# A Canadian consensus-based list of urgent and specialized in-hospital trauma care interventions to assess the accuracy of prehospital trauma triage protocols: a modified Delphi study

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Accepted Oct. 24, 2022

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**Cite as:** *Can J Surg* 2023 March 31; 66(2). doi: 10.1503/cjs.019920

**Background:** Injury severity scales have traditionally been used to assess the performance of prehospital trauma triage protocols, but they correlate weakly with the urgent needs of specialized trauma care interventions. This study aimed to develop a list of in-hospital urgent and specialized trauma care interventions that require direct transport to the highest-level trauma centre within the catchment area.

**Methods:** Based on a list of potential participants we obtained using data on training, experience, geographic location, affiliations and role within key trauma organizations, we recruited multidisciplinary trauma experts (including prehospital, emergency, surgery and intensive care clinicians, epidemiologists and clinician/decision-makers) from across Canada to complete a 3-round modified Delphi survey. We conducted a literature review of the criteria used to define urgent and specialized trauma care, and included all diagnostic and therapeutic interventions presented in previously published studies in the list of interventions to present to the panellists. The final list was determined by our advisory committee, 5 clinicians with experience in trauma care. Participants were asked to rate their level of agreement for potentially including the 38 items as urgent and specialized trauma care interventions on a 9-point Likert scale. Interventions were retained if more than 67% of participants moderately or strongly agreed (7–9 on the Likert scale). Interventions that did not reach consensus were presented again in the subsequent round.

**Results:** Twenty-three panellists were recruited. The response rate was 91%, 96% and 83% for the 3 rounds. After the Delphi process, 30 of the 38 interventions, including endotracheal intubation, blood product administration and angioembolization, and abdominal, thoracic, neurosurgical, spinal and/or orthopedic operations (excluding hip or limb surgery, and toe or finger amputation), were selected. Hospital admission to the intensive care unit and/or for observation of brain, spinal, thoracic or abdominal injuries were also retained.

**Conclusion:** We developed a Canadian consensus-based list of urgent and specialized in-hospital trauma care interventions requiring direct transportation to a major trauma centre. This list should help standardize assessments of current protocols and derive new triage tools.

**Contexte :** Les échelles de gravité des blessures sont habituellement utilisées pour évaluer les performances des protocoles de triage préhospitalier des traumatismes, mais elles sont inadaptées aux besoins urgents des interventions spécialisées en traumatologie. La présente étude visait à concevoir une liste des interventions hospitalières urgentes et spécialisées en traumatologie nécessitant un transport direct vers le centre de traumatologie du niveau le plus élevé de la circonscription hospitalière.

**Méthodes :** Nous avons constitué une liste de participants potentiels d'après des données sur la formation, l'expérience, l'emplacement géographique, les affiliations et le poste au sein d'établissements majeurs en traumatologie pour recruter différents experts en traumatologie (dont des professionnels des soins préhospitaliers, des soins d'urgence, des soins intensifs et de la chirurgie, des épidémiologistes ainsi que des cliniciens décideurs) de tout le Canada à qui nous avons demandé de remplir un questionnaire Delphi modifié en 3 étapes. Nous avons effectué une revue de la littérature des critères utilisés pour définir les soins urgents et spécialisés en traumatologie et avons inclus l'ensemble des interventions diagnostiques et thérapeutiques décrites dans les études précédentes à la liste des interventions présentées aux panélistes. Notre comité

consultatif, 5 professionnels de la santé connaissant bien la traumatologie, s'est entendu sur la liste définitive. Les participants ont noté la classification potentielle de 38 éléments comme des interventions urgentes et spécialisées en traumatologie sur une échelle de Likert en 9 points. Les interventions modérément ou fortement approuvées par plus de 67 % des participants (7–9 sur l'échelle de Likert) ont été retenues, tandis que celles qui n'ont pas abouti à un consensus ont été présentées à nouveau à l'étape suivante.

