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Alignment and Variability of Out-of-Hospital Transfusion Protocols in Canadian Critical Care Transport: A Comparative Study with Expert Recommendations

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Abstract

This study investigates how Canadian civilian critical care transport organizations (CCTOs) implement out-of-hospital transfusion (OHT) protocols, comparing current practices to expert guidance, and explores the potential value of standardizing these protocols nationwide. A nationwide cross-sectional survey included all seven Canadian CCTOs providing OHT. Protocols were evaluated for adherence to expert recommendations, focusing on key elements such as transfusion triggers and termination criteria. Analysis revealed that Canadian CCTOs followed expert guidance in 89% of assessed practices. While most protocols were closely aligned with recommendations—likely supported by networks such as CAN-PATT—variability persisted in certain areas, particularly regarding when transfusions should start and stop. Standardizing practices could offer significant advantages, including clearer policy development, better integration of emerging evidence, and more robust evaluation of transfusion outcomes. Canadian CCTOs demonstrate strong adherence to expert OHT recommendations, yet differences in protocol details highlight opportunities for harmonization. Establishing more uniform guidelines could strengthen prehospital trauma care, enhance consistency across transport teams, and support continuous improvements in patient management. Sustained efforts to refine and update OHT protocols are essential to optimize trauma outcomes nationwide.

Keywords: Prehospital, Critical care transport, Trauma, Hemorrhage, Transfusion

Introduction

Hemorrhagic shock continues to be a leading preventable cause of death worldwide, contributing to roughly 1.9 million fatalities annually [1]. Trauma is the most common trigger, particularly affecting individuals under 44 years old, and accounts for about 1.5 million deaths each year [1-3]. Rapid recognition and management of hemorrhagic shock are essential for improving survival outcomes [1]. Effective treatment focuses on controlling ongoing bleeding while restoring blood volume, oxygen transport, and coagulation function [1]. Evidence suggests that early, aggressive hemorrhage control and resuscitation significantly reduce mortality in trauma patients [1]. In this context, out-of-hospital transfusion (OHT) is emerging as a critical prehospital intervention, allowing transfusion of whole blood, red blood cells (RBCs), plasma, or specific blood products such as fibrinogen and prothrombin complex concentrate (PCC) before hospital arrival [4-7].

Implementing OHT programs in Canada faces unique challenges due to its expansive geography and remote communities [8, 9]. Many regions lack timely access to hospitals, and the long-distance transport of blood products can create delays that compromise patient care [8, 9].

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Successful deployment requires coordination among healthcare providers, logistics specialists, and local communities to ensure safe and effective delivery [8, 9]. Standardized protocols are also vital to maintain consistent, efficient, and safe care within critical care transport organizations (CCTOs) [10, 11]. Recently, national efforts aimed at harmonizing OHT practices culminated in a consensus document developed through a Delphi process with multidisciplinary experts. This initiative produced 39 consensus statements and nine quality metrics, offering a framework for standardized prehospital transfusion. Given the recency of these recommendations, the degree to which Canadian CCTOs have implemented them remains uncertain. This study aims to assess current OHT protocols in Canadian CCTOs relative to these expert guidelines, highlighting areas of standardization and variability.

Methods

This study received ethical approval from the Unity Health Toronto Research Ethics Board (REB 23-087). Reporting follows the Consensus-based Checklist for Reporting of Survey Studies (CROSS) [12].

Study design

A nationwide, cross-sectional survey was conducted to assess the implementation of out-of-hospital transfusion (OHT) protocols across Canadian civilian critical care transport organizations (CCTOs) and to compare current practices with recently published expert consensus statements [11]. Survey items were derived directly from the 39 consensus statements and nine quality metrics, each converted into a discrete question. An initial pilot was conducted with two experts in transport and transfusion medicine, which prompted revisions including rewording for clarity, merging overlapping items, and adding new questions to address gaps. The final survey addressed multiple domains, such as governance, clinical oversight, storage and transport of blood products, and transfusion initiation criteria. The survey was distributed online using JotForm (https://www.jotform.com/). Participants were selected purposively, targeting medical directors, managers, and front-line staff from each CCTO. Data were collected between June 1 and August 15, 2023, and analyzed descriptively using Microsoft Excel 365 (Version 16.75.2, Microsoft Corporation, Redmond, WA).

