



Nonclinical factors affecting intraoperative red blood cell transfusion: a systematic review

Facteurs non cliniques affectant la transfusion peropératoire de culots sanguins : une revue systématique

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Abstract

Purpose *There is significant variability in intraoperative red blood cell (RBC) transfusion practice. We aimed to use the theoretical domains framework (TDF) to categorize nonclinical and behavioural factors driving intraoperative RBC transfusion practice in a systematic review of the literature.*

Source *We searched electronic databases from inception until August 2021 to identify studies evaluating nonclinical*

factors affecting intraoperative RBC transfusion. Using the Mixed Methods Appraisal Tool, we assessed the quality of included studies and identified relevant nonclinical factors, which were coded into TDF domains by two independent reviewers using NVivo (Lumivero, QSR International, Burlington, MA, USA). We identified common themes within domains and sorted domains based on the frequency of reported factors.

Principal findings *Our systematic review identified 18 studies: nine retrospective cohort studies, six cross-sectional surveys, and three before-and-after studies. Factors related to the social influences, behavioural regulation, environmental context/resources, and beliefs about consequences domains of the TDF were the most*

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reported factors. Key factors underlying the observed variability in transfusion practice included the social effects of peers, patients, and institutional culture on decision-making (social influences), and characteristics of the practice environment including case volume, geographic location, and case start time (environmental context/resources). Studies reported variable beliefs about the consequences of both intraoperative transfusion and anemia (beliefs about consequences). Provider- and institutional-level audits, educational sessions, and increased communication between surgeons/anesthesiologists were identified as strategies to optimize intraoperative transfusion decision-making (behavioural regulation).

Conclusion Our systematic review has synthesized the literature on nonclinical and behavioural factors impacting intraoperative transfusion decision-making, categorized using the TDF. These findings can inform evidence-based interventions to reduce intraoperative RBC transfusion variability.

Study registration Open Science Framework (https://osf.io/pm8zs/?view_only=166299ed28964804b9360c429b1218c1; first posted, 3 August 2022)

Résumé

Objectif Il existe une variabilité importante dans les pratiques de transfusion peropératoire de culots sanguins. Nous avons cherché à utiliser le cadre des domaines théoriques (TDF, pour theoretical domains framework) pour catégoriser les facteurs non cliniques et comportementaux motivant les pratiques de transfusion peropératoire de culots sanguins dans une revue systématique de la littérature.

Sources Nous avons réalisé des recherches dans les bases de données électroniques de leur création jusqu'en août 2021 pour identifier les études évaluant les facteurs non cliniques affectant la transfusion peropératoire de culots sanguins. À l'aide de l'outil d'évaluation des méthodes mixtes, nous avons évalué la qualité des études incluses et identifié les facteurs non cliniques pertinents, qui ont été codés dans les domaines TDF par deux personnes les révisant de manière indépendante utilisant NVivo (Lumivero, QSR International, Burlington, MA, États-Unis). Nous avons identifié des thèmes communs au sein des domaines et trié les domaines en fonction de la fréquence des facteurs signalés.

Constatations principales Notre revue systématique a identifié 18 études : neuf études de cohorte rétrospectives, six sondages transversaux et trois études avant-après. Les facteurs liés aux influences sociales, à la régulation comportementale, au contexte et aux ressources environnementaux et les croyances concernant les domaines de conséquences du TDF étaient les facteurs

les plus rapportés. Les principaux facteurs sous-jacents à la variabilité observée dans la pratique transfusionnelle comprenaient les effets sociaux des pairs, de la patientèle et de la culture de l'établissement sur la prise de décision (influences sociales) et les caractéristiques de l'environnement de pratique, y compris le volume de cas, l'emplacement géographique et l'heure de début des cas (contexte/ressources environnementaux). Des études ont fait état de croyances variables sur les conséquences de la transfusion peropératoire et de l'anémie (croyances sur les conséquences). Des vérifications au niveau des prestataires et des établissements, des séances de formation et une communication accrue entre les chirurgien-nes et les anesthésiologistes ont été identifiées comme des stratégies pouvant optimiser la prise de décision transfusionnelle peropératoire (régulation comportementale).

Conclusion Notre revue systématique a synthétisé la littérature sur les facteurs non cliniques et comportementaux ayant une incidence sur la prise de décision transfusionnelle peropératoire, classés à l'aide du TDF. Ces résultats peuvent éclairer les interventions fondées sur des données probantes pour réduire la variabilité de transfusion peropératoire de culots sanguins.

Enregistrement de l'étude Open Science Framework (https://osf.io/pm8zs/?view_only=166299ed28964804b9360c429b1218c1; soumis pour la première fois, 3 août 2022)

Keywords intraoperative · red blood cell transfusion · theoretical domains framework · transfusion behaviour

Background and rationale

Red blood cell (RBC) transfusion is a common intervention among patients undergoing major surgery. Transfusion decision-making during surgery is a complex and dynamic process because physiologic and biochemical markers traditionally used to guide transfusion decision-making can be influenced by acute blood loss, surgical manipulation and positioning, and potent pharmacologic agents.¹ There is evidence of significant variation in RBC transfusion practice during surgery.^{2–5} Although some variation is expected based on case mix, variation not explained by disease severity or patient preference may reflect inappropriate clinical care because of under- or over-transfusion.^{6–8} In one study, two patients with the same characteristics and risk profiles had a 30% difference in their odds of transfusion when treated by different physicians or hospitals.⁹ Efforts to standardize intraoperative transfusion have focused mainly on objective physical parameters such as hemoglobin

transfusion triggers.¹⁰ Nevertheless, little research has been done to explore nonclinical and behavioural factors that underlie intraoperative transfusion decision-making. There are complex interpersonal, environmental, institutional, and psychological factors that influence the decision to transfuse RBCs in the operating room and likely explain much of the observed interphysician variability in transfusion behaviour.