**Résultats :** Vingt-trois panélistes ont été recrutés et ont été 91 %, 96 % et 83 % à répondre à chaque étape du sondage. À l'issue du processus Delphi, 30 des 38 interventions, dont l'intubation trachéale, l'administration de produits sanguins et l'angioembolisation, ainsi que les chirurgies abdominales, thoraciques, neurochirurgicales, orthopédiques et du rachis (à l'exclusion de la chirurgie de la hanche ou des membres et l'amputation des orteils ou des doigts) ont été sélectionnées. L'hospitalisation en soins intensifs ou pour observation d'un traumatisme crânien, médullaire, thoracique ou abdominal a aussi été retenue.

**Conclusion :** Nous avons élaboré une liste canadienne par consensus des interventions hospitalières urgentes et spécialisées en traumatologie nécessitant un transport direct vers un grand centre de traumatologie afin de normaliser les évaluations des protocoles actuels pour en tirer de nouveaux outils de triage.

Trauma is the leading cause of mortality, morbidity and health-related productivity loss among young adults and carries an estimated annual cost of $27 billion in Canada.[1] For critically injured patients, prompt access to a major trauma centre is associated with improved survival.[2–9] However, this benefit does not apply to those with minor injuries, who account for the vast majority of injured patients.

Although rates of in-hospital trauma-related mortality have decreased in the last decades, the relative proportion of trauma-related deaths occurring before hospital arrival has increased substantially.[10] Prehospital care of patients with trauma is complex in the context of limited resources.[11–20] Even in Canada, training and competencies of prehospital care professionals vary. Current prehospital trauma triage protocols are inaccurate to estimate severity and often fail to identify the patient's critical needs.[21,22] Injury severity is underestimated in up to 30% of patients,[23] and underestimation of patient needs for specialized care contributes considerably to preventable trauma morbidity and mortality.[24,25] To improve care and use our resources efficiently, we need to innovate and enhance prehospital trauma triage.

Identifying patients who should be transported directly to a designated trauma centre from the field is a critical component of the development and evaluation of trauma systems.[24–28] To guide prehospital decision-making, triage protocols have been developed since the 1980s.[29] These protocols, which are the gateway to the trauma system, aim to support decision-making as to whether the patient should be transported directly to a designated major trauma centre.[30] Thus, their performance in predicting the need for urgent and specialized care is critical to both the patient's outcome and the maintenance of an effective health care system.[31] Initial underestimation of patient injury severity and urgent care needs is associated with costly interhospital transfers and preventable death.[24,32,33] Conversely, overestimation of injury severity promotes inappropriate use of resources and contributes to the overcrowding experienced by trauma centres.[21,34] Historically, assessments of triage protocols have relied primarily on their ability to predict the severity of injuries using measures such as proportions of overtriage and undertriage.[35] Undertriage is defined as the transportation of a severely injured patient to a low-level trauma centre. To link this definition to the severity of injuries, severity scales such as the Injury Severity Score calculated at hospital discharge are frequently reported.[30,36] However, these severity scales are often weakly correlated to the initial need for specialized trauma care and urgent critical resource use.[26,37–39] Severity scales are based on the anatomic location and severity of the injury but do not consider the acuity, that is to say the urgency, the intensity and the complexity of specialized trauma care needed. Thus, the use of these scales as a proxy for the need for urgent and specialized trauma centre care is incomplete.[26,40,41]

Based on the available trauma literature, it is difficult to evaluate and compare the accuracy of prehospital triage protocols to correctly discriminate the patients who need urgent and specialized care offered in high-level designated trauma centres as there is a wide variation in the clinical outcomes used.[30,41] A US team developed a consensus-based definition of trauma centre need to evaluate and potentially modify the prehospital triage protocols used by prehospital care professionals and to determine the need for interfacility transfer.[42] However, the Canadian reality in terms of geography, climate, trauma population and system organization differ from that in the United States and justify the need to develop a Canadian-based consensus.[43] For instance, given its wide territory, about 1 in 5 Canadians live more than an hour away from a high-level trauma centre, and about 75% of all injured patients are treated within the trauma system.[44,45] Also, the proportion of penetrating trauma is higher in the US than in most Canadian cities.[46–48]

The aim of this study was to establish a consensus-based list of in-hospital urgent and specialized trauma care

interventions that require direct transportation to the highest-level designated trauma centre within the catchment area, applicable in the Canadian context.