Setting and participants

Critical care transport in Canada is structured differently across provinces, with variation in oversight, team composition, and scope of practice. Teams typically include physicians from multiple specialties, registered nurses, and advanced paramedics. To facilitate national coordination and standardization of OHT practices, the Canadian Prehospital and Transport Transfusion (CAN-PATT) network was established [13]. This network unites clinicians and researchers across Canada and serves as a central platform for optimizing prehospital transfusion protocols [13].

Recruitment

Survey participants were identified primarily through the CAN-PATT network, which was assumed to capture all active Canadian CCTOs performing OHT. This list was further validated against other databases and through expert consultation. A snowballing approach allowed participants to refer other eligible organizations. To maintain the integrity of the dataset, only one response per CCTO was permitted, and responses were monitored to prevent duplication. A complete list of contacted CCTOs is shown in **Figure 1**.

Figure 1. Critical care transport organizations (CCTOs) with Out-of-Hospital (OHT) programs across Canada

Results

All six civilian CCTOs within the CAN-PATT network responded to the survey, resulting in a 100% participation rate. An additional OHT-capable CCTO was identified in Quebec, while one provincial CCTO in Canada does not currently operate an OHT program. This means that out of eight provincial CCTOs nationwide, seven actively provide out-of-hospital transfusions. The organizations included in this study were: British Columbia Emergency Health Services (BCEHS), Shock Trauma Air Rescue Service (STARS) Alberta, STARS Saskatchewan, STARS Manitoba, Ornge (Ontario), Évacuations aéromédicales du Québec (EVAQ), and Emergency Health Services LifeFlight (Nova Scotia). All survey responses were complete, with no missing data.

When evaluated against the 39 expert consensus statements and nine quality metrics, participating CCTOs demonstrated a high level of compliance, with an overall adherence rate of 89%. Compliance among individual organizations ranged from 75% to 98%, indicating some variability in how protocols are implemented across provinces. The detailed results, including adherence in specific domains such as general oversight, clinical governance, storage, and transfusion initiation, are presented in **Tables 1 through 5**.

Table 1. Summary of Survey Findings: General Oversight and Clinical Governance in Out-of-Hospital Transfusion (OHT) Protocols

Question	Yes (n)	Yes (%)
Does your critical care transport organization (CCTO) have a formal protocol governing out-of-hospital blood transfusions (OHT)?	6	85.7
Was the OHT protocol developed by a multidisciplinary team, formally approved by the participating transfusion service, and aligned with current best-practice guidelines as well as local and national transfusion standards?	6	85.7
Does the OHT protocol incorporate damage-control resuscitation principles, including active management of ongoing bleeding and deliberate selection of a destination hospital capable of providing definitive hemorrhage control?	5	71.4
Does the OHT protocol clearly specify the types and quantities of blood components/products that the CCTO is authorized to store and transport, and does it also address additional components/products that may be supplied by sending facilities?	4	57.1
Is the OHT protocol subject to scheduled review and update whenever the CCTO introduces new blood products or procedures, or when new evidence significantly changes recommended practice?	6	85.7
Does the OHT protocol provide specific, tailored guidance for particular patient groups (e.g., pediatrics, obstetrics, Jehovah's Witnesses, etc.)?	5	71.4
Has your CCTO appointed named clinical lead(s) and designated contact person(s) responsible for all matters related to out-of-hospital transfusion?	7	100.0
Is there a designated individual (e.g., the OHT clinical lead) or committee within the CCTO that regularly audits and reviews OHT practices for quality assurance purposes?	6	85.7
In addition to meeting minimum regional/national transfusion competency requirements, do your prehospital providers receive specific training focused on administering blood products in the prehospital and transport medicine environment?	7	100.0
Are all clinical and administrative adverse events, errors, and near-misses related to OHT fully documented and reported through the CCTO's established incident reporting system?	7	100.0
Does the reporting of any OHT-related adverse event, error, or near-miss automatically notify both the CCTO's designated OHT lead(s) and the participating transfusion service?	6	85.7
Are key quality indicators for OHT routinely collected for every case and formally reviewed at least quarterly by the CCTO's medical advisory committee, with transfusion service representation?	3	42.9
When a patient (or substitute decision-maker) is unable to provide consent for OHT, is the absence of consent explicitly documented in the patient's CCTO record?	6	85.7
When consent for OHT is obtainable, does the documentation include a clear explanation of the risks, benefits, and available alternatives?	3	42.9
Does your critical care transport organization fully comply with all applicable Health Canada Blood Regulations, Canadian Standards Association standards, and relevant provincial requirements governing out-of-hospital transfusion?	7	100.0