The theoretical domains framework (TDF) was developed to explore factors influencing clinical behaviour.¹¹ It describes various theories of behaviour clustered into 12 domains: knowledge, skills, social/professional role and identity, beliefs about capabilities, beliefs about consequences, motivation and goals, memory, attention and decision processes, environmental context/resources, social influences, emotion, behavioural regulation, and nature of the behaviours. It is widely used in implementation research and provides a theoretical lens through which the cognitive, affective, social, and environmental influences on behaviour can be viewed. The TDF is increasingly being used to structure systematic reviews by synthesizing influences on behaviours across studies according to theoretical domains. In this context, using the TDF as a guide allows for a comprehensive examination of the influences on intraoperative transfusion practices, facilitating a nuanced understanding and identifying potential areas for intervention and improvement in clinical practices with the aim of decreasing intraoperative RBC transfusion variability.

Purpose

The aim of this systematic review was to identify nonclinical and behavioural factors that influence intraoperative RBC transfusion decision-making. More specifically, we sought to understand the psychological, social, environmental, and contextual factors that influence transfusion decisions made in the operating room.

Methods

This systematic review was conducted and reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (Electronic Supplementary Material [ESM] eAppendix 1).¹² The protocol was developed prospectively and registered with the Open Science Framework (first posted, 3 August 2022).^A

^A Available from URL: https://osf.io/pm8zs/?view_only=166299ed28964804b9360c429b1218c1 (accessed January 2024).

Search strategy

The search strategy was developed in consultation with an experienced librarian in the health care field and is presented in ESM eAppendix 2. The term “blood transfusion” was combined using the Boolean operator “or” with terms related to the following topics: shared care (e.g., team-based care), behaviour (e.g., intention-behaviour relation, decision-making), and nontechnical skills (e.g., prognostic factors, attitudes). Similarly, these latter terms were combined with each other using the same Boolean operator “or.”

Information sources

The following databases were searched from inception until 5 August 2021: Ovid MEDLINE, Embase, and Web of Science. The first 100 hits of Google Scholar were also reviewed to include the grey literature. Reference lists of any relevant systematic reviews were also reviewed to identify eligible studies. All citations identified from the literature searches were deduplicated and exported into Covidence (Melbourne, VIC, Australia).

Eligibility criteria

Studies describing any nonclinical or behavioural factor influencing intraoperative RBC transfusion decisions were included. Studies were eligible only if they specifically focused on the intraoperative period, rather than the pre-, post-, or any nonoperative context. Studies of health care professionals (i.e., anesthesiologists and surgeons) involved in intraoperative transfusion decisions and studies using patient transfusion data were both eligible for inclusion. All study designs were considered for inclusion except editorials and systematic or narrative reviews. Published abstracts were considered for inclusion provided they reported enough information to contribute to the review. Only studies published in English or French were considered for inclusion. Studies that reported clinical factors only influencing intraoperative transfusion were excluded; this included studies reporting on hemoglobin triggers, preoperative autologous transfusion, intraoperative cell salvage, intraoperative tranexamic acid, or thromboelastometric testing. Studies exclusively reporting on transfusion of blood products other than RBCs were excluded.

Study screening

Titles and abstracts were screened independently and in duplicate by a team of three reviewers (P. B., A. B., T. L.). Full texts of potentially eligible studies identified in the

first stage of screening were then reviewed for eligibility independently and in duplicate by the same team of reviewers. Disagreements were resolved either by consensus or in consultation with a senior investigator (G. M.).

Data collection

Following full-text review assessment of eligibility, included studies were imported into NVivo (QSR International, Burlington, MA, USA). Data on study characteristics including year of publication, location, study design, aim, study population, setting, and data collection method were extracted. Next, using the NVivo coding software, factors deemed to be relevant to intraoperative RBC transfusion decision-making were identified from included studies and coded into the appropriate theoretical domain of the TDF. Coding was performed independently and in duplicate by two reviewers (P. B., A. G.) and subsequently reviewed with a third author (T. L.). Disagreements were resolved by consensus or by a senior author.

Quality assessment

The quality of studies was assessed independently and in duplicate using the Mixed Methods Appraisal Tool (MMAT).¹³ The MMAT is designed to be used as a checklist for concurrently rating and/or describing papers in systematic reviews that include various study designs (i.e., reviews including qualitative, quantitative, and mixed methods studies). Quantitative studies were assessed using Section 3, which includes items pertaining to participant recruitment, outcome measurements, group comparability, and completeness of outcome data. Descriptive studies were assessed using Section 4, which has components pertaining to appropriate sampling procedure, the representativeness of the sample, outcome measurements, and an acceptable response rate. The overall quality score is calculated based on the percentage of quality criteria met by each study.

Data synthesis and analysis

Factors deemed to be relevant to intraoperative transfusion decision-making were extracted from included studies and listed. Each extracted factor was then classified according to the TDF into one of its 14 domains. The domains were then sorted based on the number of studies reporting a factor related to that domain. The number of studies describing the same theme within a domain was also considered when analyzing the data to determine which

nonclinical factors have been most reported to influence intraoperative transfusion decision-making.

