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SCIENTIFIC REVIEW

Surgical Procedures Performed by Emergency Medical Teams in Sudden-Onset Disasters: A Systematic Review

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Abstract

Background Emergency medical teams (EMTs) frequently provide surgical care after sudden-onset disasters (SODs) in low- and middle-income countries. The purpose of this review is to describe the types of surgical procedures performed by EMTs with general surgical capability in order to aid the recruitment and training of surgeons for these teams.

Methods A search of electronic databases (PubMed, MEDLINE, and EMBASE) was carried out to identify articles published between 1990 and 2018 that describe the type of surgical procedures performed by EMTs in the impact and post-impact phases of a SOD. Further relevant articles were obtained by hand searching reference lists.

Results A total of 16 articles met the inclusion criteria. Articles reporting on EMTs from a number of different countries and responding to a variety of SODs were included. There was a high prevalence of procedures for extremity soft tissue injuries (46.8%) and fractures (28.3%), although a number of abdominal and genitourinary/obstetric procedures were also reported.

Conclusions Based upon this review, deployment of surgeons or teams with experience in the management of soft tissue wounds, orthopaedic trauma, abdominal surgery, and obstetrics is recommended.

Introduction

Emergency medical teams (EMTs) often play an important part in the delivery of surgical care after sudden-onset disasters (SODs), where local health facilities are frequently damaged and local staff injured, killed, or missing [1, 2]. This is particularly true in low- and middle-income countries (LMICs), where there is often already a chronic shortage of surgical care [3]. The types of surgical procedures performed by EMTs have often been poorly documented [4]. More recently, there have been several reports published regarding the surgical response to the 2010 Haitian earthquake [5–8], and concerns have been expressed regarding a perceived variability of surgical care [9, 10]. Furthermore, surgical training in many high-income countries (HICs) is becoming more subspecialized [11], meaning that current general surgical trainees are

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receiving less exposure to other specialities. As such, a systematic review, specifically focusing on the impact (day 0 to day 3 after the disaster) and post-impact (day 3 to 4 weeks) phases of the response to SODs, may help to identify the surgical skills that are required to function in such an environment and be of assistance to disaster planners and individual surgeons to target their training.

Methods

A search of PubMed, MEDLINE (1946 to present), and Ovid EMBASE (1974 to present) electronic databases was made in March 2018 for all relevant original articles published between January 1990 and January 2018. The search strategy included the Medical Subject Heading (MeSH) terms 'disasters', 'cyclonic storms', 'earthquakes', and 'tsunamis', along with the terms 'trauma', 'surgery', 'operations', and 'procedures'. These terms were combined with 'AND' or 'OR'. The full description of the search strategy is available in Appendix A (supporting information).

The primary outcomes of interest were the surgical procedures performed by EMTs in SODs in LMICs. Secondary outcomes were the mortality, mean age, and the proportion of each gender amongst the patients treated.

Articles published in English or French between January 1990 and March 2018 that described the number and type of surgical procedures performed by an EMT during an SOD were included. Only articles describing responses in LMICs were included. These EMTs must have arrived within the first 4 weeks after the disaster (i.e. in the impact and post-impact phases of the disaster response).

Articles were excluded if they described responses to conflict/combat settings, were surgical subspeciality only (i.e. without general surgical capacity) or focused on one patient subgroup only (i.e. the elderly, children or pregnant women in isolation). In addition, articles where the total number of surgical procedures or where the breakdown of types of procedures was not reported were also excluded. Systematic reviews and literature reviews were likewise not included.

A data extraction tool (available in Appendix B, supporting information) was used by two independent reviewers to extract information from relevant articles, with any disagreements to be settled by a third independent reviewer. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used for this review [12]. The study protocol was registered with PROSPERO prior to commencement (registration number: CRD42018086775).

The extracted surgical procedures were grouped according to body region (head and neck, thorax, abdomen and pelvis, extremity soft tissue, extremity bone and joint, genitourinary and obstetric, other, not specified). The data were then analysed using descriptive statistics.

Results

A total of 9835 articles (after removal of duplicates) were identified in the literature search and screened using titles and abstracts. Of the remaining studies, 57 full-text articles were assessed. Reasons for exclusion are listed in Fig. 1. A total of 16 articles met the inclusion criteria (Table 1), describing a total of 19 SOD responses. The total number of procedures performed was recorded as described in the articles (Table 2), with a breakdown for each article available in Appendix C (supporting information).