## Methods

We conducted a modified Delphi study to establish a list of urgent and specialized trauma care interventions for which patients should be transported directly to a designated trauma centre.[49,50] The local research ethics board (Comité d'éthique de l'Université Laval) waived ethical consent requirement. The survey was conducted between October and December 2019. The views of the participating experts were given equal weight.

### *Delphi survey development*

We conducted a literature review of the criteria used to define urgent and specialized trauma care. All diagnostic and therapeutic interventions presented in previously published studies were included in the list of interventions to present to the panellists. The final list was determined by our advisory committee, 5 clinicians with experience in trauma care (É.M., M.É., N.L., R.F., C.M.). The initial list included 30 urgent and specialized care interventions. The elements considered were both the intervention itself and the interval between the trauma and the intervention. Therefore, the same intervention was proposed at predetermined, standardized time points (in the emergency department, and 6 h and 24 h after the trauma) that were determined by our advisory committee.

### *Recruitment and panel selection*

We aimed to recruit a group of multidisciplinary clinicians and scientists having relevant experience and knowledge in trauma care. This group included prehospital, emergency, surgery and intensive care clinicians, as well as epidemiologists and clinician/decision-makers from across Canada. Based on the recommendations for Delphi studies and 2 recent Delphi studies pertaining to trauma care performed in the Canadian setting,[51–53] we initially aimed to recruit 20–30 experts.[54,55] We obtained a list of potential participants using data on training, experience, geographic location, affiliations and role within key trauma organizations (Trauma Association of Canada, Canadian Association of Emergency Physicians, Canadian Association of General Surgeons, Canadian Critical Care Society, Paramedic Association of Canada). We sent invitations to participate in the study using professional email addresses.

### *Delphi method and data analysis*

We presented potential urgent and specialized trauma care interventions individually to each panellist in a standardized scheme (Appendix 1, available at www.canjsurg.ca/lookup/doi/10.1503/cjs.019920/tab-related-content). Panellists were required to rank each statement using a Likert scale ranging from 1 (the highest level of disagreement) to 9 (the highest level of agreement). A section of the survey allowed suggestions of any additional items that should be considered, added to the initial list of interventions and proposed to panellists during the second round. During the second and third rounds, items that did not reach consensus in the previous round were presented again to the panellists. In each round, we presented participants with their result in the first round in relation to group responses. We used Survey Monkey to deliver the survey.

Any intervention proposed during a round was thereafter included in the final list of in-hospital urgent and specialized trauma care interventions when more than 67% of participants moderately or strongly agreed with them (7–9 on the Likert scale).[56] Interventions were rejected when more than 67% of participants moderately or strongly disagreed with them (1–3 on the Likert scale). All other interventions that did not fulfill the criteria to be included or excluded were presented again in the subsequent round. If no consensus was reached on an intervention after the third round, it was not included in the final list.

## Results

Of the 30 trauma experts invited, 23 (77%) were recruited, 14 (61%) from eastern Canada (Ontario, Quebec and Nova Scotia) and 9 (39%) from western Canada (British Columbia, Alberta and Manitoba). The participants' characteristics are presented in Table 1. Of the 23 respondents, 13 (56%) had at least 10 years of experience as a clinician, and 9 (39%) had a decision-making role at the provincial level. Figure 1 presents the self-reported positions held by the participants.

Twenty-one panellists (91%) completed the first round, 22 (96%) the second round, and 19 (83%) the third round. During the first round, the 30 interventions were presented to the panellists, of which 20 reached consensus; all were included in the list of specialized and urgent trauma care interventions. The panellists suggested 8 other interventions, which were added to the list in the second round. During the second round, 18 interventions were presented (10 without consensus during the first round and the 8 suggested by the panellists). Consensus was reached on 10 statements, of which 9 were included in the list and 1 was excluded. During the third round, the remaining 8 statements without consensus were presented, 3 of which found consensus (1 included in the list, and 2 excluded). Five statements did not, even after this last round, find consensus.