Results

Following deduplication, 3,089 unique citations were identified by the literature searches. After title and abstract screening, 114 full text articles were assessed for final eligibility, and 18 studies were included in this review (Table 1). Reasons for full-text exclusion are detailed in Fig. 1. Included studies were published between 1990 and 2020. The majority of studies were conducted in the USA ($n = 12$), with the others being conducted in Canada ($n = 3$), Asia ($n = 1$), Europe ($n = 1$), and Australia ($n = 1$). Study designs included nine retrospective cohort studies,^{2,5,14–19} six cross-sectional survey-based studies,^{20–25} and three before-and-after studies.^{26–28} Cross-sectional studies used a variety of survey administration techniques including self-administration and interviewer-assisted, involving both electronic, paper, and mailed formats. Ten studies included patients as the unit of study,^{2,14–20,28,29} while seven surveyed a variety of physicians including surgeons and anesthesiologists,^{20,22–27} and one surveyed institutions about organizational-level blood management practices.²¹ Eleven studies focused only on physicians or patients performing or undergoing cardiac surgery procedures.^{5,14–19,21,25,26,29} All but one included study were full-text papers, and the remaining one was a published abstract.²⁸

Study quality assessment

The MMAT tool was used to assess the quality of included studies. The results are presented in Table 2. Three studies met 100% of the quality criteria,^{5,15,29} 11 met 80%,^{2,14,16,17,19–25} three met 60%,^{18,26,27} and one met 20%.²⁸ Nonrandomized quantitative comparative studies were most commonly downgraded for not reporting missing outcome data (criterion 3.3) and not adequately controlling for confounding in their statistical analysis (criterion 3.4). Quantitative noncomparative studies were most frequently downgraded for not adequately describing the characteristics of their sample relative to their target population (criterion 4.2) and for the possibility of nonresponse bias impacting their results (criterion 4.4).

Factors affecting intraoperative transfusion

A total of 48 behavioural factors influencing intraoperative RBC transfusion were identified and categorized into ten domains (Table 3). Domains are reported in descending

