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Systematic Review of Evidence-Based Guidelines for Prehospital Care

Seth Turner, MD, EMT-P, Eddy S. Lang, MDCM, CCFP(EM), CSPQ, Kathleen Brown, MD, Jantzen Franke, MD, Michelle Workun-Hill, MD, Colleen Jackson, MD, MSc, Lauren Roberts, MD, MSc, Christopher Leyton, MD, Eileen M. Bulger, MD, Eileen M. Censullo, MBA, FAARC, RRT, Christian Martin-Gill, MD, MPH for the Prehospital Guidelines Consortium

Abstract

Introduction: Multiple national organizations have identified a need to incorporate more evidence-based medicine in emergency medical services (EMS) through the creation of evidence-based guidelines (EBGs). Tools like the Appraisal of Guidelines for Research and Evaluation (AGREE) II and criteria outlined by the National Academy of Medicine (NAM) have established concrete recommendations for the development of high-quality guidelines. While many guidelines have been created that address topics within EMS medicine, neither the quantity nor quality of prehospital EBGs have been previously reported. **Objectives**: To perform a systematic review to identify existing EBGs related to prehospital care and evaluate the quality of these guidelines using the AGREE II tool and criteria for clinical guidelines described by the NAM. **Methods**: We performed a systematic search of the literature in MEDLINE, EMBASE, PubMED, Trip, and guidelines.gov, through September 2018. Guideline topics were categorized based on the 2019 Core Content of EMS Medicine. Two independent reviewers screened titles for relevance and then abstracts for essential guideline features. Included guidelines were appraised with the AGREE II tool across 6 domains by 3 independent reviewers and scores averaged. Two additional reviewers determined if each guideline reported the key elements of clinical practice guidelines recommended by the NAM via consensus. **Results**: We identified 71 guidelines, of which 89% addressed clinical aspects of EMS medicine. Only 9 guidelines scored >75% across AGREE II domains and most (63%) scored between 50 and 75%. Domain 4 (Clarity of Presentation) had the highest (79.7%) and domain 5 (Applicability) had the lowest average score across EMS guidelines. Only 38% of EMS guidelines included a reporting of all criteria identified by the NAM for clinical practice guidelines, with elements of a systematic review of the literature most commonly missing. **Conclusions**: EBGs exist addressing a variety of topics in EMS medicine. This systematic review and appraisal of EMS guidelines identified a wide range in the quality of these guidelines and variable reporting of key elements of clinical guidelines. Future guideline developers should consider established methodological and reporting recommendations to improve the quality of EMS guidelines. **Key words:** prehospital; emergency medical services; clinical guidelines

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Introduction

Over the past two decades, multiple national organizations and individuals have identified a need to incorporate more evidence-based medicine (EBM) into emergency medical services (EMS). This has been demonstrated in the creation of evidence-based guidelines (EBGs) written directly for care in the out-of-hospital setting, as well as guidelines focused on in-hospital care that recognize and address the importance of initiating an evidence-based approach from the initiation of

patient care by prehospital personnel. Yet the incorporation of robust evidence evaluation to systematically guide prehospital care has been a slow-moving process. In its 2007 landmark publication "Emergency Medical Services: At the Crossroads," the National Academy of Medicine (NAM, formerly the Institute of Medicine) highlighted that most prehospital interventions were based upon weak evidence or expert opinion alone (1). Since that time, new standards for research and guideline development have continued to shine a spotlight on this issue.

Based on a recognized need to improve the quality and evidence assessment for prehospital guidelines, considerable efforts have been undertaken over the past decade to increase the number and quality of prehospital EBGs. In 2012, the National EMS Advisory Council (NEMSAC) and the Federal Interagency Committee on EMS (FICEMS) convened an expert panel that created an eight-step model for the development of prehospital EBGs (2). Following this guidance, the National Highway Traffic Safety Administration (NHTSA) funded several individual prehospital EBGs (3–8). Additional funded efforts have aimed to better understand challenges to guideline implementation (9, 10), as well as the development of performance measures to evaluate the quality of prehospital care (11, 12). Further recognizing a need to establish a sustainable process to develop, implement, and evaluate prehospital EBGs, in 2013 NHTSA entered into a cooperative agreement with the National Association of EMS Physicians (NAEMSP) to create the National Prehospital EBG Strategy (13). The Strategy identified seven key action items aimed to promote the development, implementation, and evaluation of prehospital EBGs, and led to the formation of the Prehospital Guidelines Consortium (PGC), comprised of 35 member organizations collaborating to see this Strategy fulfilled (14). Concurrently, EMS guidelines have continued to be developed, published, and implemented by multiple entities, all of which support these collaborative efforts to improve the availability and use of scientific evidence in prehospital care.