A total of 30 interventions were retained by consensus (Table 2), leaving 3 items not included in the list by consensus, and another 5 not included by lack of consensus

**Table 1. Characteristics of panellists**

| Characteristic | No. (%) of panellists *n* = 23 |
|---|---|
| **Province** | |
| British Columbia | 4 (17) |
| Alberta | 4 (17) |
| Manitoba | 1 (4) |
| Ontario | 4 (17) |
| Quebec | 9 (39) |
| Nova Scotia | 1 (4) |
| **Years in practice** | |
| < 5 | 4 (17) |
| 5–9 | 5 (22) |
| 10–14 | 4 (17) |
| 15–19 | 2 (9) |
| ≥ 20 | 6 (26) |
| **Decision-making role** | |
| Local level | |
| No role | 9 (39) |
| Administrator | 4 (17) |
| Director/chief | 9 (39) |
| Not reported | 1 (4) |
| Regional level | |
| No role | 13 (56) |
| Administrator | 2 (9) |
| Director/chief | 5 (22) |
| Not reported | 3 (13) |
| Provincial level | |
| No role | 12 (52) |
| Administrator | 3 (13) |
| Director/chief | 6 (26) |
| Not reported | 2 (9) |

even after 3 rounds (Box 1). The final list of urgent and specialized trauma care interventions included endotracheal intubation, blood product administration, angioembolization, abdominal, thoracic, neurosurgical, spinal and/or orthopedic operations (excluding hip and limb surgery, and toe and finger amputation) and hospital admission to the intensive care unit for observation of brain, spinal, thoracic or abdominal injuries (Table 3).

## Discussion

A total of 30 in-hospital urgent and specialized trauma care interventions were retained after this 3-round modified Delphi study. By grouping them together, we obtained 14 situations in which experts believed that patients should be transported directly from the prehospital environment to the highest-level designated trauma centre within the catchment area. This list of outcomes will provide researchers assessing trauma triage tools in the Canadian context with a standardized outcome measure.

Similar to our study, a US study aimed to establish a list of criteria for which injured patients need the resources of a trauma centre, with a future goal of evaluating field triage and interhospital transfer guidelines.[42] Using a modified Delphi process of 5 rounds, the panel of 14 trauma experts assessed 26 specialized trauma care interventions. Several items retained in that study are similar to ours, even if the time frames differ, and some procedures, such as emergency cesarean delivery and thoracotomy, were included specifically in the items retained. We chose to use broader items and interventions, such as thoracic or abdominal