Ten of the articles concerned EMT responses after earthquakes [5–8, 13–18], and four of these reported on the 12 January 2010 earthquake in Haiti [5–8]. A further five articles were concerned with EMT responses after a tsunami [2, 19–22] with four of the five concerned with the tsunami in Asia that occurred on 26 December 2004 [2, 19, 20, 22]. Only one article reported on an EMT response after a typhoon [23]. Of the included articles, seven of the articles described the workload of civilian teams, seven described military teams, and two described mixed military/civilian teams.

Team composition was varied. Of the 19 EMT responses described in the 16 articles, 12 had general surgeons as team members, nine had orthopaedic surgeons present, three had obstetricians/gynaecologists, and two had other surgical subspecialists. Seven did not report their team composition.

The majority of surgical procedures performed were extremity soft tissue procedures (46.8%), followed by extremity bone and joint procedures (28.2%). Abdominal and pelvic procedures (7.7%) and genitourinary and obstetric (5%) were also performed. A minority of described procedures were head and neck (1.1%) or thoracic (0.2%). A proportion of procedures fell into the "other" category (7.8%) or were not specified by the authors (3.2%). The mortality rate, average patient age, and gender were not consistently reported in the articles reviewed.

Discussion

EMTs responding to the early stages of SODs expect to encounter patients with injuries directly related to the disaster, as well as surgical and obstetric emergencies (such as appendicitis, strangulated hernia, and Caesarean sections for obstructed labour). Given the baseline shortages in surgical staffing and infrastructure in LMICs, teams should also be prepared to provide care for patients with chronic