Despite these efforts, neither the quantity nor quality of prehospital EBGs have been previously evaluated. In 2011, the NAM laid out specific criteria with which to assess the quality of clinical practice guidelines (CPGs) (15), and tools like the Appraisal of Guidelines for Research and Evaluation (AGREE) II have provided an objective and systematic means of assessing that quality (16). While these tools have been adopted in the development or assessment of EBGs across other medical disciplines (17–19), they have not been used consistently for the prehospital setting. Such an initiative has the potential to inform future work, to fill gaps between existing guidelines, to facilitate improvements in guideline quality, and to facilitate implementation of guidelines by end users. We therefore aimed to perform a systematic review of the medical literature to identify existing EBGs related to prehospital care. We further aimed to evaluate the quality of these guidelines with the AGREE II tool, and determine which guidelines meet the quality standards for CPGs set by the NAM. Finally, to promote improvements in the quality of future guidelines, we aimed to determine if there are any components of guideline development that are consistently missing or of lower quality across existing prehospital EBGs.

METHODS

Study Design

We performed a systematic review and evaluation of published guidelines related to prehospital care. This project was developed and overseen by members of the PGC Development Committee and PGC leadership. Two investigators (ST, EL) developed the methodology and systematic protocol outlined below, with input and support from a working group of the committee.

Search Strategy

Two investigators (ST, EL) and a health librarian at the University of Calgary conducted a search of the literature for guidelines related to prehospital care in June 2016. We searched EMBASE, MEDLINE, PubMed (excluding articles identified in MEDLINE), Trip, and guidelines.gov for articles published prior to May 2016, excluding non-English language publications. The keywords and search strategy are described in Supplementary Table 1, which was adapted for each database.

This strategy was then repeated in September 2018, updating the data to include articles between May 2016 and September 2018. At the time of this second search, MEDLINE and PubMed had become fully compatible, and guidelines.gov had ceased operation. Further, we noted that the Trip database provided no novel articles during the first search, so we excluded it as well. Finally, we manually searched bibliographies, updated articles where relevant, and removed duplicates that were not found in the initial screening process. The most recent available version of any guideline was evaluated.

Guideline Selection and Categorization

Two investigators (ST, CL) independently screened titles for relevance to prehospital care, and then

TABLE 1. Appraisal of Guidelines for Research and Evaluation (AGREE) II instrument Domains.

Domain	No.	Item
1. Scope and Purpose	1	The overall objective(s) of the guideline is (are) specifically described.
	2	The health question(s) covered by the guideline is (are) specifically described.
	3	The population (patients, public, etc.) to whom the guideline is meant to apply is specifically described.
2. Stakeholder Involvement	4	The guideline development group includes individuals from all relevant professional groups.
	5	The views and preferences of the target population (patients, public, etc.) have been sought.
	6	The target users of the guideline are clearly defined.
3. Rigor of Development	1	Systematic methods were used to search for evidence.
	2	The criteria for selecting the evidence are clearly described.
	3	The strengths and limitations of the body of evidence are clearly described.
	4	The methods for formulating the recommendations are clearly described.
	5	The health benefits, side effects, and risks have been considered in formulating the recommendations.
	6	There is an explicit link between the recommendations and the supporting evidence.
	7	The guideline has been externally reviewed by experts prior to its publication.
	8	A procedure for updating the guideline is provided.
4. Clarity of Presentation	1	The recommendations are specific and unambiguous.
	2	The different options for management of the condition or health issue are clearly presented.
	3	Key recommendations are easily identifiable.
5. Applicability	1	The guideline describes facilitators and barriers to its application.
	2	The guideline provides advice and/or tools on how the recommendations can be put into practice.
	3	The potential resource implications of applying the recommendations have been considered.
	4	The guideline presents monitoring and/or auditing criteria.
6. Editorial Independence	1	The views of the funding body have not influenced the content of the guideline.
	2	Competing interests of guideline development group members have been recorded and addressed.

reviewed abstracts to retain publications containing two key features of guidelines – recommendations for practice based on a literature review. We used the kappa statistic to estimate inter-rater reliability, and all disagreements were mediated by consensus of two additional investigators (EL, KB). Again, we repeated this process for the second search. However, the newer articles were then screened by ST and JF, and disagreements were mediated by CM.

Each guideline was categorized based on the American Board of Emergency Medicine (ABEM) 2019 Core Content of EMS Medicine (20). Guidelines were categorized into multiple topic areas if appropriate based on the primary content (e.g. primary questions or recommendations) addressed by each guideline. For the content area of "special considerations for evaluation, treatment, transport, and destinations," a guideline was only categorized in this area if primarily described as addressing special considerations for time-life critical conditions or special patient populations, consistent with the limited ABEM description of this category.

Guideline Appraisal

We used AGREE II for the guideline appraisal process. AGREE II is a validated tool that looks at six key domains, encompassing 23 different items, of guideline quality (Table 1) (16). Each item is scored on a seven-point scale, with an online training program and user-guide providing direction on how to score. In addition, appraisers are asked to rate the overall quality of the guideline, and to provide a recommendation for its use. However, these values are meant to be subjective in nature, so we did not include them in this study.