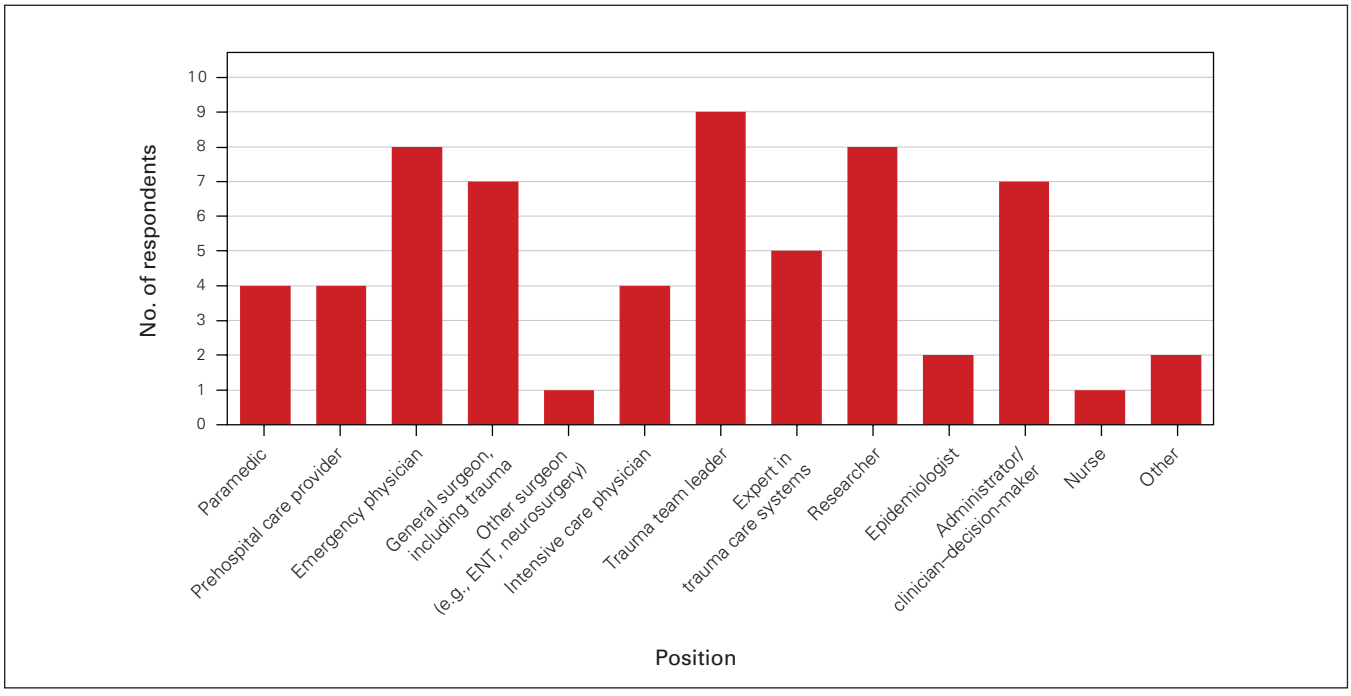


**Fig. 1.** Panellists' positions. Panellists could have more than 1 position. ENT = otorhinolaryngologist.

**Table 2. In-hospital urgent and specialized trauma care interventions for which patients should be transported directly to a designated trauma centre within the catchment area, retained by consensus**

| Intervention | % agreement |
|---|---|
| **Consensus obtained during first round** | |
| Endotracheal intubation or insertion of supraglottic airway device in ED | 100 |
| Endotracheal intubation or insertion of supraglottic airway device in prehospital setting | 71 |
| Chest tube for pneumothorax inserted in ED | 90 |
| Chest tube for hemothorax inserted in ED | 71 |
| Chest tube for hemothorax inserted within first 24 h after trauma | 81 |
| ≥ 1 blood transfusion products administered in ED | 95 |
| Massive protocol transfusion (as per local definition) administered in ED | 81 |
| Massive protocol transfusion (as per local definition) administered within first 24 h after trauma | 76 |
| Angioembolization procedure for pelvic bleeding performed within 6 h | 81 |
| Angioembolization procedure for pelvic bleeding performed within 24 h | 100 |
| Angioembolization other than for pelvic bleeding (e.g., spleen injury) performed within 6 h | 95 |
| Angioembolization other than for pelvic bleeding (e.g., spleen injury) performed within 24 h | 90 |
| Abdominal surgery performed within 6 h | 86 |
| Abdominal surgery performed within 24 h | 90 |
| Neurosurgery performed within 6 h | 95 |
| Neurosurgery performed within 24 h | 95 |
| Orthopedic surgery for pelvic fracture (excluding hip fracture) performed within 6 h | 90 |
| Orthopedic surgery for pelvic fracture (excluding hip fracture) performed within 24 h | 67 |
| Hospital admission for observation after traumatic brain injury (without any surgery) | 86 |
| Hospital admission to intensive care unit | 95 |
| **Consensus obtained during second round** | |
| Surgery after amputation of a limb (proximal to hand or foot) | 75 |
| Surgery after amputation of a hand or a foot (excluding fingers and toes) | 75 |
| Surgery for spinal fracture or ligamental instability within 6 h | 74 |
| Surgery for spinal fracture or ligamental instability within 24 h | 80 |
| Surgery for penetrating trauma in neck, thorax, abdomen or pelvis within 6 h | 84 |
| Surgery for penetrating trauma in neck, thorax, abdomen or pelvis within 24 h | 85 |
| Orthopedic surgery for femur fracture (excluding hip fracture) within 6 h | 75 |
| Hospital admission for observation of thoracic injury (without any surgery) | 95 |
| Hospital admission for spinal fracture or ligamental instability (without any surgery) | 90 |
| **Consensus obtained during third round** | |
| Hospital admission for observation of abdominal injury (without any surgery) | 79 |

ED = emergency department.