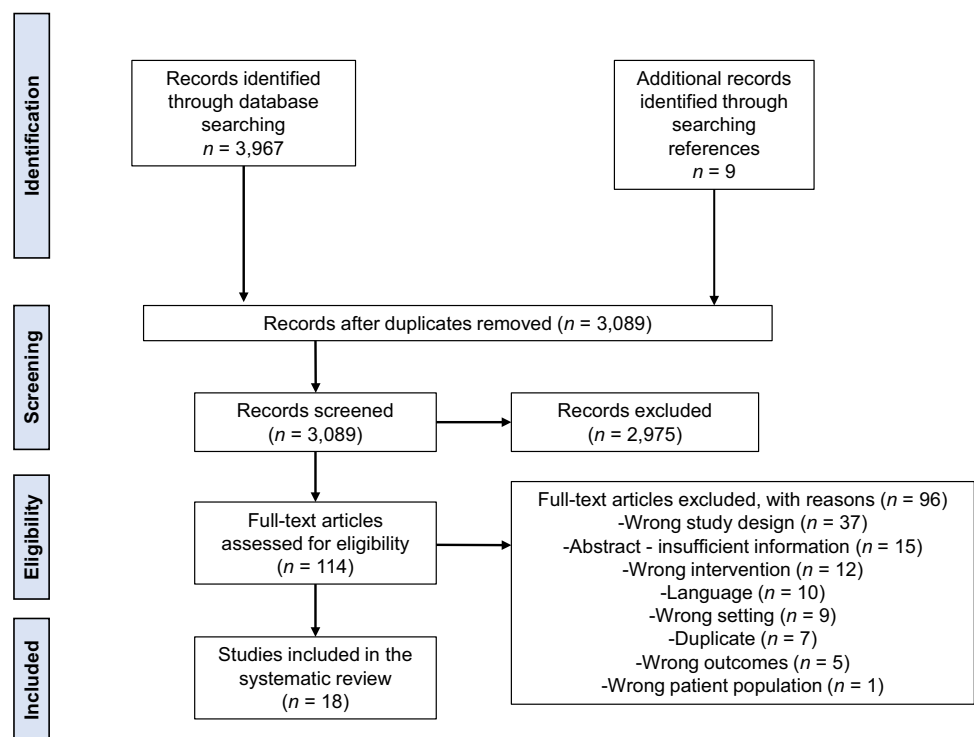
Table 1 Study characteristics

First author	Year	Country	Design	Aim	Setting	Data collection method	Participants
Addis ¹⁴	2020	USA	Retrospective cohort study	Investigate the role time of day plays in perioperative outcomes	Single academic centre	Retrospective chart review	Adult cardiac surgery patients involving CPB
Bennett–Guerrero ⁵	2010	USA	Retrospective cohort study	Assess hospital-level variation in use of allogeneic RBCs	798 American hospitals	Retrospective chart review (STS database)	Patients undergoing primary isolated CABG with CPB
Bennett ²⁰	2018	Canada	Cross-sectional survey study	Describe current practices in perioperative blood management and explore differences between surgeons and anesthesiologists	31 Canadian hospitals	Web-based survey	Canadian liver surgeons and anesthesiologists
Brown ²⁹	2011	USA	Retrospective cohort study	Examine the impact of team changeover and unfamiliar teams in cardiovascular surgery on clinical outcome measures	Single academic centre	Retrospective chart review (institutional databases)	Patients undergoing elective or urgent cardiovascular surgery
Camaj ²¹	2017	USA	Cross-sectional survey study	Improve understanding of “organizational contributors” to hospital variation in low-volume intraoperative transfusion rates	Cardiac surgical programs	Electronic survey	The Michigan Society of Thoracic and Cardiovascular Surgeons Quality Collaborative institutions
Cote ¹⁵	2015	Canada	Retrospective cohort study	Determine whether differing practice patterns had an impact on variation in perioperative transfusion	Single hospital	Retrospective chart review (cardiac surgery database)	All patients who underwent cardiac surgery at the Saint John Regional Hospital
Fischer ²⁷	2015	Germany	Before-and-after study	Analyze barriers to PBM implementation and outline a strategy to introduce and manifest PBM	Single academic centre	Self-administered questionnaire	Physicians (surgeons and anesthesiologists) attending the introduction session of PBM and the PBM lecture 1 year thereafter
Goodnough ¹⁶	1991	USA	Retrospective cohort study	Describe the variability in transfusions among institutions and determine factors that may account for variability	18 academic tertiary-care hospitals	Audit of 30 consecutive adult patients in 18 programs	540 patients undergoing elective first-time CABG
Hensley ²⁶	2019	USA	Before-and-after study	Describe effective methods for audits with feedback to the cardiac anesthesiologists	Single academic centre	Retrospective chart review (electronic record system)	Attending cardiac anesthesiologists
Jin ¹⁷	2013	USA	Retrospective cohort study	Quantitate the contribution of hospital influence on individual surgeons’ transfusion practices	12 American hospitals	Retrospective chart review (STS database)	Patients who underwent CABG operations
Maddux ¹⁸	2009	USA	Retrospective cohort study	Assess institutional variability of intraoperative RBC use in on-pump CABG surgery	144 American hospitals	Retrospective chart review (Hospital Clinical Services Group quality indicator database)	Patients undergoing isolated CABG surgery
Matot ²²	2004	Israel	Cross-sectional survey study	Evaluate the attitude of anesthesiologists and gynecologists to the use of blood during Cesarian delivery	7 university hospitals and 3 nonteaching hospitals	Scenario-based survey	Hospital-based anesthesiologists and gynecologists
McQuilten ¹⁹	2014	Australia	Retrospective cohort study	Investigate the differences in perioperative transfusion rates in cardiac surgery and what hospital factors may contribute	25 Australian hospitals	Retrospective chart review (cardiac surgery database)	Adults undergoing cardiac surgery
Qian ²	2013	USA	Retrospective cohort study	Examine the hospital variability in use of RBCs in patients undergoing major noncardiac surgery	American academic medical centres	Retrospective chart review (University Health System Consortium database and the American Hospital Association Annual Survey File)	Patients who underwent elective or urgent primary THR, colectomy, and pancreaticoduodenectomy surgeries
Rodrigues ²⁸	2015	USA	Before-and-after study	Reduce the number of patients transfused and the use of blood by 10% by improving interdisciplinary communication about transfusion	Single academic centre	Retrospective chart review	Patients undergoing surgery
Salem–Schatz ²³	1990	USA	Cross-sectional survey study	Evaluate the influence of several clinical and nonclinical factors on transfusion decision-making	3 American hospitals	Face-to-face survey	122 general and orthopedic surgeons and anesthesiologists

Table 1 continued

First author	Year	Country	Design	Aim	Setting	Data collection method	Participants
Salem-Schatz ²⁴	1993	USA	Cross-sectional survey + retrospective cohort study	Explore the relationship between physicians' knowledge and attitudes regarding the use of blood products and the quality of their transfusion practice	2 large American teaching hospitals	Mixed-methods design including face-to-face survey and chart review	17 attending orthopedic and general surgeons
Shehata ²⁵	2007	Canada	Cross-sectional survey study	Quantify hospital variation in RBC transfusion decisions perioperatively for patients undergoing CABG	32 Canadian hospitals	Self-administered mailed questionnaires	All anesthesiologists and cardiac surgeons involved in CABG in Canada

CABG = coronary artery bypass graft; CPB = cardiopulmonary bypass; PBM = patient blood management; RBC = red blood cell; STS = Society of Thoracic Surgeons; THR = total hip replacement

Fig. 1 PRISMA flow diagram

order based on the number of studies that reported factors related to each domain (Fig. 2).

SOCIAL INFLUENCES

Twelve studies reported the impact of social influences on intraoperative transfusion decision-making.^{2,5,15–21,23–25} These included the influence of colleagues on transfusion decisions, as well as the impact of patient preferences on these decisions. The effect of local institutional culture on intraoperative transfusion decisions was reported by ten studies, the most of any factor in this review.

BEHAVIOURAL REGULATION

Seven studies described factors related to behavioural regulation.^{14,17,21,23,26–28} Several strategies to improve intraoperative transfusion decision-making were described and/or tested. Institutional transfusion guidelines were reported to be helpful in guiding intraoperative transfusion practice in three studies.^{14,21,27} Effective communication between the anesthesiologist and surgeon was noted to be essential to guide intraoperative transfusion,¹⁷ and was shown to decrease intraoperative transfusion and postoperative anemia in one study.²⁸ Provider-level

intraoperative transfusion audits were reported to decrease transfusion rates in two studies,^{21,26} with another study discussing the importance of hospital-level transfusion audits and feedback.¹⁷ Educational sessions were also reported to reduced unwarranted RBC transfusion.²³

ENVIRONMENTAL CONTEXT/RESOURCES

The effects of environmental context and resources on intraoperative transfusion practice were discussed in six studies.^{2,5,14,21,23,29} Several environmental factors were associated with increased rates of intraoperative transfusion including later case start times,¹⁴ academic hospital settings,⁵ geographic region,⁵ and lower hospital case volumes.^{2,5} Other factors such as team changeover did not appear to affect intraoperative transfusion.²⁹ Resource considerations including local blood product availability and the presence of RBC units in the operating room also did not appear to significantly affect intraoperative transfusion decisions.^{21,23}