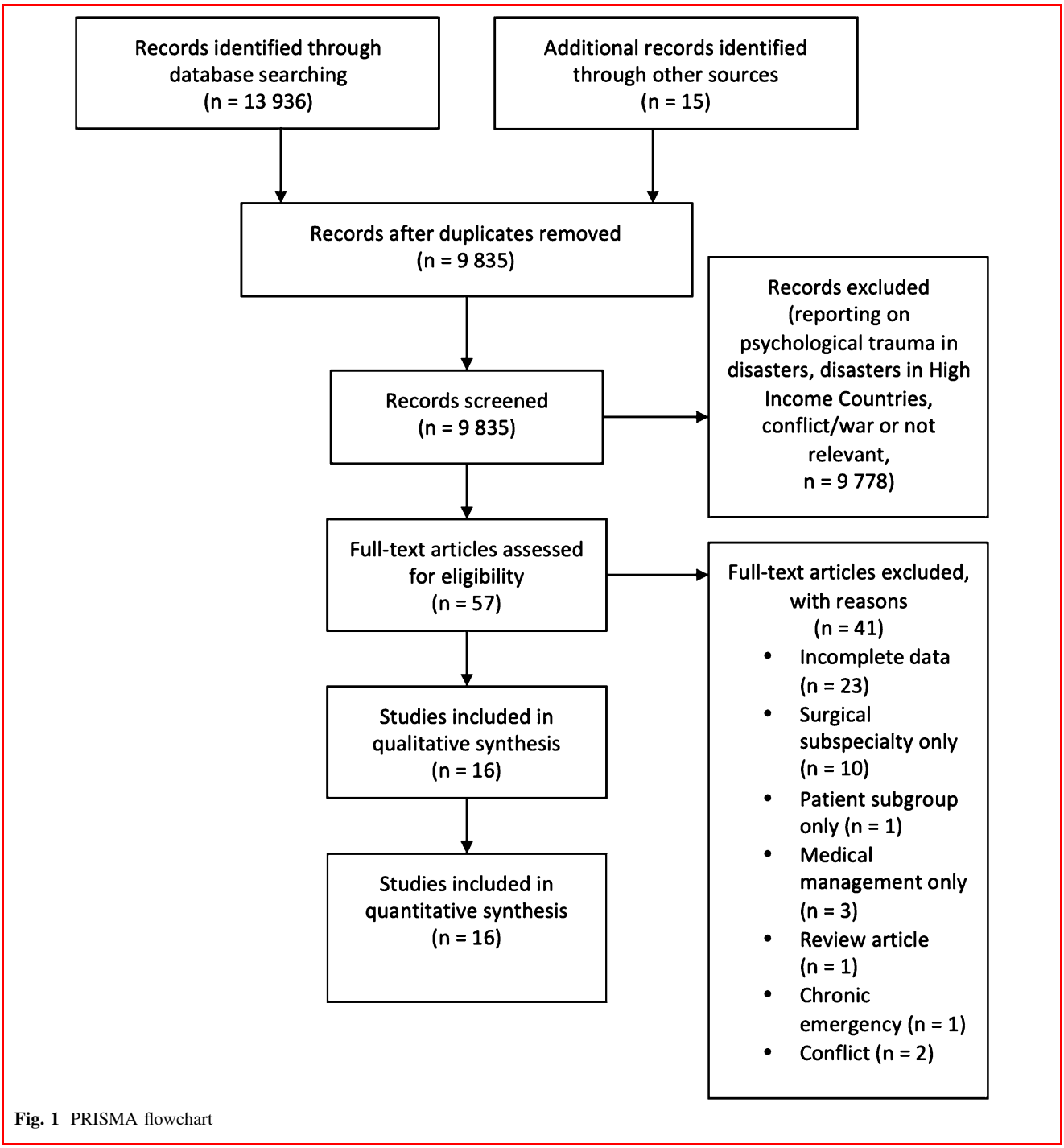

Fig. 1 PRISMA flowchart

untreated surgical diseases. Nickerson et al. [4], in a systematic review on surgical skills needed in humanitarian emergencies, noted both a high number of obstetric and orthopaedic procedures. This review included deployments for SODs, chronic humanitarian emergencies, and conflict, thereby comparing teams with vastly different caseloads and objectives. To the authors' knowledge, this systematic review is the first to specifically address the surgical procedures performed by EMTs in SODs in isolation.

As anticipated, there were a high number of procedures for fractures and soft tissue injuries. Three quarters of the procedures (75.1%) were performed on the extremities for fractures and soft tissue wounds. The majority of these procedures were for trauma. This highlights the need for experience in managing extremity fractures, muscle, tendon and nerve injuries, and soft tissue wounds as a prerequisite for surgeons responding to the impact and post-impact phases of a SOD. Procedures for thoracic and

Table 1 EMT mission details and team composition

Author	Disaster type	Location/Year	Nationality	Civilian/ military	Post-disaster arrival time (days)	Duration of mission (days)	Type
Talbot et al. [5]	Earthquake	Haiti/2010	Canada	Military	9	39	Field hospitals
McIntyre et al. [6]	Earthquake	Haiti/2010	USA	Civilian	4	21	Local hospital support
Read et al. [23]	Typhoon	Philippines/2013	Australia	Civilian	9	21	Field hospital
Tan et al. [13]	Earthquake	Indonesia/2009	Singapore	Military	4	11	Local hospital support
Bridgewater et al. [2]	Tsunami	Indonesia/2004	Australia	Civilian	13	13	Local hospital support
Chambers et al. [20]	Tsunami	Indonesia/2004	Australia	Military	14	26	Field hospital
Riddez et al. [19]	Tsunami	Indonesia/2004	Norway	Civilian	21	54	Field hospital
Holian et al. [21]	Tsunami	Papua New Guinea/1998	Australia	Mixed	5	15	Local hospital support
Malish et al. [14]	Earthquake	Peru/2007	USA	Military	3	3	Field hospital
Helminen et al. [15]	Earthquake	Pakistan/2005	Mixed	Civilian	13	20	Field hospital
Lee et al. [22]	Tsunami	Indonesia/2004	Singapore	Mixed	10	11	Field hospital
Schnitzer et al. [16]	Earthquake	Iran/2003	USA	Civilian	2	4	Field hospital
Peranteau et al. [7]	Earthquake	Haiti/2010	USA	Civilian	10	6	Local hospital support
Jiang et al. [17]	Earthquake	China/2008	China	Military	3	30	Field hospital
Bar-on et al. [8]	Earthquake	Armenia/1988	Israel	Military	12	10	Field hospital
	Earthquake	Turkey/1999	Israel	Military	4	10	Field hospital
	Earthquake	India/2001	Israel	Military	6	10	Field hospital
	Earthquake	Haiti/2010	Israel	Military	4	10	Field hospital
Chauhan et al. [18]	Earthquake	Nepal/2015	India	Military	1	33	Field hospital

abdominal trauma, traditionally the domain of the HIC trauma surgeon, were rare in the articles included. This is presumably because few EMTs are on scene and have functioning surgical facilities within the first few days following an SOD and, by this stage, most of the patients with traumatic intracranial, thoracic and abdominal wounds have either been treated by local health facilities or have succumbed.

