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Criteria used to define appropriate red blood cell transfusion in the perioperative setting: a scoping review

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Abstract

Introduction Intraoperative red blood cell (RBC) transfusion strategies vary depending on multiple factors. Several studies have documented significant variability in RBC transfusion practices during surgery. This scoping review aimed to identify and describe existing criteria or clinical decision-making tools used to evaluate intraoperative and immediate post-operative RBC transfusion appropriateness.

Methods A scoping review was conducted and reported according to Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines with extension for scoping reviews. A systematic search of MEDLINE and EMBASE was conducted. Relevant references were also explored. Studies reporting on the development, use, or validation of a clinical tool or set of criteria to adjudicate the appropriateness of intra- or post-operative RBC transfusions were eligible for inclusion.

Results A total of 3,342 de-duplicated articles were identified. 135 underwent full text review, and 28 were included in the analysis. One tool was designed specifically for use during surgery. Adjudication of perioperative RBC transfusion appropriateness was determined using pre-existing published society guidelines in 61% of studies. 29% used a pre-defined set of criteria selected by the study team, and one study used RAND-UCLA to achieve consensus on appropriate transfusion criteria.

Conclusion This review identified several tools that were used to adjudicate the appropriateness of intraoperative and immediate postoperative RBC transfusions. Almost all studies adjudicated transfusion appropriateness based on guidelines intended for use outside of perioperative settings. Further research is required to develop RBC transfusion adjudication criteria that specifically integrate the unique factors that influence transfusion in the perioperative setting.

Keywords Red blood cell transfusion, Intraoperative transfusion, Blood transfusion criteria, Transfusion thresholds, Transfusion guidelines, Surgical blood loss, Transfusion decision-making

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Introduction

The intraoperative administration of red blood cell (RBC) transfusions is a complex clinical decision-making process. While factors such as the type of surgical procedure, patient characteristics, and provider preferences influence transfusion practices, these elements alone cannot fully explain the observed variability [1]. Existing clinical practice guidelines offer limited recommendations for intraoperative RBC transfusion; however, guidelines exhibit significant heterogeneity and often lack robust underlying evidence base derived from the intraoperative setting [2, 3].

Current guidelines advocate for a multifaceted approach, including hemoglobin and hematocrit levels, blood loss volume, signs of end-organ ischemia, and hemodynamic stability when determining the need for RBC transfusion during surgery [2–4]. Nonetheless, the absence of well-defined, evidence-based transfusion triggers necessitates significant reliance on clinician judgment and individual preferences during decision-making. This has resulted in wide variation in practice, with some clinicians adopting a more restrictive approach and others favouring a more liberal strategy for intraoperative RBC transfusion, though a restrictive approach has increasingly been favoured [3]. Despite being one of the most common medical interventions, intraoperative RBC transfusion remains relatively understudied when compared to transfusion practice outside of the operating room [5].

There is a growing body of evidence suggesting potential negative effects of RBC transfusion on specific patient populations. For instance, in cancer patients, RBC transfusion has been linked with the promotion of tumor growth, attachment, and spread [6]. Additionally, RBC transfusion-related immunomodulation (TRIM) encompasses a complex process with both proinflammatory and immunosuppressive consequences for these patients [7–9]. Intraoperative RBC transfusions in cancer surgery patients have been associated with increased rates of 30-day postoperative mortality, major complications, total number of complications, and prolonged length of stay [10]. The limited evidence guiding transfusion decisions exposes patients to unnecessary risks and may result in inefficient resource allocation within healthcare systems. Establishing appropriate, evidence-based practices for intraoperative RBC transfusion is imperative to optimize patient outcomes, minimize complications, and promote value-based care [11].

While strategies to optimize RBC transfusion practices in the OR are needed, methods to define appropriate transfusion must first be defined. Elucidating these factors will help develop protocols for care and facilitate superior outcomes for surgical patients. To minimize inappropriate transfusion events in the intraoperative setting, we first must be able to reliably select events that are inappropriate or not clinically indicated. This scoping review aims to identify and characterize existing criteria or clinical decision-making tools that have been used to evaluate intraoperative or early postoperative RBC transfusion appropriateness.

Methods

This scoping review adhered to five published evidence-based strategies for scoping reviews [12]. Reporting conforms to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines with extension for scoping reviews [13]. A protocol for this scoping review was written and published on Open Science Framework (https://osf.io/3uejz/).

