynamic and evolving research landscape.

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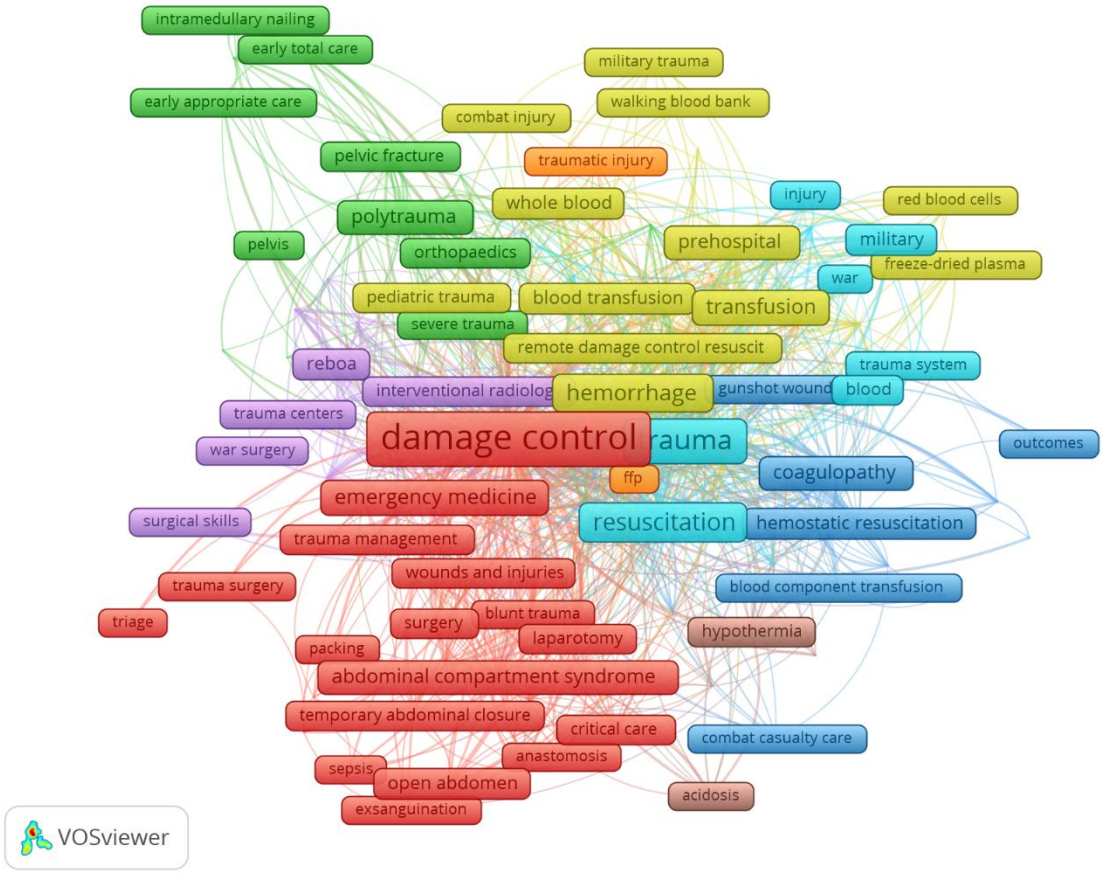

Figure 2: Keywords are most frequently utilized in the literature and Co-Occurrence Network Visualization.

RQ4.What Are The Patterns And Structural Dynamics Of International Research Collaboration In Emerging Frontiers Of Damage Control Resuscitation, As Evidenced By Country-Level Co-Authorship Networks?

The country-level co-authorship network depicted in Figure 3 demonstrates a highly centralized, asymmetric global collaboration structure, with the United States occupying a dominant position across all key indicators (428 documents, 15,476 citations, TLS 179). This prominence reflects its substantial research productivity and extensive international collaborative reach, positioning it as the principal hub within the global DCR research network. Moreover, the strong linkage strength indicates that the United States maintains frequent and diverse co-authorship ties with multiple countries, facilitating knowledge dissemination and multicenter research. Similarly, the United Kingdom (116 documents; TLS 99) emerges as a secondary hub, reinforcing the leading role of high-income countries with well-established trauma systems and research infrastructure. The high citation counts observed in countries such as Canada and Germany, despite relatively fewer publications, suggest that their contributions are particularly impactful and of high quality. This pattern can be attributed to strong academic institutions, participation in influential multicenter trials, and emphasis on evidence-based trauma care.

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In contrast, Figure 3 also reveals disparities in global research collaboration, particularly among emerging and lower-output countries. Nations such as China and India, despite moderate publication counts, demonstrate relatively low citation impact and weak TLS, indicating limited integration into the global research network. This may reflect barriers such as language, funding constraints, or limited participation in international collaborative studies. Interestingly, countries such as Norway, Sweden, and the Netherlands exhibit high TLS relative to their publication volume, suggesting strong collaborative engagement and strategic partnerships that enhance their visibility and influence. Additionally, the presence of countries such as Colombia and South Africa highlights the growing contribution of middle-income regions, potentially driven by increasing trauma burden and the need for context-specific research. Overall, the network structure in Figure 3 underscores the critical role of international collaboration in advancing DCR research, while also revealing opportunities to strengthen inclusivity and global knowledge exchange across underrepresented regions.

