# Disaster preparedness of Canadian trauma centres: the perspective of medical directors of trauma

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**Background:** Owing to their constant readiness to treat injured patients, trauma centres are essential to regional responses to mass casualty incidents (MCIs). Reviews of recent MCIs suggest that trauma centre preparedness has frequently been limited. We set out to evaluate Canadian trauma centre preparedness and the extent of their integration into a regional response to MCIs.

**Methods:** We conducted a survey of Canadian level-1 trauma centres ($n$ = 29) to characterize their existing disaster-response plans and to identify areas where preparedness could be improved. The survey was directed to the medical director of trauma at each centre. Descriptive statistics were used to analyze responses.

**Results:** Twenty-three (79%) trauma centres in 5 provinces responded. Whereas most (83%) reported the presence of a committee dedicated to disaster preparedness, only half of the medical directors of trauma were members of these committees. Almost half (43%) the institutions had not run any disaster drill in the previous 2 years. Only 70% of trauma centres used communications assets designed to function during MCIs. Additionally, more than half of the trauma directors (59%) did not know if their institutions had the ability to sustain operations for at least 72 hours during MCIs.

**Conclusion:** The results of this study suggest important opportunities to better prepare Canadian trauma centers to respond to an MCI. The main areas identified for potential improvement include the need for the standardization of MCI planning and response at a regional level and the implementation of strategies such as stockpiling of resources and novel communication strategies to avoid functional collapse during an MCI.

**Contexte :** Comme ils sont constamment prêts à traiter des patients traumatisés, les centres de traumatologie jouent un rôle essentiel dans les réponses régionales aux incidents qui font de nombreuses victimes (multiple casualty incidents — MCI). Des analyses de ce type d'incidents survenus récemment indiquent que la préparation des centres de traumatologie a souvent été limitée. Nous avons cherché à évaluer l'état de préparation des centres de traumatologie au Canada et l'importance de leur intégration dans les réponses régionales aux MCI.

**Méthodes :** Nous avons sondé les centres de traumatologie de niveau 1 du Canada ($n$ = 29) afin de caractériser leurs plans actuels d'interventions en cas de catastrophe et de déterminer les aspects de leur préparation qui pourraient être améliorés. Le sondage était adressé au directeur médical de la traumatologie de chaque centre. Des statistiques descriptives ont servi à analyser les réponses.

**Résultats :** Vingt-trois (79 %) centres de traumatologie de 5 provinces ont répondu. La plupart (83 %) ont signalé l'existence d'un comité chargé de la préparation aux catastrophes, mais la moitié seulement des directeurs médicaux de la traumatologie étaient membres de tels comités. Presque la moitié (43 %) des établissements n'avaient pas fait d'exercice de simulation d'une catastrophe depuis 2 ans. Seulement 70 % des centres de traumatologie utilisaient des moyens de communication conçus pour fonctionner durant de tels incidents. Plus de la moitié des directeurs médicaux de la traumatologie (59 %) ne savaient en outre pas si leur établissement pouvait poursuivre ses activités pendant au moins 72 heures au cours d'un MCI.

**Conclusion :** Les résultats de cette étude indiquent qu'il existe d'importantes possibilités de mieux préparer les centres de traumatologie du Canada à répondre à un MCI. Les principaux aspects à améliorer comprennent la nécessité de normaliser la préparation aux MCI et les réponses à l'échelle régionale, ainsi que la mise en œuvre de stratégies telles que le stockage de ressources et l'adoption de stratégies de communication innovatrices afin d'éviter l'effondrement fonctionnel au cours d'un MCI.