Search strategy

A comprehensive search strategy was developed in February 2023 in consultation with a library information specialist. Search terms included: "red blood cell transfusion", "blood adjudication", "appropriate or inappropriate", "decision support", "clinical audit" (Appendix 1). A systematic search of MEDLINE and EMBASE was carried out, in August 2023. The search included all available records from database inception to August 2023; no temporal restrictions were applied.

A grey literature search was also conducted in Google Scholar using the strategy: "'appropriateness" OR "decision making"' OR "audit", "red blood cell transfusion", where the first 100 results were screened for inclusion. Additionally, the reference lists of all included studies were manually searched for relevant publications. Deduplication of articles was performed prior to the screening process. A flow diagram (Fig. 1) illustrates the search and selection process.

Study selection

The literature screening and data extraction processes were facilitated using Covidence, a web-based software platform designed to streamline systematic and scoping reviews. Covidence was utilized for title and abstract screening, full-text review, and data extraction to ensure consistency and efficiency throughout the review process. Two independent reviewers, general surgery residents, screened titles and abstracts to identify studies for full-text review. Studies deemed appropriate for inclusion were selected for further assessment. Disagreements between reviewers were resolved through discussion or referred to a third reviewer, a hepatopancreaticobiliary surgeon, for adjudication. Two independent reviewers examined each remaining full-text article to assess for eligibility for inclusion. Disagreements were resolved by consensus. Although the frequency of reviewer disagreements and inter-rater reliability were not formally

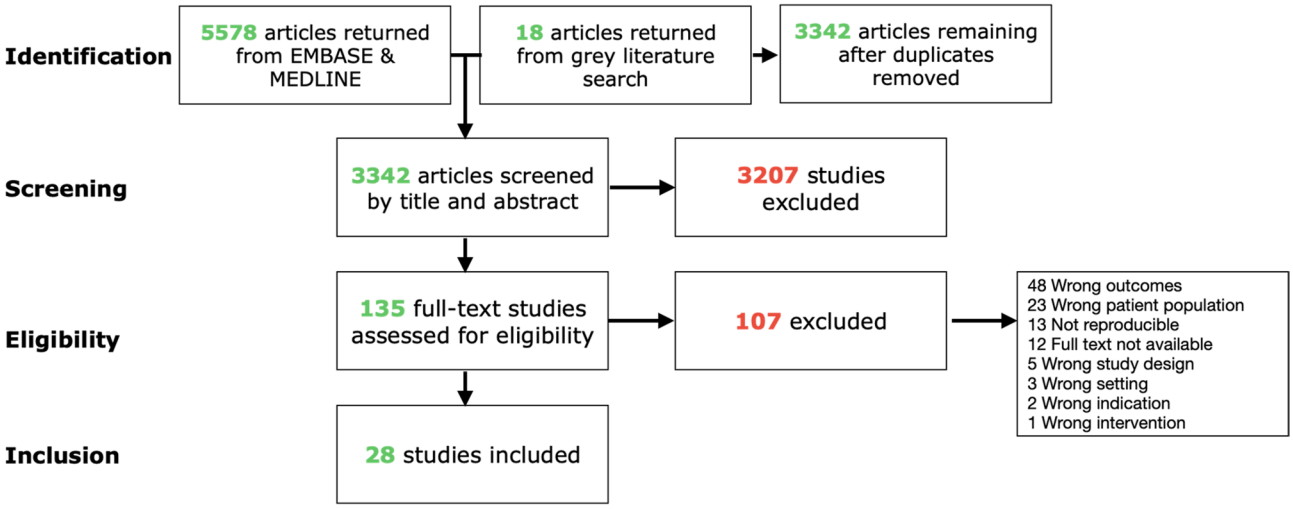

Fig. 1 PRISMA Flow diagram

recorded, disagreements were infrequent and resolved through structured discussion, with input from a third reviewer when necessary.

Eligibility criteria

Eligible study designs included randomized control trials, cohort studies, case-control studies, and systematic reviews relevant to the research question, published in any language. Studies were included if they reported the development, implementation, or evaluation of criteria, questionnaires, tools, instruments, or sets of rules used to adjudicate the clinical appropriateness of RBC transfusion events as defined by individual study authors in the intraoperative and immediate post-operative period. Animal studies, pediatric studies, case series with fewer than 5 patients, editorials, commentaries, and narrative reviews were excluded.