BELIEFS ABOUT CONSEQUENCES

Beliefs about the consequences of transfusing and not transfusing were reported by seven studies.^{2,14,22–24,27} Beliefs reported to affect intraoperative transfusion

decisions included the legal repercussions of not transfusing and the morbidity associated with transfusion.²² Physicians tended to overestimate the consequences of both transfusing and not transfusing; physicians reporting personal experience with anemia-related complications were more likely to both overestimate the risks associated with anemia and to have higher rates of appropriate transfusion.²³ Physicians were reported to weigh the benefits of intraoperative transfusion more heavily than the risks.^{14,23} The financial cost of intraoperative transfusion did not appear to affect transfusion decisions.²³ Significant variability in beliefs about the effects of transfusion and anemia was identified, resulting in substantial practice heterogeneity.^{2,27}

KNOWLEDGE

Knowledge of the evidence underlying intraoperative transfusion decision-making was reported by five studies.^{2,17,23,24,27} The evidence underlying intraoperative transfusion practice was reported as poor and was thought to contribute to increased variability in transfusion practice.^{2,27} Physicians felt that transfusion-related education provided during medical training was insufficient, and that it was difficult to stay up to date with the published evidence underlying intraoperative

Table 2 Quality of included studies

First author	Year	Criteria from the Mixed Methods Appraisal Tool ¹³										% of quality criteria met
		3.1	3.2	3.3	3.4	3.5	4.1	4.2	4.3	4.4	4.5	
Addis ¹⁴	2020	1	1	0	1	1						80%
Bennett-Guerrero ⁵	2010	1	1	1	1	1						100%
Bennett ²⁰	2018						1	1	1	0	1	80%
Brown ²⁹	2011	1	1	1	1	1						100%
Cama ²¹	2017						1	0	1	1	1	80%
Cote ¹⁵	2015	1	1	1	1	1						100%
Fischer ²⁷	2015						1	0	1	0	1	60%
Goodnough ³⁹	1991	1	1	1	0	1						80%
Hensley ²⁶	2019	1	1	0	0	1						60%
Jin ¹⁷	2013	1	1	0	1	1						80%
Maddux ¹⁸	2009	1	1	0	0	1						60%
Matot ²²	2004						1	0	1	1	1	80%
McQuilten ¹⁹	2014	1	1	0	1	1						80%
Qian ²	2013	1	1	1	1	0						80%
Rodrigues ²⁸	2015	0	0	0	0	1						20%
Salem-Schatz ²³	1990						1	0	1	1	1	80%
Salem-Schatz ²⁴	1993						1	0	1	1	1	80%
Shehata ⁴⁰	2007						1	1	1	0	1	80%

0 = criteria not met; 1 = criteria met

Table 3 Intraoperative transfusion behavioural factors distributed to the theoretical domains framework domains

TDF domain	Factors	Studies citing the domain	
Social influences	Influence of other physicians affects intraoperative transfusion decisions	Cote <i>et al.</i> ¹⁵	
		Jin <i>et al.</i> ¹⁷	
		Bennett <i>et al.</i> ²⁰	
	Patient preference affects intraoperative transfusion decisions	Salem-Schatz <i>et al.</i> ²³	
		Salem-Schatz <i>et al.</i> ²⁴	
	Local institutional culture affects intraoperative transfusion decisions	Salem-Schatz <i>et al.</i> ²³	
		Qian <i>et al.</i> ²	
		Bennett-Guerrero <i>et al.</i> ⁵	
		Cote <i>et al.</i> ¹⁵	
		Goodnough <i>et al.</i> ¹⁶	
Behavioural regulation	Institutional transfusion guidelines help guide intraoperative transfusion practice	Jin <i>et al.</i> ¹⁷	
		Maddux <i>et al.</i> ¹⁸	
		McQuilten <i>et al.</i> ¹⁹	
	Communication between anesthesiologists and surgeons is essential to guide transfusion in the operating room	Camaj <i>et al.</i> ²¹	
		Salem-Schatz <i>et al.</i> ²⁴	
	Educational programs would improve intraoperative transfusion practice	Shehata <i>et al.</i> ²⁵	
		Addis <i>et al.</i> ¹⁴	
	Hospitals should assess their intraoperative transfusion practice routinely	Camaj <i>et al.</i> ²¹	
		Fischer <i>et al.</i> ²⁷	
	Transfusion audits decrease intraoperative transfusion	Fischer <i>et al.</i> ²⁷	
Rodrigues ²⁸			
Environmental context/resources	Later case start times increase the intraoperative transfusion rate	Salem-Schatz <i>et al.</i> ²³	
	Academic hospital settings transfuse at higher rates than community sites in the operating room	Jin <i>et al.</i> ¹⁷	
	Hospital with higher volumes transfuse less frequently in the operating room	Camaj <i>et al.</i> ²¹	
		Hensley <i>et al.</i> ²⁶	
	Geographic region influences intraoperative transfusion rates	Fischer <i>et al.</i> ²⁷	
	Team changeover does not affect intraoperative transfusion	Addis <i>et al.</i> ¹⁴	
	Blood product availability does not affect intraoperative transfusion decisions	Bennett-Guerrero <i>et al.</i> ⁵	
	The presence of RBC units in the operating room does not increase intraoperative transfusion	Qian <i>et al.</i> ²	
	Beliefs about consequences	Blood product cost does not affect intraoperative transfusion decisions	Bennett-Guerrero <i>et al.</i> ⁵
		Concerns about legal repercussions lead to overtransfusion in the operating room	Bennett-Guerrero <i>et al.</i> ⁵
Variations in belief about consequences of transfusion/anemia lead to practice variation in intraoperative transfusion		Brown <i>et al.</i> ²⁹	
Concerns about the risks of intraoperative transfusion affect transfusion practice		Salem-Schatz <i>et al.</i> ²³	
		Physicians overestimate the risks of anemia in the operating room	Camaj <i>et al.</i> ²¹
Physicians overestimate the risks of intraoperative transfusion		Salem-Schatz <i>et al.</i> ²³	
Personal experience with anemia complications lead to overestimation of the risks of anemia		Salem-Schatz <i>et al.</i> ²³	
Personal experience with anemia complications lead to higher rates of appropriate transfusion		Salem-Schatz <i>et al.</i> ²⁴	
Physicians weigh the benefits of intraoperative transfusion more heavily than the risks		Addis <i>et al.</i> ¹⁴	
		Salem-Schatz <i>et al.</i> ²³	