Mass casualty incidents (MCIs) occur as a result of natural disasters, transportation incidents, terrorism or other means and result in more patients than locally available resources can generally manage.[1] Owing to a variety of human and natural factors, such events have been occurring with increasing frequency and with increasingly devastating consequences.[2,3] Detailed analyses of prior MCIs have provided insight into the management of these incidents. The US Department of Homeland Security has developed 15 plausible natural and manmade disaster scenarios that would result in large numbers of casualties. Most of these scenarios predict hundreds to thousands of critically injured patients, who would overwhelm existing disaster responses.[4,5] Canada's role in international affairs might not make it a prime target for terrorism; however, a review of the Canadian Disaster Database suggests that an all-hazards plan capable of dealing with natural, technological and terrorism-related MCIs is required (Table 1).[6]

As a result of their constant readiness to treat injured patients, trauma centres and the trauma systems of which they are a part are an essential resource for regional responses to MCIs.[7] This readiness is based on the availability of skilled personnel, life-support equipment, blood and blood products and diagnostic tools.[8] On a smaller scale, trauma centre preparedness is tested with large-scale industrial accidents, high-speed motor vehicle collisions and shootings all involving multiple patients, such that multiple-casualty events and emergency department surges are challenges met daily in all of the country's trauma centres.

It is commonly believed that trauma centre disaster preparedness is a priority and that it has been optimized to the greatest extent possible. However, reviews of a number of recent MCIs, such as the 9/11 New York terrorist attacks, the London and Madrid bombings and Hurricane Katrina, suggest that trauma centres' preparedness is limited in several critical domains. These domains include leadership,[9] hazard planning,[9] communications,[9–14] sustainability of peak operations,[15] education,[16] interagency cooperation[17] and funding.[18] These vulnerabilities have been identified previously by the World Health Organization (WHO)[1] and by centres that have provided assistance during MCIs.[9–15,17] These deficiencies also indicate that the medical and surgical response to disasters is heavily dependent on an array of nonmedical institutions and external services and needs to be integrated into a regional response.

With this background, we set out to evaluate Canadian trauma centres' MCI preparedness and the extent of their integration into a regional response to MCIs.

## Methods

### *Study design*

We conducted a survey of Canadian level-1 trauma centres to better characterize their existing disaster-response plans and to identify potential areas where disaster preparedness planning could be improved. We directed our survey to trauma medical directors, believing that regional responsibilities would mandate their participation in their centres' planning for MCIs. This project was reviewed and approved by the St. Michael's Hospital Research Ethics Board.

### *Trauma centre identification*

There is currently no inventory of trauma centres in Canada. Many, but not all, trauma centres across Canada are accredited by the Trauma Association of Canada (TAC) after a site verification visit.[19] In the broadest sense,

**Table 1. Deaths and injuries from disasters since 1980 in Canada***

| Disaster type, location | Deaths | Injuries | Year |
|---|---|---|---|
| **Bomb** | | | |
| Yellowknife, NWT | 9 | 0 | 1992 |
| Montréal, Que. | 3 | 45 | 1984 |
| Toronto, Ont. | 0 | 10 | 1982 |
| **Transportation** | | | |
| Rogers Pass, BC (MVC) | 6 | 21 | 2000 |
| Windsor, Ont. (MVC) | 7 | 33 | 1999 |
| Thamesville, Ont. (train collision) | 2 | 60 | 1999 |
| Peggy's Cove, NS (aircraft collision) | 229 | 0 | 1998 |
| Montréal, Que. (aircraft collision) | 12 | 0 | 1998 |
| Les Éboulements, Que. (bus collision) | 43 | 0 | 1997 |
| Toronto, Ont. (subway collision) | 3 | 140 | 1995 |
| Alert, Nunavut (aircraft collision) | 18 | 0 | 1991 |
| Dryden, Ont. (aircraft collision) | 24 | 45 | 1989 |
| Off the coast of NL (sinking) | 34 | 0 | 1987 |
| Hinton, Alta. (train collision) | 23 | 71 | 1986 |
| Gander, NL (aircraft collision) | 256 | 0 | 1985 |
| Web, Sask. (MVC) | 22 | 11 | 1980 |
| **Tornado** | | | |
| Pine Lake, Atla. | 12 | 140 | 2000 |
| Edmonton, Alta. | 27 | 600 | 1987 |
| Hopeville, Ont. | 12 | 500 | 1985 |
| Montréal, Que. | 5 | 26 | 1982 |
| **Hurricane/typhoon** | | | |
| Halifax, NS, and Charlottetown, PEI | 8 | Unknown | 2003 |
| Northumberland strait | 6 | 0 | 1990 |
| West Coast, BC | 5 | 0 | 1984 |
| **Landslide** | | | |
| Joe Rich, BC | 7 | 0 | 1990 |
| Squamish, BC | 9 | 0 | 1981 |
| Belmoral Mine, Que. | 8 | 0 | 1980 |
| **Industrial accident** | | | |
| Taylor, BC | 0 | 15 | 1999 |
| Plymouth, NS | 26 | 0 | 1992 |
| **Shooting** | | | |
| Montréal, Que. (École Polytechnique) | 14 | 10 | 1989 |
| Montréal, Que. (Concordia University) | 4 | 0 | 1992 |
| Montréal, Que. (Dawson College) | 2 | 17 | 2007 |