Data extraction

The following data were extracted from the included studies: author, year of publication, country, study design, funding source, criteria used for transfusion adjudication, method of criteria selection, unit of adjudication, study population characteristics, as well as available data pertaining to the adjudication of transfusion events if available, including percentage of appropriate transfusion and rater availability. Extraction was conducted using a predefined data extraction form to ensure consistency across studies. Key data points were captured to identify themes and trends within the literature. Synthesis focused on descriptive analysis to map the existing evidence on intraoperative and postoperative RBC adjudication practices, highlighting both areas of consensus and knowledge gaps. Themes were identified related to method of defining appropriate transfusion, variables used to define appropriate transfusion, and any external guidelines that may have been referenced.

Complex or ambiguous criteria were reviewed independently by two reviewers. When discrepancies in interpretation arose, such as unclear definitions of "major bleeding" or varying transfusion thresholds based on clinical context, these were discussed and resolved through consensus. In some cases, criteria were categorized into broader themes (e.g., physiologic thresholds, clinical signs of instability, or surgical context) to facilitate synthesis. This approach allowed us to standardize definitions across studies while preserving important nuances in how appropriateness was operationalized.

We abstracted all explicit hemoglobin (Hb) or hematocrit (Hct) thresholds from included studies and harmonized units (g/dL converted to g/L). When only Hct thresholds were reported, we approximated Hb in g/L using Hct% ≈ 3 × Hb[g/dL], i.e., Hct × 3.3 g/L). Where authors provided explicit g/L conversions (e.g., mmol/L or % to g/L), we used those values.

Data synthesis followed scoping review guidance, emphasizing thematic organization and narrative synthesis to summarize findings across the varied study designs without quantitatively pooling results.

Results

After deduplication, 3,342 articles were screened. Of these, 135 were selected for full-text review, resulting in the inclusion of 28 studies for analysis. Studies originated from geographically diverse regions: North America ($n = 13$) with 9 from the United States and 4 from Canada, Europe ($n = 9$), Africa ($n = 2$), Australia, ($n = 2$), and Asia ($n = 2$). The stated primary objectives of each study varied, including the adjudication of transfusion events, the development of adjudication criteria, and the evaluation of interventions on transfusion appropriateness.

While studies published in any language were eligible for inclusion, all studies that met inclusion criteria and were ultimately included were published in English. No studies were excluded due to language barriers.

Across the 28 included studies, commonly cited quantitative triggers clustered at 70, 80, 90, and 100 g/L. Specifically, 70 g/L was used in 17 studies (61%), 80 g/L in 16 (57%), 100 g/L in 15 (54%), and 90 g/L in 7 (25%). Less frequently reported values included 75, 85, and 87 g/L and checklist-derived thresholds (56, 64, 72, 81, 89 g/L) from a single study. Considering all unique thresholds across studies, the median threshold was 80 g/L (IQR 70–90; range 50–100 g/L). In terms of adjudication structure, most studies combined Hb/Hct thresholds with contextual criteria, blood loss and/or hemodynamic instability (13 studies), often with comorbidity-specific adjustments, whereas 4 studies relied on Hb/Hct thresholds alone and 2 used algorithmic approaches without an explicit Hb cutoff (e.g., % red-cell loss) (see Supplementary Fig. 1, and Table 3). Several studies reported multiple Hb thresholds for different perioperative phases, comorbidities, or bleeding scenarios; thus, counts exceed the total number of included studies.

Table 1 Summary of included studies by method of defining appropriateness

Adjudication Method	Studies
Expert Opinion (n = 9)	Boralessa, 2001 [14]
	van Gammeren, 2016 [15]
	Chiu-Wen Chou, 2014 [16]
	Goodnough, 1991 [17]
	Gyedu, 2021 [18]
	Hoeltge, 1989 [19]
	Mozes, 1989 [20]
	Picton, 2018 [21]
	Ross, 2013 [22]
Guidelines (n = 17)	Audit, 1998 [23]
	Barr, 2011 [24]
	Burke, 2014 [25]
	Coffin, 1989 [26]
	Colomina, 2012 [27]
	Di Bartolomeo, 2019 [28]
	French, 2002 [29]
	Joubert, 2013[30]
	Bennet, 2012 [31]
	Matthew, 2022 [32]
	Merelle, 2020 [33]
	Saporito, 2022 [34]
	Sardar, 2018 [34]
	Shin, 2020 [35]
	Silverman, 2004[36]
	Spradbrow, 2016[37]
	Unal, 2020 [38]
RAND-UCLA (n = 1)	Bennet 2018 [39]
Not described (n = 1)	Tuckfield, 1997 [40]