Table 3 continued

TDF domain	Factors	Studies citing the domain
Knowledge	It is difficult to keep up to date with transfusion evidence	Fischer <i>et al.</i> ²⁷
	There is not enough transfusion education during training	Fischer <i>et al.</i> ²⁷
	The evidence base underlying intraoperative transfusion is poor, leading to increased variability in transfusion practice	Qian <i>et al.</i> ² Fischer <i>et al.</i> ²⁷
	Poor knowledge leads to higher rates of inappropriate transfusion	Salem-Schatz <i>et al.</i> ²⁴
	Knowledge deficiencies about intraoperative transfusion are widespread	Salem-Schatz <i>et al.</i> ²³
	Most physicians do not use published transfusion guidelines	Jin <i>et al.</i> , ¹⁷ Salem-Schatz <i>et al.</i> ²³
Social/professional role and identity	Anesthesiologists are the primary transfusion decision-makers	Bennett <i>et al.</i> ²⁰
	Transfusion decisions are multidisciplinary	Cote <i>et al.</i> ¹⁵
	Intraoperative transfusion clinical practice guidelines threaten professional autonomy	Fischer <i>et al.</i> ²⁷
	Surgeons are more likely to transfuse at higher hemoglobin levels in the operating room than anesthesiologists	Matot <i>et al.</i> ²²
Nature of the behaviours	There is uncertainty as to the primary decision maker for intraoperative transfusion	Salem-Schatz <i>et al.</i> ²⁴
	Physicians become more restrictive with intraoperative transfusion over the course of their careers	Bennett <i>et al.</i> ²⁰
	Rates of intraoperative transfusion are rising	Cote <i>et al.</i> ¹⁵
	It is difficult to change transfusion behaviour in the operating room	Fischer <i>et al.</i> ²⁷
	Most physicians transfuse 2 units of RBCs at a time in the operating room	Matot <i>et al.</i> ²²
Memory, attention, and decision processes	Physicians are more worried about errors of omission than errors of commission related to intraoperative transfusion	Salem-Schatz <i>et al.</i> ²³
	Decision fatigue leads to overtransfusion in the operating room	Addis <i>et al.</i> ¹⁴
	Errors in reasoning and oversimplification lead to variation in intraoperative transfusion practice	Fischer <i>et al.</i> ²⁷
Beliefs about capabilities	Overwhelming clinical responsibility leads to mistransfusion in the operating room	Fischer <i>et al.</i> ²⁷
	Intraoperative transfusion decisions are complex	Qian <i>et al.</i> ²
	Lack of self-efficacy is associated with a worse intraoperative transfusion practice	Fischer <i>et al.</i> ²⁷
Motivation and goals	Greater confidence in intraoperative transfusion practice is associated with lower knowledge levels	Salem-Schatz <i>et al.</i> ²³
	Older physicians are more confident in their intraoperative transfusion practice	Salem-Schatz <i>et al.</i> ²³
	Physicians want to make the right intraoperative transfusion decisions to optimize patient health/recovery	Fischer <i>et al.</i> ²⁷

RBC = red blood cell; TDF = theoretical domains framework

transfusion.²⁷ Poor transfusion knowledge was associated with higher rates of inappropriate transfusion.²⁴ Knowledge deficiencies about intraoperative transfusion were reported as widespread, with most physicians not routinely using published intraoperative RBC transfusion guidelines.^{17,23}

SOCIAL/PROFESSIONAL ROLE AND IDENTITY

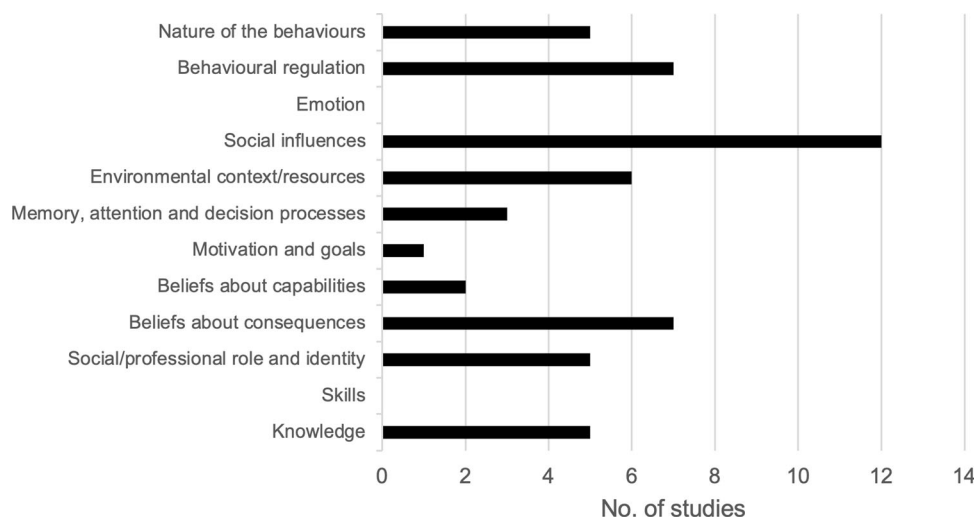
The professional role of surgeons and anesthesiologists in making intraoperative transfusion decisions was discussed in five studies.^{15,20,22,24,27} There appeared to be variability among studies as to the primary decision-maker for intraoperative transfusion. One study identified the

anesthesiologist as the primary decision-maker,²⁰ another reported that transfusion decisions are multidisciplinary,¹⁵ and another reported uncertainty regarding the primary decision-maker, even within a single institution.²⁴ One study reported that surgeons are more likely to transfuse at higher hemoglobin values compared with anesthesiologists.²²