MVC = motor vehicle collision.
*Data include events with 4 or more deaths or 10 or more injuries occurring in Canada between 1980 and 2007.

the TAC distinguishes level-1 centres as those that provide a central leadership role in the regional and provincial trauma system. These centres usually provide most tertiary and major trauma care in the system, complex and unique (quaternary) trauma services for the province and academic leadership, including trauma training and research programs. Whereas there is a comprehensive list of essential criteria to meet the requirements for level-1 designation, the TAC also explicitly states that a centre with level-1 designation must have "a liaison role with other trauma system components (prehospital services and rehabilitation services) as well as emergency preparedness," emphasizing the importance of integration into the larger system.[20] In addition to centres verified by the TAC, however, there might also be trauma centres designated without verification by regional authorities. Additionally, several centres might play an ad hoc role in a regional system without having verification or designation. Since the focus of the current survey was centres fulfilling the role of level-1 trauma centres in their regions, several approaches were employed to ensure that all centres fulfilling the role of level-1 regional trauma centres were captured.

We captured centres accredited by TAC. In addition, provincial representatives of the American College of Surgeons Committee on Trauma (ACS-COT) were asked to identify centres that fulfilled the role of a level-1 trauma centre in their respective regions.[21] Since these representatives play a leadership role in the organization of trauma services in their province, we believed they would have sufficient regional knowledge to identify centres designated by regional authorities and those playing an ad hoc role as a level-1 centre in their systems.

### *Survey respondents*

By virtue of being a designated trauma centre, each centre has a physician assigned as the medical director of trauma. We believed that as a result of their role in the institution, the medical directors of trauma would be well integrated into their facilities' response plans. The survey was therefore directed to these individuals. We identified the relevant individuals through the TAC, hospital websites and through direct communication with physicians in study institutions.

### *Survey methodology*

Review of the relevant literature on disaster planning and on the experiences of trauma centres that have provided assistance during MCIs provided the basis for the design of the survey instrument.[10–15,17] We identified 6 domains as critical to disaster preparedness. These domains were leadership, hazard planning, communications, sustainability of peak operations, education and interagency cooperation. A letter of introduction outlining the objectives of the survey was sent by mail with the survey to each of the potential respondents. Respondents were given 2 weeks to complete the survey, at which time a reminder letter was sent. Any further nonrespondents were contacted by email and a follow-up reminder was sent.

### *Statistical analysis*

We used descriptive statistics to analyze responses. All data were analyzed using SAS software (version 9.1).

## RESULTS

### *Respondent institutions*

Through review of the TAC website and direct communication with provincial representatives of the ACS-COT, we identified 29 centres fulfilling the role of a level-1 trauma centre in 7 provinces. Of these centres, 23 (79%) centres in 5 provinces responded to the survey. Whereas most centres (96%) reported being designated as trauma centres by a provincial authority (96%), two-thirds had been verified by the TAC (Table 2).

### *Leadership*

There were deficiencies identified in MCI leadership and planning. Whereas most centres (83%) reported the presence of a committee dedicated to disaster preparedness, only half reported that medical directors of trauma were members of these committees. Further, only half of the trauma directors (47%) believed there was adequate stakeholder representation on the disaster preparedness committees at their institutions.