Sixteen studies were retrospective, nine prospective, two employed a pre- post- study design, and one utilized the RAND-UCLA methodology. Seventeen studies based their definition of appropriate RBC transfusion on published guidelines, nine relied on author/expert opinion, one on the RAND-UCLA appropriateness method (RAM), and one study did not define appropriate transfusion (Table 1).

Table 2 summarizes the published guidelines referenced by the 17 studies that used guidelines to define appropriate transfusion events. The Association for the Advancement of Blood & Biotherapies (AABB) [5] and the British Committee for Standards in Haematology [41] guidelines were most frequently cited. AABB was cited five times and the British committee cited three times.

Nine studies based their definition of appropriate transfusion on author/expert opinion. Of these, eight employed a component including hemoglobin threshold, ranging from 56 g/dL[42] to 130 g/dL[43]. Four studies incorporated blood loss as criteria for transfusion [14, 43–45]. Mozes et al. defined blood loss as "major bleeding with signs of hypovolemia"[45], while Boralessa et al.[14] and Hoeltge et al.[44] did not define a specific volume of intraoperative blood loss that would indicate an appropriate transfusion. Ross et al.[43] defined major blood loss as exceeding 1000 mL. Figure 2 depicts the number of studies that used each variable to define appropriate intraoperative transfusion. Complete definitions for appropriate transfusion threshold were variable across all 28 studies and can be found in Appendix 2.

Bennet et al. used the RAND-UCLA Appropriateness method (RAM) to develop clinical guidelines for the appropriate use of perioperative RBC transfusions for patients undergoing hepatectomy. The final criteria were divided into the intraoperative and early postoperative settings. Intraoperative criteria included significant bleeding and ST changes trumping other factors. Other intraoperative rules included hemoglobin 75 g/L or less, transfusing at hemoglobin of 85 g/L or less requiring strong justification, and transfusing at greater than 95 g/L as inappropriate. Post-operative appropriate transfusion triggers in patients without coronary artery disease (CAD) was 70 g/L, and 80 g/L in those with CAD. Alternatively, in the immediate post-operative period, or with a hemoglobin drop of more than 15 g/L later in the post-operative period, it is considered appropriate to transfuse at a hemoglobin of less than 75 g/L.

Discussion

This scoping review highlights various definitions of appropriate RBC transfusion employed in several included studies. Few definitions were specifically tailored to the intraoperative or early postoperative settings, despite the focus of all 28 studies adjudicating