NATURE OF THE BEHAVIOURS

Five studies reported factors categorized into the nature of the behaviours domain.^{15,20,22,23,27} Physicians reported that their transfusion practice has become more restrictive over the course of their careers.²⁰ Physicians appeared to be

Fig. 2 Number of studies attributed to each theoretical domain



more concerned about committing errors of omission than errors of commission, leading them to be more likely to transfuse rather than observe in situations where the indication for transfusion is equivocal.²³ These individual differences in transfusion practice were reported to be related to the degree of interventionism or noninterventionism of the physician.

MEMORY, ATTENTION, AND DECISION PROCESSES

Three studies discussed factors related to the memory, attention, and decision processes domain,^{2,14,27} including the effect of decision fatigue¹⁴ on intraoperative transfusion decision-making. The observed variability in intraoperative transfusion practice between physicians was attributed to errors in reasoning and oversimplification.²⁷ The decision processes underpinning intraoperative transfusion were noted to be a complex sequence of decisions involving numerous health care professionals.²

BELIEFS ABOUT CAPABILITIES

Factors associated with belief about individual capability to make intraoperative transfusion decisions were reported in two studies.^{23,27} Lack of self-efficacy was associated with higher rates of inappropriate intraoperative transfusion, and higher levels of confidence were associated with lower transfusion knowledge. Older physicians were reported to be more confident in their transfusion practice.

MOTIVATION AND GOALS

Only one study discussed factors that motivated intraoperative transfusion decision-making, stating that physicians are generally motivated to make decisions that they deem are in the patient's best interest.²⁷

Discussion

In this systematic review, the most frequently reported factors that influence intraoperative RBC transfusion decision-making in the included studies pertained to the social influences, behavioural regulation, environmental context/resources, and beliefs about consequences domains of the TDF. Key factors underlying the observed variability in transfusion practice included the social effects of peers, patients, and local institutional culture on decision-making (social influences), as well as various environmental characteristics of the practice environment such as volume, geographic location, and case start time (environmental context/resources). Physicians often held varying beliefs about the consequences of both intraoperative transfusion and anemia (beliefs about consequences). Studies reported several strategies to optimize intraoperative transfusion decision-making including provider- and institutional-level audits, educational sessions, and increased communication between surgeons and anesthesiologists (behavioural regulation).

The social influences and environmental factors underlying intraoperative RBC transfusion decisions were among the most cited factors in included studies. These include factors such as team dynamics, peer norms, communication patterns within the surgical team, and the overall organizational culture in the operating room. The interplay of these elements significantly shapes decision-making processes, reflecting the intricate web of social and environmental influences on the use of RBC transfusions during surgical procedures. Social norms have a significant impact on human behaviour; people constantly gauge and shape their actions based on those of their peers, rarely departing from social standards. Accordingly, this also governs clinical decisions made by physicians, wherein

social norms are formed at the levels of the profession, institution, and peer group.³⁰ The effect of peers on intraoperative transfusion decisions was commonly discussed in included studies. For instance, one survey-based study reported that half of all attending physicians changed their minds about whether or not to give a patient a transfusion at least once a month based on the advice of colleagues.²³ The importance of joint decision-making was further highlighted by another study, which implemented a mandatory discussion of intraoperative transfusion strategies in the preoperative timeout between the anesthesiologist and surgeon,²⁸ resulting in a 40% reduction of the rate of intraoperative RBC transfusion. Peer pressure from other physicians has been reported as an influential factor for other health care decisions, including physician hand hygiene³¹ and patient disposition in the emergency department.³²

The effect of local institutional culture was also commonly discussed in included studies. This refers to the shared values, practices, and norms within a specific health care institution, influencing the approach towards intraoperative RBC transfusion decisions. Elements such as institutional policies, leadership attitudes, and the prevailing clinical practices collectively contribute to shaping the organizational culture, which, in turn, plays a crucial role in determining the patterns and rationale behind RBC transfusions in the intraoperative setting. Medical trainees are exposed to practice standards through a combination of local practice styles, specialty-specific techniques, and general professional behavioural norms.³³ In this review, local institutional culture was the most studied nonclinical factor driving intraoperative transfusion practice, with included studies reporting that hospital characteristics accounted for between 20%²⁵ and 70%¹⁷ of the observed variability in RBC transfusion practice in the operating room. This underlines the importance of institutional norms and hospital-wide blood management programs in optimizing intraoperative transfusion practice and minimizing unwarranted transfusion.