### *Hazard planning and preparedness*

The survey identified wide variations in knowledge regarding hazard preparedness across trauma centres. Only half of the trauma directors (52%) reported the presence of a single all-hazards emergency management plan; one-third didn't know if such a plan existed in their institutions. When asked about strategies to manage surge, less than two-thirds of centres (61%) reported plans to increase surgical capacity during an MCI. Whereas trauma directors most commonly identified the trauma surgeon or the surgeon-in-chief (32%) or administrative

**Table 2. Respondent trauma centre characteristics**

| Trauma centre | No. (%) | Regional designation | TAC verification |
|---|---|---|---|
| Adult | 18 (78) | 18 (100) | 12 (67) |
| Pediatric | 5 (22) | 4 (80) | 3 (60) |

TAC = Trauma Association of Canada.

staff (chief executive officer, vice-president, chief of staff; 18%) as the individual who held the authority to suspend elective procedures, one-third of trauma directors (36%) did not know who possessed the authority to suspend such operations. Only a minority of respondents (17%) reported emergency department, operating and/or intensive care unit surge estimates, and more than half of the trauma directors (57%) were not aware if estimated surge capacity had been assessed at their institutions.

Most centres (65%) reported the presence of a plan to manage chemical, biological, radiation and nuclear events (CBRN). Less than half (44%) reported estimates of their decontamination capacity (mean 16, range 4–30 patients/h).

There was statistically significant variation across trauma centres when queried about practice drills. Almost half (43%) of the centres had not run any type of disaster drill in the previous 2 years. Among centres that reported disaster drills, strategies most often used were tabletop exercises, followed by multidepartment live exercises. Nurses and allied health professionals were the individuals who most commonly participated in these drills; physicians were reported to be the health care professionals least commonly involved. Fewer than half of the medical directors of trauma (44%) reported that their centres had been involved in a live mass casualty exercise with other hospitals, first responders and/or other relevant stakeholders. At centres where interagency drills had taken place, the most common external agencies involved were emergency medical services, police and fire departments. A minority (20%) of exercises involved the coast guard or the Red Cross, and only 1 trauma centre participated in an exercise with the military or the local urban search and rescue team (Table 3).

**Table 3. Practice drills during the last 2 years***

| Practice drill | No. (%) |
|---|---|
| Any exercise during last 2 years | 13 (57) |
| **Type** | |
| Tabletop drills | 11 (85) |
| Small-team drills | 8 (62) |
| Multidepartment live exercise | 9 (69) |
| Multihospital/agency | 8 (62) |
| **Participants in single-centre drills** | |
| Physicians | 10 (77) |
| Nurses | 12 (92) |
| Allied health professionals | 12 (92) |
| Administrators | 11 (85) |
| Multihospital/agency drills | 10 (44) |
| **Participants in multihospital/agency drills** | |
| Other trauma centres | 3 (30) |
| Police department | 6 (60) |
| Fire department | 7 (70) |
| Coast guard | 2 (20) |
| Red cross | 2 (20) |
| Emergency medical services | 10 (100) |
| Urban search and rescue | 1 (10) |
| Military | 1 (10) |

*Percentages derived from centres that reported any type of practice drill during the last 2 years.

### *Communications*

We identified a wide variation in planned communication assets during an MCI. Only 70% of trauma directors reported the presence of communication assets designed to function during an MCI; the remaining 30% did not know if such assets were available at their institutions. Trauma centres reported a mean of 3 different available communication assets. The most common asset was land-linked phone lines followed by mobile phones (Table 4).

Only 5 centres (22%) from 3 provinces reported the presence of a real-time monitoring system to assess regional resources and capacity to respond during an MCI. These systems were reported to monitor intensive care unit beds (100%), overall hospital beds (80%) and emergency department capacity (80%). However, only 40% of resource-monitoring systems were reported to monitor operating room and staff availability.

### *Sustainability of peak operations*

More than half of the trauma directors (59%) did not know if their institutions had the ability to sustain operations at maximum occupancy for at least 72 hours during an MCI. Among those centres that claimed sustainability of peak operations, most stored resources such as water (88%), food (62%) or fuel (88%) for such a purpose.