Table 2 List of guidelines referenced

Author & Year of Study (*n* = 17)	Study Title	Guidelines Referenced for Definition of Appropriate Transfusion
Audet, 1998 [23]	Improving the appropriateness of red blood cell transfusions in patients undergoing orthopedic surgery	Practice strategies for elective red blood cell transfusion. American College of Physicians, American College of Physicians + input of experts in transfusion medicine
Barr, 2011 [24]	The appropriateness of red blood cell use and the extent of overtransfusion: right decision? Right amount?	Northern Ireland Regional Transfusion Committee
Burke, 2014 [25]	Evaluation of preoperative and intraoperative red blood cell transfusion practices at Maputo Central Hospital, Mozambique	Mozambican Ministry of Health, World Health Organization Blood Transfusion Safety, Clinical use of blood handbook. Geneva, Switzerland: World Health Organization; 2001.
Coffin, 1989 [26]	Algorithms for evaluating the appropriateness of blood transfusion	Algorithms were based on written Guidelines by a group of physicians.
Colomina, 2012 [27]	Appropriateness of red blood cell use in orthopedic surgery and traumatology: analysis of transfusion practice	British Committee for Standards in Haematology
Di Bartolomeo, 2019 [28]	Patient Blood Management: transfusion appropriateness in the post-operative period	Italian Society of Transfusion Medicine and Immunohematology (SIMTI) Working Party: Recommendations for the transfusion management of patients in the peri-operative period. II. The post-operative period. Blood Transfusion 2011; 9: 320–335.
French, 2002 [29]	Appropriateness of red blood cell transfusion in Australasian intensive care practice	Australian National Health and Medical Research Council guidelines
Joubert, 2013 [30]	The utilization of red cell concentrates at Kimberley Hospital Complex, Northern Cape Province, South Africa	British Committee for Standards in Haematology, Clinical Resource Efficiency Support team (CREST). Better use of blood in Northern Ireland. Guidelines for blood transfusion, practice; 2001. p. 1–55., National Health and Medical Research Council and the Australasian Society of Blood Transfusion, in cooperation with the Commonwealth Department of Health and Ageing, the Royal Australasian College of Surgeons, the Australian and New Zealand College of Anaesthetists. Clinical practice guidelines on the use of blood products; 2001. p. 1–101
Joy, 2012 [31]	The appropriateness of blood transfusion following primary total hip replacement	British Orthopaedic Association's Blood Conservation in Elective Orthopaedic Surgery
Matthew, 2022 [32]	Appropriateness of red cell transfusion practices in an intensive care unit: A prospective observational study	British Committee for Standards in Haematology (BCSH) in 2012
Merolle, 2020 [33]	Postoperative patient blood management: transfusion appropriateness in cancer patients	Italian Society of Transfusion Medicine and Immunohematology (SIMTI) Working Party: Recommendations for the transfusion management of patients in the peri-operative period. II. The post-operative period. Blood Transfusion 2011; 9: 320–335.
Saporito, 2022 [34]	Perioperative inappropriate red blood cell transfusions significantly increase total costs in elective surgical patients, representing an important economic burden for hospitals	Transfusion thresholds and other strategies for guiding allogeneic red blood cell transfusion, Indications for and Adverse Effects of Red-Cell Transfusion, Patient Blood Management: Recommendations From the 2018 Frankfurt Consensus Conference, International consensus statement on the peri-operative management of anaemia and iron deficiency
Sardar, 2018 [34]	Improving Blood Transfusion Practices in a Community Hospital Setting: Our Experience with Real-Time Clinical Decision Support	American Association of Blood Banks (AABB) 2016 guidelines
Shin, 2020 [35]	Effect of patient blood management system and feedback programme on appropriateness of transfusion: An experience of Asia's first Bloodless Medicine Center on a hospital basis	Guidelines on blood transfusion, 4th edition (complete revision in 2016). Korea centres for disease control and prevention, Korean Society of Blood Transfusion
Silverman, 2004 [36]	The appropriateness of red blood cell transfusions in the peripartum patient	current hospital transfusion guidelines
Spradbrow, 2016 [37]	Evaluating appropriate red blood cell transfusions: a quality audit at 10 Ontario hospitals to determine the optimal measure for assessing appropriateness	The AABB recommendations for the Choosing Wisely campaign of the American Board of Internal Medicine

Table 2 (continued)

Author & Year of Study (*n* = 17)	Study Title	Guidelines Referenced for Definition of Appropriate Transfusion
Unal, 2020 [38]	Peri-operative blood transfusion in elective major surgery: incidence, indications and outcome - an observational multicentre study	an updated report by the American Society of Anesthesiologists Task Force on Perioperative Blood Management