Table 2. Survey Results Out-of-Hospital Transfusions (OHT) Protocols: Storage and transport of blood components and products

Question	Yes (n)	Yes (%)
Are all blood components and products stored in storage containers that have been fully validated according to the participating transfusion service's national and regional accreditation requirements?	7	100.0

Are the storage containers routinely inspected and monitored for any signs of damage, compromise, or defects at predetermined intervals (e.g., beginning and end of shift, prior to any OHT administration, and upon return to the transfusion service)?	6	85.7
When the storage container is equipped with a temperature-monitoring device, is it always checked for any temperature excursions before blood products are issued for out-of-hospital transfusion?	5	71.4
Have all prehospital providers who handle blood components and products undergone specific training on the safe storage, transport, and handling of the containers, as well as on the standardized procedures for receiving blood products from and returning them to the participating transfusion service?	7	100.0

Table 3. Survey Results Out-of-Hospital Transfusions (OHT) Protocols: Initiation of out-of-hospital transfusion

Question	Yes (n)	Yes (%)
Does the OHT protocol specify objective clinical and/or biochemical triggers to guide the decision to initiate transfusion?	5	71.4
Which of the following specific triggers are explicitly included in your OHT protocol?		
• Systolic blood pressure <90 mmHg	5	71.4
• Heart rate >110 beats/min	4	57.1
• Clinical evidence of end-organ hypoperfusion	4	57.1
• Serum lactate >4 mmol/L	3	42.9
• Hemoglobin <90 g/L	4	57.1
• Base excess <−6 mmol/L	2	28.6
Beyond acute hemorrhagic shock, may OHT be initiated in other clinical situations when the transport physician judges that the potential benefits clearly outweigh the risks?	6	85.7
Is it permissible to start OHT without direct physician authorization if performed under a clearly defined medical directive or when any delay in waiting for physician approval would likely cause significant patient harm (e.g., profound hemodynamic instability)?	4	57.1
Is the clinical indication for initiating OHT always clearly documented in the patient's transport record?	7	100.0
Whenever clinically and logistically feasible, does the prehospital team collect a pre-transfusion blood sample for subsequent ABO/Rh typing and compatibility testing by the receiving hospital's transfusion service?	2	28.6

Table 4. Survey Results Out-of-Hospital Transfusions (OHT) Protocols: Types, delivery, and monitoring of blood components and products

Question	Yes (n)	Yes (%)
Which blood components and products does your CCTO routinely carry for out-of-hospital transfusion?		
• Red blood cells (RBCs)	6	85.7
• Fresh frozen plasma (FFP) or thawed plasma	1	14.3
• Platelets	0	0
• Freeze-dried/lyophilized plasma	0	0
• Low-titer O whole blood	0	0
Does your CCTO stock and transport prothrombin complex concentrate (PCC) 2000 IU and fibrinogen concentrate 4 g as alternatives or adjuncts to plasma?	2	28.6
When needed, can additional blood components or products (e.g., extra RBC units, thawed plasma, platelets, or specific coagulation factor concentrates) be promptly requested and obtained from the sending facility?	7	100.0
Do prehospital providers have immediate access to a comprehensive standard operating procedure (SOP) that addresses indications, administration, monitoring, and management of adverse reactions for out-of-hospital transfusion?	6	85.7
Are red blood cells and plasma always administered using an approved, portable, commercial blood-warming device?	7	100.0
Is patient temperature measured within 30 minutes of initial assessment and then at least every 30 minutes (or continuously when possible) until handover at the receiving hospital?	6	85.7
Are active warming measures and hypothermia-prevention strategies applied to all patients receiving out-of-hospital transfusion to maintain normothermia (≥36 °C)?	7	100.0
Are point-of-care measurements of hemoglobin, lactate, and/or base excess used to guide the ongoing need for and response to out-of-hospital transfusion?	7	100.0
Are transfusion reactions monitored and managed according to the same clinical standards and protocols used for in-hospital transfusions?	7	100.0