### *Education and interagency cooperation*

When queried regarding mandatory training of staff to respond to an MCI, only one-third (39%) of institutions required physicians, nurses and allied health professionals to be trained. Further, only 9% of centres had made arrangements to have military agencies participate in the training of staff members for an MCI response. Only 22% of centres have signed mutual aid agreements or memoranda of understanding with other health care institutions, military or governmental agencies and nongovernmental

**Table 4. Communication strategies designed to function at level-1 trauma centres during a mass casualty incident**

| Communication strategy | No. (%)* |
|---|---|
| Land-linked phone lines | 13 (81) |
| Two-way radios | 7 (44) |
| Mobile phones | 12 (75) |
| Satellite phones | 3 (19) |
| Web-based | 7 (44) |

*Only 16 of 23 (70%) trauma directors reported the presence of such communication strategies at their centres. The percentages reported above are based on the information provided by those 16 responders.

organizations regarding disaster planning and cooperation during MCIs. Almost half of the trauma directors (43%), however, reported that they were not aware if such agreements were in place.

## Discussion

Natural and manmade disasters, and their devastating impact, have evolved substantially over the last 2 centuries. The industrial revolution and the population boom of the 20th century have led to environmental degradation and unplanned human settlements that generate increasing vulnerabilities. The exponential exposure of the population to a growing number of hazards has led to a progressive increase in the ratio of people affected per person killed by a natural disaster during the 20th century.[3] In 2003, 1 of every 25 people worldwide was affected by a natural disaster. Further, the exponential growth of transportation and industry during this period has generated an expanse in technological hazards that, when coupled with population growth, increases the risk of disasters producing mass casualties. In addition, political and religious turmoil have increased the threat of terrorist attacks, which continue to evolve in complexity and impact. These increasing threats and recent MCIs have positioned MCI planning and response as a top priority. However, in Canada much of the focus has been placed on pandemic scenarios and CBRN event planning, which may leave Canadian centres inadequately prepared for other MCIs.

Trauma centres frequently play a central role in MCIs, and close examination of prior incidents provides an opportunity to improve disaster planning and responses to future incidents. There have been problem areas consistently identified in trauma centres' responses to previous MCIs, including leadership, hazard planning, sustainability of peak operations, communication, education, interagency cooperation and regional integration. We identified both similar and novel problems in these areas in our study. The main areas identified for potential improvement included the need for the standardization of MCI planning and response at a regional level and the implementation of strategies such as stockpiling of resources and novel communication strategies to avoid functional collapse during an MCI.

Physicians usually play a leading role in their institutions' responses to an MCI. Review of trauma centres' responses to the 9/11 attacks attributed the relatively successful surgical response to the involvement of senior surgeons in triage and surgical coordination and supervision of key areas. However, important weaknesses were also identified. For example, most of the involved surgeons were not familiar with their hospitals' disaster plans, since there was no surgical representation on the hospitals' disaster committees.[10] In the present study, we identified similar deficiencies; only half of Canadian medical directors of trauma were members of their institutions' disaster preparedness committees and more than half believed there was inadequate stakeholder representation on those committees. The leadership and authority required to adequately respond to MCIs can only be instituted with previous planning. There is a need for greater opportunity for involvement of trauma directors in disaster planning leadership roles.

In addition to ensuring broad stakeholder involvement, disaster committees must ensure adequate preparation for a broad range of scenarios. Since we currently cannot accurately predict which type of MCI is more probable, disaster preparedness plans should be capable of responding to all types of incidents and provide the ability to escalate a response.[1] In our study, only half of the trauma directors identified the presence of an all-hazards emergency management plan at their institutions. Further, less than half of the trauma centres had run any type of disaster drill in the past 2 years. Of those who had, tabletop exercises were the most common strategy used. These findings suggest a need to more effectively integrate health care professionals into disaster planning so that their roles and responsibilities during a response to an MCI are clearly understood.

Health services should be accessible and functioning at maximum capacity immediately after MCIs. To achieve this goal, disaster preparedness plans must ensure that the physical and human resources needed for appropriate levels of care are available even in the absence of community support mechanisms. Rivara and colleagues[22] evaluated the ability of trauma centres in the United States to respond to an MCI by identifying precisely the physical resources that were available during an American Independence Day, traditionally one the busiest days of the year. Whereas they reported that 15% of the trauma centres were already operating at 95% capacity or more, the survey concluded that US trauma centres may have the capacity to absorb the casualties resulting from an MCI. However, this capacity may have been overestimated, since personnel resources and nonsurgical hospital resources were not evaluated.