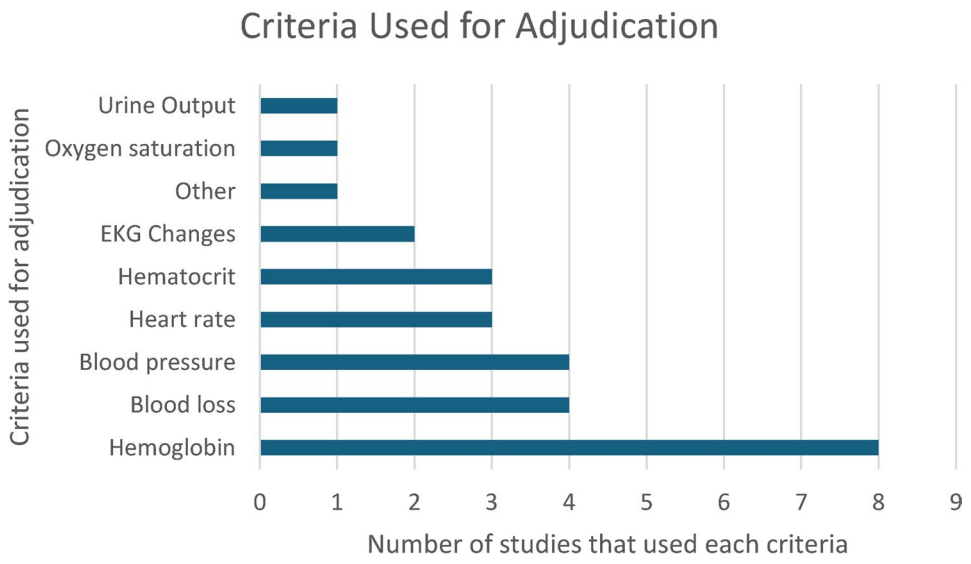

Fig. 2 Variables for adjudication according to author/expert opinion. The number of studies that used each criteria as part of their adjudication process to determine whether or not a transfusion event was appropriate

intraoperative and early postoperative transfusion events. This underscores a significant gap in the existing literature. Transfusion guidelines derived from trials or studies conducted in settings outside of the perioperative setting are not directly extrapolatable to the intraoperative setting for many reasons. Surgical patients may have different physiologic conditions and patterns of acute blood loss that will influence their transfusion needs; the hemodynamic stability of patients in the operating room can fluctuate and require dynamic management, while the controlled environment of settings like intensive care units may not capture the same acute changes. Moreover, the physiological consequences of surgery and anesthesia are not present in non-surgical patients and can alter patients' response to anemia and transfusion. Many transfusion guidelines extrapolate on the TRICC trial for transfusion recommendations, which was designed and validated for patients in intensive care settings [46]. While many of the studies included in this review relied on general transfusion guidelines developed for non-surgical settings, recent efforts such as the 2023 AABB International RBC transfusion guidelines and the National Blood Authority of Australia's Perioperative Patient Blood Management provide more nuanced, perioperative-specific recommendations that may serve as a foundation for future adjudication criteria [47, 48].

Although the variables used to define appropriate transfusion demonstrated considerable overlap, the specific thresholds for these variables varied widely. Estimated blood loss thresholds indicating appropriate transfusion ranged from > 500 mL[44], to > 1500 mL[49] depending on many co-existing variables such as hemoglobin concentration, patient comorbidities, and age. Pre-transfusion hemoglobin concentration was the most common adjudication variable with appropriate transfusion thresholds ranging from 70 g/L – 130 g/L depending on comorbidities and risk factors. Similarly, hemodynamic parameters including heart rate, blood pressure, temperature, and oxygen saturation were also frequently used with considerable variability in acceptable ranges. The variability across criteria highlights the difficulty of defining what is an appropriate transfusion event, which in turn can result in over or under transfusion in the operating room. This can impact patient clinical outcomes, as well as healthcare resource utilization. These results suggest the necessity to develop clinical tools and criteria specifically tailored for intraoperative settings to guide the identification of truly inappropriate transfusion events.

Inconsistent or non-specific transfusion criteria can lead to both over- and under-transfusion, each of which carries distinct risks. Over-transfusion has been associated with increased rates of infection, thromboembolic events, and immunomodulation, which may be especially consequential in surgical oncology populations due to potential effects on tumor recurrence and progression [50, 51]. Conversely, under-transfusion in the context of significant anemia may compromise oxygen delivery, exacerbating perioperative morbidity such as myocardial ischemia, cognitive dysfunction, and delayed wound healing [52]. These decisions also carry implications for health system resource allocation; RBCs are a limited and costly resource, and inappropriate transfusion represents a substantial burden on blood bank services and healthcare costs [35]. Furthermore, variability in transfusion practices may contribute to inequities in patient outcomes, as decisions become susceptible to individual provider bias or institutional norms rather than standardized, evidence-based care. A standardized approach tailored to the perioperative setting is therefore essential not only to guide appropriate transfusion but to promote patient safety, optimize outcomes, and support value-based care [53].

Appropriateness studies synthesize available evidence as well as expert opinion to establish when the benefits of a health intervention outweigh its risks [54]. Bennett et al. utilized RAND-UCLA Appropriateness Method (RAM) to develop perioperative transfusion recommendations for hepatectomy [39]. RAM is a structured, iterative process that fosters independent critical thinking and subsequent judgement revision based on group discussion. These iterations yield a quantitative measure of agreement among panelists, clarifying consensus and disagreement, ultimately helping to standardize measurement and definitions. Notably, Bennett et al. provided one of the few perioperative-specific transfusion criteria sets identified in this scoping review.