Interestingly, only one study discussed the influence of patient preference on intraoperative transfusion decision-making. In this survey study by Salem–Schatz *et al.*, while the majority of physicians (85%) agreed that the patient's wishes should be taken into account when deciding whether or not to order an RBC transfusion in the intraoperative period, only 23% said that their transfusion decisions were significantly influenced by patient preference.²³ Thus, there appeared to be a discrepancy between what physicians think should be done compared with what is actually done. The Blood Transfusion Priority Setting Partnership has highlighted the best communication with patients regarding their options related to transfusion and its alternatives as an area of uncertainty.³⁴ While some

patients may wish to defer intraoperative transfusion decisions entirely to the surgical team, others wish for their preferences to be incorporated into transfusion decisions made on their behalf while under anesthesia. For instance, a recent survey study found that 40% of patients wanted to discuss transfusion choices with the medical staff.³⁵ Therefore, there is likely a role for incorporating patient preferences and values into transfusion decisions, particularly when the indication for transfusion is equivocal. This extends beyond a simple dichotomy of accepting or refusing transfusions and instead involves a comprehensive assessment of a patient's willingness to accept the potential risks associated with transfusion or anemia. This approach entails integrating these individual preferences into the decision-making process regarding transfusions made on their behalf.

While many studies focused on the social and environmental factors influencing intraoperative transfusion behaviour, others emphasized the impact of individual practice patterns on intraoperative transfusion variability. Despite published intraoperative transfusion guidelines by prominent organizations,^{36–38} provider-level factors continue to heavily influence transfusion decisions; one study by Shehata *et al.* reported that up to 80% of the variance in transfusion practice is because of individual physician characteristics.²⁵ Included studies described a variety of factors that may underlie this practice variation. Firstly, physicians generally perceive the quality of the available evidence guiding intraoperative transfusion practice as poor, preventing uptake of published transfusion guidelines and perpetuating so-called “inertia” of previous practice.²⁷ Furthermore, variation in beliefs about the consequences of both intraoperative transfusion and anemia compounded with individual previous experience with the complications of both are also described as influencing transfusion practice. Other factors related to the nature of transfusion behaviours that underlie physician-level practice variation include the general interventionist or noninterventionist tendencies of physicians and the propensity for physicians to be more concerned about errors of omission (i.e., the consequences of nontransfusion) rather than errors of commission (i.e., the consequences of giving a transfusion). Finally, transfusion decisions may also be modified by factors such as decision fatigue, errors in reasoning, oversimplification, and mental stress. The influence of these physician-level factors may be minimized by using strategies such as educational sessions about the evidence underlying intraoperative transfusion or implementing evidence-based intraoperative transfusion algorithms to guide decision-making.

The main strengths of this review lie in its methodological rigour. Using the TDF to synthesize and

categorize the behavioural factors underlying intraoperative transfusion decision-making has identified modifiable behaviours that can be integrated into future interventions aimed at reducing transfusion variability and unwarranted RBC transfusion. These include individual and hospital-wide transfusion audits, educational programs, institutional intraoperative transfusion algorithms, and strategies to increase intraoperative communication between physicians involved in transfusion decision-making. Each of these may be able to significantly decrease transfusion rates in the operating room, underscoring the influence of these behavioural factors on transfusion decisions. Unfortunately, given the limited number of studies testing each strategy, we were unable to calculate an aggregate effect size to quantify the degree to which they reduce intraoperative transfusion.

The limitations of this review are largely related to the nature of the available data published in the literature. While there has been extensive research into the clinical factors that influence intraoperative transfusion (including hemoglobin triggers), relatively little attention has been paid to the effects of nonclinical and behavioural factors on these decisions. These factors likely have a stronger influence on transfusion decisions in the intraoperative context than in the nonoperative environment because of the unique nature of the intraoperative setting. For example, while these decisions are usually made by a single health care provider in the nonoperative setting, multiple individuals including surgeons, anesthesiologists, and perfusionists may influence transfusion decision-making in the operating room. Further, factors such as the potential for major surgical blood loss and the perceived consequences of intraoperative anemia are not present in the nonoperative setting and are likely to significantly impact the decision processes underlying intraoperative transfusion. Only 18 studies were identified in this review, and the majority of these only examined a small number of the nonclinical factors that influence transfusion decision-making. Furthermore, there is an even greater paucity of data regarding transfusion practice in noncardiac surgery, as greater than half of included studies focused on transfusions administered in the context of cardiac surgical procedures. Factors impacting intraoperative transfusion decisions made in the context of cardiac surgery, particularly among patients undergoing cardiopulmonary bypass, are not necessarily transferrable to the noncardiac setting given the significant differences in transfusion practice between these two settings. Additional research is required in noncardiac surgical environments to enhance our understanding of intraoperative transfusion practices in these noncardiac settings. Finally, included studies spanned a 30-year period. Specific contextual factors and practices related to intraoperative transfusions

may have evolved over this period with advancements in medical technology, changes in clinical guidelines, and shifts in health care culture. Although temporal trends were not specifically explored in this review, future research could explore how certain behavioural factors have adapted or changed over the years in the context of intraoperative transfusions. This could provide valuable insights into the dynamic nature of these practices and inform recommendations for contemporary clinical settings.

In summary, our systematic review has synthesized the literature describing nonclinical and behavioural factors underlying intraoperative transfusion decision-making and has categorized these factors using the TDF. These results can help in the design of future evidence- and theory-based interventions aimed at decreasing intraoperative RBC transfusion variability.

Author contributions *Tori Lenet* contributed to all aspects of this manuscript, including conception and design; acquisition, analysis, and interpretation of data; and drafting the article. *Pauline Berthelot* contributed to study conception, protocol writing, design, and data acquisition. *Alexa Grudzinski*, *Alexander Banks*, and *Joseph Tropiano* contributed to data analysis and manuscript editing. *Daniel McIsaac*, *Alan Timmouth*, and *Dean Fergusson* contributed to the conception and editing of the manuscript. *Andrea Patey* provided content expertise and contributed to data interpretation and editing of the manuscript. *Guillaume Martel* contributed to study conception, data interpretation, and editing of the manuscript.

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