Table 5. Survey Results Out-of-Hospital Transfusions (OHT) Protocols: Transfusion adjuncts and resuscitation targets

Question	Yes (n)	Yes (%)
Is tranexamic acid (TXA) administered as early as possible (ideally within 3 hours of injury) whenever out-of-hospital transfusion is initiated for traumatic hemorrhagic shock?	7	100.0
Is TXA administered as early as possible whenever out-of-hospital transfusion is initiated for hypovolemic shock due to postpartum hemorrhage?	6	85.7
Does the OHT protocol mandate the administration of calcium (calcium gluconate or calcium chloride) at predefined intervals (e.g., after the second unit of blood product and then after every four additional units)?	7	100.0
In adult patients on warfarin or a direct oral factor Xa inhibitor (rivaroxaban, apixaban, edoxaban) who require OHT for active bleeding, is prothrombin complex concentrate (PCC) 2000 IU administered empirically?	4	57.1
Once the following systolic blood pressure targets are achieved in acute traumatic hemorrhagic shock, is ongoing OHT reassessed and potentially discontinued: • ≥90 mmHg for blunt trauma • ≥110 mmHg if traumatic brain injury is suspected or confirmed • ≥80 mmHg for penetrating trauma	6	85.7
During prolonged transports (especially inter-facility transfers) or when active bleeding has been controlled, are the volume and rate of ongoing OHT guided by the following parameters in addition to systolic blood pressure?		
• Heart rate	5	71.4
• Lactate level	4	57.1
• Hemoglobin concentration	5	71.4
• Base excess/base deficit	4	57.1
• Clinical signs of end-organ perfusion (e.g., urine output, mental status, signs of cardiac ischemia)	5	71.4

Results

All seven Canadian CCTOs with active out-of-hospital transfusion (OHT) programs participated in the survey, including organizations from British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Nova Scotia. Collectively, these seven represent the majority of provincial critical care transport programs offering OHT, with only one provincial CCTO in Canada currently not providing prehospital transfusions. Survey completion was complete for all participants.

Across the organizations, adherence to the 39 expert consensus statements and nine quality metrics averaged 89%, though individual compliance ranged from 75% to 98%, highlighting some variability in protocol implementation. Most CCTOs had structured OHT protocols developed by multidisciplinary teams and incorporated core elements of damage-control resuscitation. Leadership roles for OHT oversight were clearly defined, with nearly all programs having dedicated personnel or committees to monitor quality and manage adverse events, though fewer than half systematically tracked performance metrics.

Storage and transport practices were broadly consistent with national and regional standards. All organizations trained prehospital providers in safe handling of blood products, and nearly all regularly monitored storage conditions to ensure product integrity. Initiation of transfusion was typically guided by clinical and laboratory indicators, such as blood pressure and hemoglobin, although pre-transfusion blood typing was not consistently performed.

Red blood cells were the most widely transported product, while platelets, whole blood, and freeze-dried plasma were not routinely carried. A minority of programs used fibrinogen concentrate and prothrombin complex concentrate (PCC) as alternatives to thawed plasma, with some organizations awaiting additional safety data before expanding use. All programs had clear procedures for transfusion administration and patient monitoring, including the use of portable warming devices and hypothermia prevention measures.

Tranexamic Acid was universally administered for trauma-related hemorrhagic shock, while PCC was selectively given to patients on anticoagulants. Ongoing transfusion was reassessed based on physiologic targets such as systolic blood pressure, heart rate, and lactate, with the majority of programs adjusting the rate and volume according to these measures, particularly during prolonged transport.