While scoping reviews do not routinely assess methodological quality, a comparative discussion of the approaches used to define transfusion appropriateness reveals important insights. Definitions based on established clinical guidelines benefit from broad familiarity and some degree of standardization; however, most guidelines were developed for non-operative settings, limiting their external validity when applied intraoperatively. Conversely, criteria based solely on author or expert opinion may offer more flexibility and clinical relevance but are often subject to bias, lack reproducibility, and may not reflect consensus. The RAND-UCLA Appropriateness Method (RAM), as used by Bennett et al., represents a structured and transparent alternative that integrates both best available evidence and multidisciplinary expert judgment. RAM includes a formal rating process followed by moderated discussion and re-rating, allowing panelists to revise opinions in light of peer perspectives. This iterative process generates quantitative measures of agreement, helping distinguish between consensus and controversial areas [55, 56]. Its application to perioperative transfusion in hepatectomy patients by Bennett et al. yielded one of the few context-specific tools identified in our review. This method's ability to generate procedure-specific, evidence-informed, and expert-vetted criteria suggests it may be a valuable model for future efforts to standardize intraoperative transfusion adjudication.

Given the numerous varying definitions of appropriate transfusion strategies highlighted in this review, it is challenging to determine which set of guidelines are most appropriate for the perioperative setting. The criteria and guidelines that were cited in included studies in this review were largely informed by physiologic parameters and transfusion triggers studied outside of the perioperative setting. While this data was extrapolated to the perioperative setting, it was not designed to consider the unique factors of perioperative physiology and the dynamic nature of the operating room. When adjudicating the appropriateness of perioperative transfusion, it is necessary to consider the imperfect nature of this extrapolation.

The choice and application of transfusion appropriateness criteria in the perioperative setting are heavily influenced by contextual factors that must be considered in future criteria development. Surgical complexity plays a major role; high-risk procedures with anticipated major blood loss, such as liver or cardiac surgery, may necessitate different transfusion thresholds compared to lower-risk operations. Patient comorbidities, particularly cardiovascular, pulmonary, or hematologic conditions, also modify transfusion requirements and complicate rigid adherence to standard thresholds. Moreover, institutional resources, including the availability of point-of-care testing, intraoperative monitoring tools, and blood conservation technologies, vary across settings and can influence transfusion decision-making [3]. Geographic and healthcare system differences, such as national blood supply limitations or differing guideline adoption, further contribute to variability in practice.

Importantly, the dynamic and time-sensitive nature of the operating room presents unique challenges for applying complex or rigid adjudication tools. Intraoperative decisions must often be made within seconds based on evolving hemodynamic parameters, estimated blood loss, and clinical judgment. As such, adjudication frameworks that rely on lengthy deliberation or retrospective documentation may lack feasibility in real time. This underscores the need for transfusion decision-support tools that are not only evidence-informed and context-specific

but also streamlined, intuitive, and responsive to the constraints of the intraoperative environment. The ideal criteria would balance clinical nuance with simplicity, enabling rapid application without sacrificing accuracy or safety.

Practical implementation of perioperative transfusion criteria will require careful consideration of integration into existing clinical workflows and institutional systems. Embedding decision-support algorithms into electronic health record (EHR) platforms could enable real-time prompts at the point of transfusion ordering, using patient-specific data such as current hemoglobin, hemodynamics, and estimated blood loss. To minimize workflow disruption, integration should align with existing order sets, intraoperative anesthesia records, and transfusion request processes, avoiding redundant documentation. Training programs for surgeons, anesthesiologists, and perioperative nurses should emphasize both the rationale for the criteria and practical application, supported by case-based learning and simulation where feasible. Linking the criteria to quality improvement programs, such as routine audit-and-feedback cycles, can reinforce adherence and identify barriers early. Institutions should also evaluate cost-benefit implications, recognizing that while upfront investment in EHR modification and training may be required, long-term savings may result from reductions in inappropriate transfusion, improved patient outcomes, and optimized blood product utilization.