**Box 1. In-hospital urgent and specialized trauma care interventions for which patients do NOT need to be transported directly to the highest-level designated trauma centre within the catchment area**

**Consensus obtained during second round**

- Orthopedic surgery for hip fracture within 24 h

**Consensus obtained during third round**

- Orthopedic surgery for hip fracture within 6 h
- Surgery after amputation of a finger or toe

**Excluded owing to lack of consensus after third round**

- Chest tube for pneumothorax inserted within first 24 h
- ≥ 1 blood transfusion products administered within first 24 h
- Orthopedic surgery for femur fracture (excluding hip fracture) within 24 h
- Orthopedic surgery for limb injury (excluding femur and hip fracture) within 6 h
- Orthopedic surgery for limb injury (excluding femur and hip fracture, or amputation) within 24 h

**Table 3. Final list of in-hospital urgent and specialized trauma care interventions for which patients should be transported directly to the highest-level designated trauma centre within the catchment area**

| Intervention | Time frame |
|---|---|
| Endotracheal intubation or insertion of supraglottic airway device (in ED or prehospital setting) | In ED |
| Chest tube inserted for pneumothorax | In ED |
| Chest tube inserted for hemothorax | Within 24 h |
| ≥ 1 blood transfusion products administered | In ED |
| Massive transfusion protocol activated | Within 24 h |
| Abdominal, neurologic, spinal or pelvic surgery | Within 24 h |
| Surgery for penetrating trauma in neck, thorax, abdomen or pelvis | Within 24 h |
| Orthopedic surgery for femur fracture (excluding hip fracture) | Within 6 h |
| Surgery after amputation of a limb (excluding fingers and toes) | NA |
| Angioembolization procedure for pelvic bleeding or other (e.g., spleen injury) | Within 24 h |
| Hospital admission in intensive care unit | None |
| Hospital admission for spinal fracture or ligamental instability | None |
| Hospital admission for observation of traumatic brain injury (without any surgery) | None |
| Hospital admission for observation of abdominal injury (without any surgery) | None |
| Hospital admission for observation of thoracic injury (without any surgery) | None |

ED = emergency department; NA = not applicable.

surgery within 6 hours of the trauma. In addition, Lerner and colleagues[42] used expert opinion to determine the interventions to rate, whereas we used a literature review, which may explain why we had more total items to rate (38 v. 26). Finally, like the study by Lerner and colleagues,[42] our study was not intended to modify the role of prehospital clinicians but, rather, to establish a context-adapted outcome measure that will allow us to assess the triage tools they are using.

Few studies have assessed trauma triage protocols according to the need for specialized trauma centre resources.[57–61] Intensive care unit admission and need for urgent surgery are criteria that those studies and our list have in common. Some of the studies also proposed the requirement for blood products,[61] endotracheal intubation[59] and hospital admission[59] as additional criteria.

The optimal outcome measure to assess the diagnostic accuracy of prehospital trauma triage protocols remains unclear. The use of injury severity is an objective measure but does not consider the urgency of the condition. However, there is a certain level of subjectivity when using the interventions performed as an outcome measure. Willenbring and colleagues[39] prospectively studied a cohort of patients with trauma and found that 5% of those with an Injury Severity Score less than 15 met at least 1 criterion for trauma care needs, as per the US Delphi study highlighting the importance of considering the interventions in the assessment of prehospital trauma triage tools.[42] Finally, being treated in a major trauma centre may be of more benefit to some patients with lower injury severity, such as older adults.[62,63] All these aspects should be considered in the assessment of diagnostic accuracy, particularly relative to the assessment of undertriage.