Discussion

This study offers a detailed assessment of how Canadian critical care transport organizations (CCTOs) implement out-of-hospital transfusion (OHT) protocols compared to recently published expert recommendations [11]. All seven Canadian CCTOs providing OHT were included, allowing a comprehensive national perspective. Three main observations emerged: widespread adherence to expert guidelines, persistent variability in specific aspects of the transfusion process—particularly initiation and cessation criteria—and the potential advantages of standardizing OHT practices to support policy development, evidence interpretation, and evaluation of effectiveness.

Adherence to expert recommendations

Overall, Canadian CCTOs demonstrated an 89% adherence to expert-recommended OHT practices. Considering that these recommendations were released within the year prior to this study, the findings likely reflect pre-existing OHT practices rather than adaptations to the new guidance. This baseline alignment is promising, particularly in the context of trauma care, which is complex and variable globally. The observed high adherence may be influenced by collaborative structures such as the CAN-PATT network and the limited number of CCTOs offering OHT in Canada [13]. Canada's publicly funded healthcare system, administered at the provincial level, results in provincially governed CCTOs rather than hospital-based programs, concentrating OHT provision within a small number of organizations. The CAN-PATT model may offer a useful framework for other countries aiming to harmonize prehospital transfusion practices.

Variability in transfusion indications

Despite overall alignment, there was notable variability in criteria for initiating and discontinuing OHT. Two key areas of inconsistency were identified: the timing of transfusion initiation in prehospital settings and the selection of blood products. While multiple predictive tools exist for guiding massive transfusion in trauma patients within emergency departments, their applicability in prehospital environments—especially for non-traumatic major hemorrhage—is limited [14]. Previous work by Vopelius-Feldt *et al.* highlighted the importance of tailored protocols that account for patient demographics and Canada's geographic challenges [11].

Blood component selection also presented challenges. Divergent expert opinions regarding the risk of Rh-D sensitization contributed to a preference for O Rh-D negative red blood cells in CCTOs [11]. Limited plasma availability further complicated decision-making, prompting consideration of alternatives such as Prothrombin Complex Concentrate (PCC) and fibrinogen. These challenges reflect not only local considerations but also global difficulties in defining transfusion indications and selecting appropriate products. Collectively, these findings emphasize the need for ongoing collaboration between frontline clinicians and transfusion specialists to refine OHT protocols and improve consistency in prehospital transfusion practices.

Opportunities for standardizing OHT practices

Even though definitive evidence demonstrating the life-saving impact of prehospital transfusions is limited, standardizing OHT protocols offers several practical benefits. Expert-guided recommendations can help organizations develop clear policies, interpret new research effectively, and assess the real-world impact of OHT. Standardized practices also promote consistency across different CCTOs, which is particularly critical given current shortages of Type O red blood cells. For instance, national guidelines can provide a framework for prioritizing and allocating OHT resources during acute blood supply constraints. Furthermore, structured training programs and well-defined governance are especially important for CCTOs that operate without onboard physicians. Clear leadership roles and comprehensive education ensure that clinical teams are prepared to deliver transfusions safely, reducing risks and optimizing patient outcomes.

Strengths and Limitations

A major strength of this study is its comprehensive national scope, encompassing all seven Canadian CCTOs currently offering OHT. Nevertheless, several limitations should be acknowledged. The findings are specific to Canadian practice and may not be generalizable to other healthcare systems or countries, where OHT protocols and regulatory environments differ. The reliance on self-reported survey data introduces the possibility of reporting bias or inaccuracies. Additionally, while this study evaluates adherence to expert recommendations, it does not directly examine the impact of these protocols on patient outcomes.

Conclusion

This cross-sectional analysis provides insight into how Canadian CCTOs implement OHT relative to expert recommendations. The results highlight the importance of structured, standardized protocols in prehospital trauma care. The high degree of consistency across organizations suggests a strong foundation for the safe and effective management of trauma patients during transport. As OHT practices continue to evolve, ongoing efforts to refine protocols, expand training, and enhance governance will be essential to further improve patient care and optimize outcomes in prehospital transfusion.

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