Previous research underscores the considerable variation in intraoperative transfusion practices, prompting stakeholder organizations to emphasize the need to minimize inappropriate blood produce use [3, 57, 58]. The development and implementation of clinical practice guidelines is one way to mitigate variation in clinical practice. A systematic review of guidelines for intraoperative transfusion demonstrated limited actionable guidance to address this issue [2]. Our scoping review is congruent with this literature, demonstrating a wide range of definitions for appropriate transfusion, and the paucity of criteria specific to the intraoperative setting. The development of clinical tools to help adjudicate which operative transfusion events are appropriate is one strategy to assess if clinical practice guidelines are being applied appropriately. To address stakeholder recommendations and reduce inappropriate transfusion events, consistent and reliable clinical criteria or tools for intraoperative transfusion adjudication are required.

From an economic standpoint, institutional analyses demonstrate substantial variation in transfusion costs, from several hundred thousand to millions annually, with inappropriate transfusions increasing per-case hospital expenditure by nearly US$10,000[59]. Finally, implementation science frameworks such as those proposed by the ICTMG and perioperative IS researchers offer structured approaches for guideline adoption that may aid uptake of adjudication criteria in surgical settings [60, 61].

Study limitations

It is important to acknowledge the limitations of this study. Scoping reviews do not include quality assessments or risk of bias evaluations for the included studies. This limits the ability to draw definitive conclusions about the relative reliability of different definitions of appropriate RBC transfusion. While we highlight the variability observed, some methodologies may be inherently more robust than others, a nuance not captured in our analysis. The grey literature search was limited to screening the first 100 results in Google Scholar, which may have introduced selection bias and led to the omission of potentially relevant sources beyond this initial set. While a more detailed quantitative analysis (e.g., distribution of hemoglobin thresholds across studies) could provide additional insight, this was beyond the scope of our predefined scoping review methodology and may be better addressed in a future systematic review.

Publication bias may also be a concern, as some criteria or tools used in clinical practice may not be formally published in the academic literature and thus would not have been captured in our review. This is particularly relevant for institutional protocols or context-specific decision-making frameworks that are applied in practice but remain undocumented in peer-reviewed sources. Moreover, the wide range of practice settings included in this review introduces heterogeneity that may obscure important institutional or regional differences in how transfusion appropriateness is defined and applied. These factors highlight the challenges in fully capturing the nuances of perioperative transfusion practices across diverse healthcare environments.

Our review aimed to map existing literature on criteria and tools for transfusion event adjudication. Consequently, the data synthesis is descriptive, and without quantitative data analysis. These limitations preclude definitive conclusions or recommendations on which criteria should be used to adjudicate transfusion events.

Future research direction

Future research should prioritize the development and validation of standardized perioperative RBC transfusion adjudication criteria using a phased, mixed-methods approach. Early phases could employ qualitative and consensus-building methods (e.g., Delphi, nominal group technique) to refine candidate criteria with input from surgeons, anesthesiologists, transfusion medicine specialists, nurses, and patient representatives. Validation studies should include sufficiently large and diverse samples to capture variability across surgical specialties,

institutions, and patient populations; sample size calculations should be based on anticipated event rates for transfusion and relevant postoperative outcomes. Effectiveness should be evaluated using both process measures (e.g., adherence to criteria, proportion of appropriate vs. inappropriate transfusions) and patient-centered outcomes (e.g., postoperative morbidity, mortality, length of stay, health-related quality of life). A realistic multi-phase timeline should be planned, progressing from pilot feasibility testing to multicenter trials, with predefined decision points for modification. Consideration should also be given to regulatory and institutional approval pathways, particularly if criteria are to be embedded in electronic health record decision-support systems or linked to quality improvement metrics.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12893-025-03279-9.

Supplementary Material 1.

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Authors' contributions
Victoria Ivankovic, Tori Lenet, Kameela Alibhai, and Daniel Lamanna contributed to data collection, analysis, and manuscript writing and revision. Risa Shorr contributed to the development of the search strategy, data collection, and manuscript writing and revision. Dean Fergusson and Guillaume Martel conceived the study idea, provided supervision, and contributed to manuscript writing and revision. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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Data availability
All data generated or analysed during this study are included in this published article [and its supplementary information files].

Declarations

Ethics approval and consent to participate
Ethics approval was not required for this study as it is a scoping review that involved the analysis of publicly available literature and did not involve human participants or identifiable data.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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