Now that we have established a Canadian list of urgent and specialized trauma care interventions for which patients should be transported directly to a major designated trauma centre, bypassing other hospitals if required, the next logical step in the process of improving the care of severely injured patients is to re-evaluate the performance of and optimize current triage protocols. We plan to use this list to assess trauma triage tools currently employed in Canada instead of using the traditional Injury Severity Score as the outcome measure. We also plan to conduct a prospective cohort study to identify potential prehospital predictors of the need for urgent and specialized trauma care interventions (e.g., physiologic and/or anatomic characteristics, trauma mechanism), which might be variables already used in trauma tools or new predictors. We will then derive a new tool to accurately predict the need for urgent and specialized trauma care interventions such as endotracheal intubation, blood product administration, angioembolization, and abdominal, thoracic, neurosurgical, spinal and/or orthopedic operations (excluding hip or limb surgery, and toe or finger amputation).

### *Limitations*

Although we tried to form a panel in which all provinces were represented, most participants were from Ontario and Quebec. Panellists with different areas of expertise were recruited; however, the fact that no orthopedic surgeon completed the survey may have skewed the results toward noninclusion of criteria relevant to orthopedic trauma. Most panellists were from urban academic centres. However, rural residents are at proportionally higher risk for trauma and trauma-related death than urban dwellers.[64,65] Given that some rural communities are far from a designated trauma centre, it would have been informative to include survey questions relative to the distance or the delay experts believed that direct transport to a trauma centre would be acceptable and preferable. Furthermore, the generalizability of our results to other countries and health care settings may be limited, as resources and trauma system organizations vary between countries.

The list was designed to assess the need for patients to be initially transported to a major trauma centre from the prehospital setting, not to determine the need for interfacility transfer, as it was beyond the scope of this study. Some rare but urgent interventions such as emergency cesarean delivery were not included specifically in our study. We considered them to be included in more general statements, such as abdominal surgery within 6 hours.

Definitions of consensus in Delphi studies vary between 50% and 97%, and are poorly reported in the literature.[52,56] We chose to define consensus as 67% or more of participants being moderately to strongly in agreement to include the item in the list of in-hospital urgent and specialized trauma care interventions. However, consensus of at least 75% was reached for 26 of the 30 items retained, with an average of 86%. No opportunity for the panellists to discuss the results was included in our Delphi process. This might have provided additional value to our study, as divergent opinions and their justifications might have influenced the final determination by some panellists. Finally, there are major controversies regarding the benefits of different prehospital models of care that go beyond the scope of our study.

## Conclusion

We developed a Canadian consensus-based list of urgent and specialized trauma care interventions for which patients should be transported directly to the highest-level designated trauma centre within the catchment area. According to Canadian trauma experts, patients requiring interventions such as endotracheal intubation, blood product administration, angioembolization, and abdominal, thoracic, neurosurgical, spinal and/or orthopedic operations (excluding hip or limb surgery, and toe or finger amputation) or hospital admission for observation of brain, spinal, thoracic or abdominal injuries would benefit from being transported directly to a major trauma centre from the prehospital environment. This list provides objective criteria for evaluating the diagnostic accuracy of prehospital trauma triage protocols used in the Canadian setting and may potentially lead to the establishment of new tools.

**Acknowledgements:** The authors warmly thank the experts who took the time to complete the survey: Dr. Gilles Bourgeois, Dr. Julien Clément, Dr. Myreille D'Astous, Dr. Christopher Evans, Dr. David Evans, Dr. Lawrence Gillman, Mr. Éric Hamel, Mrs. Jennie Helmer, Dr. Radoslav Krouchev, Dr. Christopher Lee, Dr. Matthew S. Leyenaar, Dr. Mireille Paradis, Mr. Maxime Robitaille-Fortin, Dr. Tom Stelfox, Dr. Mathieu Toulouse, Dr. Justin W. Yan and Dr. Natalie Yanchar.

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**Competing interests:** None declared.

**Contributors:** É. Mercier, N. Le Sage and M. Émond designed the study. É. Mercier, A. Nadeau and C. Malo acquired and analyzed the data, with input from L. Moore, P.-G. Blanchard and R. Fleet. É. Mercier and A. Nadeau wrote the manuscript, with oversight by all authors. All authors critically revised the manuscript and gave final approval of the article to be published.

**Funding:** This project was funded by a grant from the Fonds de recherche du Québec – Santé.



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