Several large-scale incidents have demonstrated the impact of disasters on hospital infrastructure and suggest a need for stockpiling essential resources (e.g., food, water, fuel). During Hurricane Katrina, for example, a dedicated alternate trauma centre outside of Katrina's wake was established. This centre, which was specifically designated to manage the surge of injured patients, quickly ran out of critical stores, taking almost a week to acquire adequate supplies.[15] The 2004 Indian Ocean tsunami damaged 61% of health facilities and killed 7% of health workers in the province of Aceh, Indonesia, limiting disaster relief.[23] Mass casualty incidents such as these have shown that a hospital's ability to function relies on lifelines and other basic services such as electrical power, waste management disposal, water and sanitation.[23] As a result, functional collapse, not structural damage, is the usual reason for hospital services failing during emergencies.[23] The Bioterrorism and Mass Casualty Preparedness Supplements to the 2003 and 2004

National Hospital Ambulatory Medical Care Surveys identified that only 45% of more than 700 hospitals in the United States studied stockpile resources to manage MCIs.[24] Despite the experiences of other jurisdictions during MCIs, our study identified strategies to prevent functional collapse in only one-third of Canadian trauma centres; these included the stockpiling of essential resources such as food, water and fuel. However, most trauma directors did not know if their centres were vulnerable to functional collapse.

One of the most important elements for the coordination of any level of response during an MCI is the sharing of information. However, communication deficiencies among the disaster scene, regional stakeholders and even within trauma centres have been proven to be the rule and not the exception during MCIs. Failure of hospital phone lines due to unrestricted incoming calls, failure of mobile phone networks, nonfunctional Internet connections and internal pager system failures were problems identified during the response of level-1 trauma centres to the 9/11 terrorist attacks, Hurricane Katrina and the July 2005 London bombings.[10–13] This led to the collapse of intrafacility communications and rendered these centres dependent on "runners" to transmit information within the trauma centre. Further, interagency communication failed as well and isolated these facilities from receiving knowledge pertaining to incoming casualties. In spite of this, land-linked phone lines and mobile phones were the most common communication strategies identified in our study. Given the experiences of American and English trauma centres during MCIs, opportunity to optimize communication strategies in Canadian trauma centres clearly exists. Specifically, the ability to exchange information within fixed facilities (i.e., trauma centres) and with mobile platforms (i.e., disaster command posts) has been ineffective during MCIs owing to the failure of single communication strategies or the inability to exchange information across different communication systems (i.e., land-linked phone lines and radio systems).[10,13] Interoperable communication systems may be the solution; these systems provide the ability to interconnect any device that provides an audio signal to another device with little or no manual intervention.[25] The adoption of such strategies is critical to allow for adequate communication among the trauma centre, local agencies, communities and media.

A lack of MCI education across all types of health care professions has previously been identified. The Centers for Disease Control National Ambulatory Medical Care Survey identified that less than 50% of office-based physicians were trained to identify bioterrorism-related diseases.[26] Only one-third of health administration training programs in the United States include bioterrorism and mass casualty management in their curricula.[16] We identified similar deficiencies in our study, since only one-third of Canadian trauma centres require their staff to be trained to respond to MCIs.

The development of collaborative military and civilian training platforms in the United States has generated active exchange of expertise and can lead to improved preparation for MCI response. One such collaborative program is the senior visiting surgeon program of the ACS-COT. This program is a scientific exchange between leaders in civilian trauma care in the United States and experienced military clinicians at Landstuhl Regional Medical Center in Germany.[27] Other examples of joint military–civilian training are simulation training exercises focused on surgical response during MCIs that have been included in the curriculum of the US Army Trauma Training Centre at University of Miami. This training partnership uses swine models to simulate waves of injured patients and also simulates concurrent resource limitations such as power outages and security breaches to simulate actual MCI conditions. The program has been useful in prospectively identifying deficiencies in preparation, triage and team interactions.[28] We identified only 2 Canadian trauma centres (9%) that have joint military and civilian training platforms; however, these programs are predominantly designed as one-way exchanges of information in which senior trauma surgeons train junior military trauma surgeons.