Another finding was the high number of procedures for non-traumatic surgical conditions, notably 183 (5.9%) hernia repairs. This likely reflects the unmet burden of surgical disease prevalent in LMICs. There were also 155 (5%) gynaecological, genitourinary, and obstetric procedures including 35 (1.1%) Caesarean sections. While this is likely to be an underestimation of the true burden as it does not include local health facilities, it highlights that EMTs require obstetric capability. Considering that obstetric and general surgical procedures constitute 20 of the 48 essential surgical procedures as listed in Essential Surgery report [24], such expertise appears vital as EMTs are likely to continue to be required to perform these procedures until local health facilities are again functional.

As this review demonstrates, a broad range of surgical skills are required by EMTs when responding to SODs in LMICs. Disaster planners must therefore include surgeons with broad surgical training, include multiple subspecialist surgeons, or be part of a coordinated response with multiple EMTs providing different subspecialist services. A team based upon three 'specialists'—a general surgeon, an obstetrician/gynaecologist, and an orthopaedic surgeon, would seem best suited to meet the anticipated need. The Australian Medical Assistance Team (AUSMAT), a type 2 EMT, follows this model, with their general surgeons being expected to cover all areas not treated by the specialist obstetrician/gynaecologist and orthopaedic surgeon. This highlights the ongoing requirement for broadly trained general surgeons. Such surgeons may be increasingly difficult to find as surgical training in HICs has become more subspecialized [11]. Lin et al. [25] in a recent study comparing the logbooks of American general surgical trainees with the surgical logbooks of Médecins sans Frontières/ Doctors Without Borders surgeons in both long-term humanitarian projects and SODs, found that general surgical trainees now lacked exposure to obstetrics, gynaecology, and orthopaedics. This will have implications for humanitarian actors responding to chronic humanitarian crises, often under a single-surgeon model.

There was a large degree of heterogeneity amongst reporting styles, consistent with findings by previous authors [4]. While some of the articles included contained

Table 2 Surgical procedures performed by EMTs

Procedure	Total
Head and neck	33 (1.1%)
Spinal procedures	3
Craniotomy/neurosurgery	6
Tracheotomy	4
Other head and neck	3
Ear, nose throat—unspecified	11
Eyes—unspecified	6
Thoracic	5 (0.2%)
Chest drain insertion	5
Abdominal/pelvic	236 (7.7%)
Laparotomy	39
Appendectomy	14
Hernia repair	183
Extremity soft tissue	1445 (46.8%)
Skin graft	162
Dressing changes	139
Tendon/nerve repair	8
Burns debridement	3
Fasciotomy	30
Wound debridement/repair	992
Soft tissue procedure-unspecified	111
Extremity bone and joint	871 (28.2%)
External fixation	230
ORIF	88
Amputations	122
Revision of amputation	39
Intramedullary nail	5
Reduction of fracture/dislocation	260
Other bone and joint	127
Genitourinary/obstetric	155 (5%)
Hysterectomy	12
Pelvic EUA	1
Caesarean section	35
Dilation and curettage	10
Normal vaginal delivery	60
Circumcisions	6
Other obstetric/gynaecology	3
Other urology	28
Other	241 (7.8%)
Incision and drainage	20
Unspecified general surgery	6
Examination under anaesthesia	4
Endoscopy	2
Tumours (unspecified procedures)	34
Trauma (unspecified)	172
Dialysis catheter insertion	3
Not specified	99 (3.2%)
Total procedures	**3085 (100%)**

detailed descriptions of operations, others had less precise categorisation and descriptions of procedure types. There have been calls for a more consistent and rigorous approach to record keeping by EMTs [26], and this would facilitate high-quality research and evaluation of the work and impact of EMTs. The differences in reporting techniques and data recorded meant that analysis beyond descriptive statistics were considered unlikely to provide meaningful conclusions. Basic patient details, such as gender and age of patients, were not consistently reported, and key epidemiological measures, such as mortality rate and overall burden of surgical disease, were often not included. Furthermore, the role of their individual EMT in the overall response to the SOD was infrequently reported, limiting the ability to contextualize their contribution to complex multi-national and multi-agency responses. Finally, this study focused on a fairly limited group of high-profile disasters. There is understandably a significant interest in the responses to such catastrophic disasters, but less has been published regarding the response to smaller-scale disasters.

Conclusion

Surgeons and surgical teams are frequently required to perform a wide range of procedures when responding to SODs in LMICs. While there is considerable heterogeneity between the studies included in this review, it is clear that experience in the management of extremity injury (both soft tissue and orthopaedic) is vital. In addition, surgeons should be prepared to manage obstetric and abdominal cases and should be aware that procedures for chronic surgical problems are likely to be required.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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