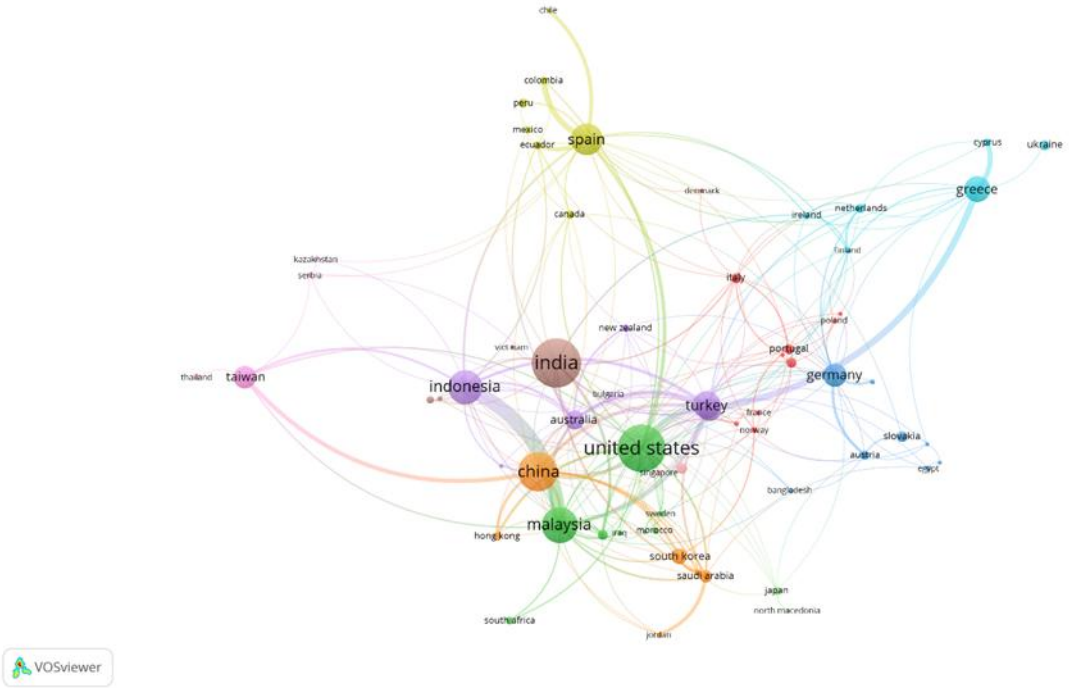

Figure 3: The Patterns And Structural Dynamics Of International Research Collaboration In Emerging Frontiers Of Damage Control Resuscitation, As Evidenced By Country-Level Co-Authorship Networks Xxx

Conclusion

In conclusion, this bibliometric analysis systematically examined the evolution and research landscape of Emerging Frontiers in DCR from 2000 to 2026, focusing on publication growth, influential studies, thematic development, and global collaboration patterns. Accordingly, the study addressed key questions concerning temporal trends in scholarly output, identification of high-impact publications, prevailing and emerging research themes, and the structural dynamics of international co-authorship networks. Furthermore, the findings indicate a clear upward trajectory in publication volume, particularly after 2015, reflecting the increasing recognition of DCR as a critical component in modern trauma care. Highly cited works were predominantly centered on transfusion strategies and hemorrhage control, demonstrating their

foundational role in shaping clinical practice and research direction. Keyword co-occurrence analysis revealed that core themes such as trauma, hemorrhage, and resuscitation remain dominant. At the same time, newer areas, including endovascular techniques, whole-blood transfusion, and prehospital interventions, signify ongoing advancement and diversification. In addition, the collaboration network highlighted a concentration of research productivity and influence among high-income countries, with expanding yet uneven participation from other regions.

This study contributes to the field by providing a structured overview of the intellectual and collaborative patterns that define DCR research, offering insight into how the domain has evolved from fundamental principles to more specialized, technology-driven approaches. The findings have practical relevance, particularly in informing research prioritization, encouraging broader international collaboration, and supporting evidence-based improvements in trauma systems and resuscitation strategies. Nonetheless, certain limitations should be considered, including the reliance on a single database, restriction to English-language publications, and exclusion of non-article document types, which may limit the comprehensiveness of the analysis. In response, future investigations may expand data sources, include multilingual literature, and integrate qualitative approaches to deepen understanding of emerging trends. Overall, this analysis highlights the value of bibliometric methods in mapping research development and identifying knowledge gaps. Likewise, the study underscores the growing significance of DCR in trauma care and provides a foundation for continued research and innovation to improve patient outcomes.

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Author Contribution Statement: All authors contributed significantly to the development of this manuscript. Rahman, R.A.A., was responsible for the conceptualization, methodology, and overall supervision of the study. Abu Bakar, M.Z., handled data collection, analysis, and interpretation of results. Mirza, A.M.I, Md Zaid, M.N., and Sulaiman, M.N., contributed to the literature review, drafting, and critical revision of the manuscript. All authors read and approved the final version of the manuscript prior to submission.

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