Whereas there have been several opportunities for improvement identified at the level of individual facilities, it is evident that a coordinated response also requires integration of trauma centres into regional disaster planning. Many of the incidents described above provide significant insights into preparation for future disasters. For example, a review of the response to 9/11 indicated that there was no inventory of trauma centres, their locations or their resources (Dr. John Fildes, Chairman of the ACS-COT: personal communication, 2008). The response to Hurricane Katrina demonstrated miscommunications among public health agencies, government relief agencies, hospitals, infectious disease services and trauma centres, which resulted in a substantially suboptimal integration of medical responses.[17] As there was no formal trauma centre representation at regional emergency operations centres, there was very limited interaction among hospitals, and there was no unified plan for systematic coordination among trauma centres. This led to confusion and uncertainty regarding the availability of resources at individual institutions and hampered efforts to attempt a region-wide inventory of those resources. Whereas the emergency operations centres functioned effectively in coordinating and administering relief and recovery efforts, they were not used efficiently to coordinate clinical activities at regional hospitals.[17]

Additional problems identified by the steering committee of the Atlantic and Gulf States Disaster Medical Coalition included a lack of access to medical records, poor information exchange, no plans for ongoing care of special populations and insufficient interagency cooperation.[17] These problems were addressed by the creation of a medical collaborative integrated network that attempts

to blend medical and nonmedical assets essential for disaster response through collaboration, education and liaisons. Similarly, in the present study, we identified multiple approaches to improve regional collaborations. These included real-time systems capable of monitoring intensive care unit beds and emergency department capacity in 3 provinces and mutual aid agreements or memoranda of understating with regional stakeholders regarding disaster planning and response, which were found to be in place at 22% of Canadian trauma centres. Such strategies should be more broadly implemented to optimize the regional response to MCIs in other regions of Canada.

### *Limitations*

Given the central role medical directors of trauma play in their trauma centres and in their respective trauma systems, we assumed they would be well integrated into their regional MCI response plans. However, trauma directors might have been unaware of some aspects of their institutions' response plans. As a result, our survey may have underestimated trauma centre preparedness. Nevertheless, because of their central role during an MCI, lack of knowledge on the part of trauma directors would, in itself, reflect a lack of trauma centre preparedness. Moreover, if central stakeholders such as trauma medical directors are unaware of their centres' preparedness to respond to an MCI, it is likely that many other key physician stakeholders are also unaware of their roles during such an event.

**Box 1. Recommendations for improvement of disaster preparedness in Canada**

**Leadership**

- Medical directors of trauma should assume a central role in their institutions' disaster preparedness committees.

**Planning**

- Mass casualty incident planning drills and response should be standardized at a regional level.
- All relevant stakeholders should be involved in the design, rehearsal and implementation of such disaster plans.

**Communication**

- Trauma centres must expand their communication strategies to avoid being isolated during an MCI.
- The adoption of interoperable communication systems is critical to ensure interagency communication.

**Sustainability of operations**

- Trauma centres should stockpile resources such as water, food and fuel to avoid functional collapse and guarantee 72 hours of peak operations.

**Education**

- Trauma centres should facilitate the development of joint military and civilian MCI training platforms.

**Interagency cooperation**

- Trauma centres should establish mutual aid agreements or memoranda of understanding with regional MCI response stakeholders.

MCI = mass casualty incident.

## CONCLUSION

Taken together, the results of this study suggest important opportunities to better prepare Canadian trauma centres to respond to an MCI. The main recommendations for achieving higher levels of disaster preparedness can be seen in Box 1. Further, trauma medical directors should become actively involved in disaster and emergency preparedness planning at their centres. Motivation to plan for MCIs should not only arise in the aftermath of one of these events.

**Competing interests:** None declared.

**Contributors:** Drs. Gomez, Ahmed, Tien and Nathens designed the study. Drs. Gomez and Nathens acquired the data, which Drs. Gomez, Haas and Nathens analyzed. Drs. Gomez, Haas and Nathens wrote the article. All authors reviewed the article and approved its publication.

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