Each guideline was appraised by 3 of 7 investigators (ST, CL, EB, JF, LR, MW, CJ), and we combined these appraisals with the calculation of cumulative domain totals (Table 1). We then averaged the cumulative domain totals across all domains, which provided an overall score for each guideline. Next, we grouped these scores into quartiles, which provided an aggregate assessment of guideline quality. Finally, we averaged the cumulative domain totals across all guidelines, which revealed specific areas in which prehospital guidelines tended to score well or poorly.

Guidelines were also evaluated based on criteria for clinical practice guidelines established for the National Guidelines Clearinghouse by the U.S. Department of Health and Human Services, Agency for Healthcare Research and Quality (AHRQ) (21). These criteria were adopted from and based on the NAM publication "Clinical Practice Guidelines We Can Trust (22)." Guidelines were assessed across 6 core criteria with subcomponents summarized in Table 2. Appraisals were determined by consensus of CM and EC through full-text review of each guideline. Supplementary content linked to or referred to by the published guideline was reviewed and considered toward meeting any criterion. Based

TABLE 2. Inclusion Criteria for Clinical Practice Guidelines. Adapted from the National Guideline Clearinghouse (NGC) (21) and the National Academy of Medicine (22).

Criteria	Description
1. Systematically Developed Recommendations	The clinical practice guideline contains systematically developed statements including recommendations intended to optimize patient care and assist physicians and/or other health care practitioners and patients to make decisions about appropriate health care for specific clinical circumstances.
2. By an Association or Similar Organization	The clinical practice guideline was produced under the auspices of a medical specialty association; relevant professional society; public or private organization; government agency at the Federal, State, or local level; or health care organization or plan. A clinical practice guideline developed and issued by an individual(s) not officially sponsored or supported by one of the above types of organizations does not meet the criteria.
3. Systematic Review	The clinical practice guideline is based on a systematic review of evidence as demonstrated by documentation of each of the following features in the clinical practice guideline or its supporting documents.
a. Statement	An explicit statement that the clinical practice guideline was based on a systematic review.*
b. Search Strategy	A description of the search strategy that includes: - A listing of database(s) searched, - A summary of search terms used, and - The specific time period covered by the literature search including the beginning date (month/year) and end date (month/year)
c. Study Selection	A description of the study selection that includes: - The number of studies identified, - The number of studies included, and - A summary of inclusion and exclusion criteria.
d. Synthesis of Evidence	A synthesis of evidence from the selected studies, e.g., a detailed description or evidence tables.
e. Summary of Evidence Synthesis	A summary of the evidence synthesis (see 3d above) included in the guideline that relates the evidence to the recommendations, e.g., a descriptive summary or summary tables.
4. Assessment of Benefits/Harms and Alternative Care Options	The clinical practice guideline or its supporting documents contain an assessment of the benefits and harms of recommended care and alternative care options.
5. English and to the Public	The full text guideline is available in English to the public upon request (for free, or for a fee).
6. Current	The guideline is current and the most recent version.**

*If an explicit statement that the clinical practice guideline was based on a systematic review was not provided but all other criteria and subcriteria describing a systematic review were determined to be present, that subcriterion was marked as complete. Guideline developers should be advised to contain such an explicit statement in future guidelines.

**The NGC Inclusion Criteria and IOM recommend a guideline should be developed, reviewed, or revised within the past five years. For the purpose of this systematic review, this criterion was waved.

on the guideline search strategy, all publications were in English, available to the public (for free or for a fee), and the most recent version of the guideline was reviewed; these criteria are not reported further.

RESULTS

Guideline Search

The initial search strategy yielded N = 2188 citations (Figure 1) - EMBASE (N = 519), MEDLINE (N = 1175), PubMed (N = 14), Trip (N = 416), and guidelines.gov (N = 64). Of these citations, we excluded N = 1975 for relevance after an initial screening of titles, with an inter-rater agreement of kappa = 0.35. Of the remaining citations, N = 167 were excluded after a second screening of abstracts for the key guideline features, with an inter-rater agreement of kappa = 0.57. Finally, N = 46 citations were retained for full review.

The second search yielded N = 367 citations (Figure 1) - EMBASE (N = 108) and MEDLINE (N = 259). Given the more manageable number, only one round of screening was necessary. N = 342 were excluded, with an inter-rater agreement of kappa = 0.57. Therefore, 25 citations were retained from this second search, resulting in a total number of guideline appraisals of 71.

Guideline Topics

Most appraised guidelines (N = 68, 96%) (3, 5, 6, 8, 23–86) addressed clinical aspects of EMS medicine based on classification according to the 2019 revised ABEM Core Content of EMS Medicine (Supplementary Table 2) (20), and some guidelines notably addressed multiple topics. The most commonly addressed aspects of clinical EMS medicine were injury (N = 34, 48%) (5,

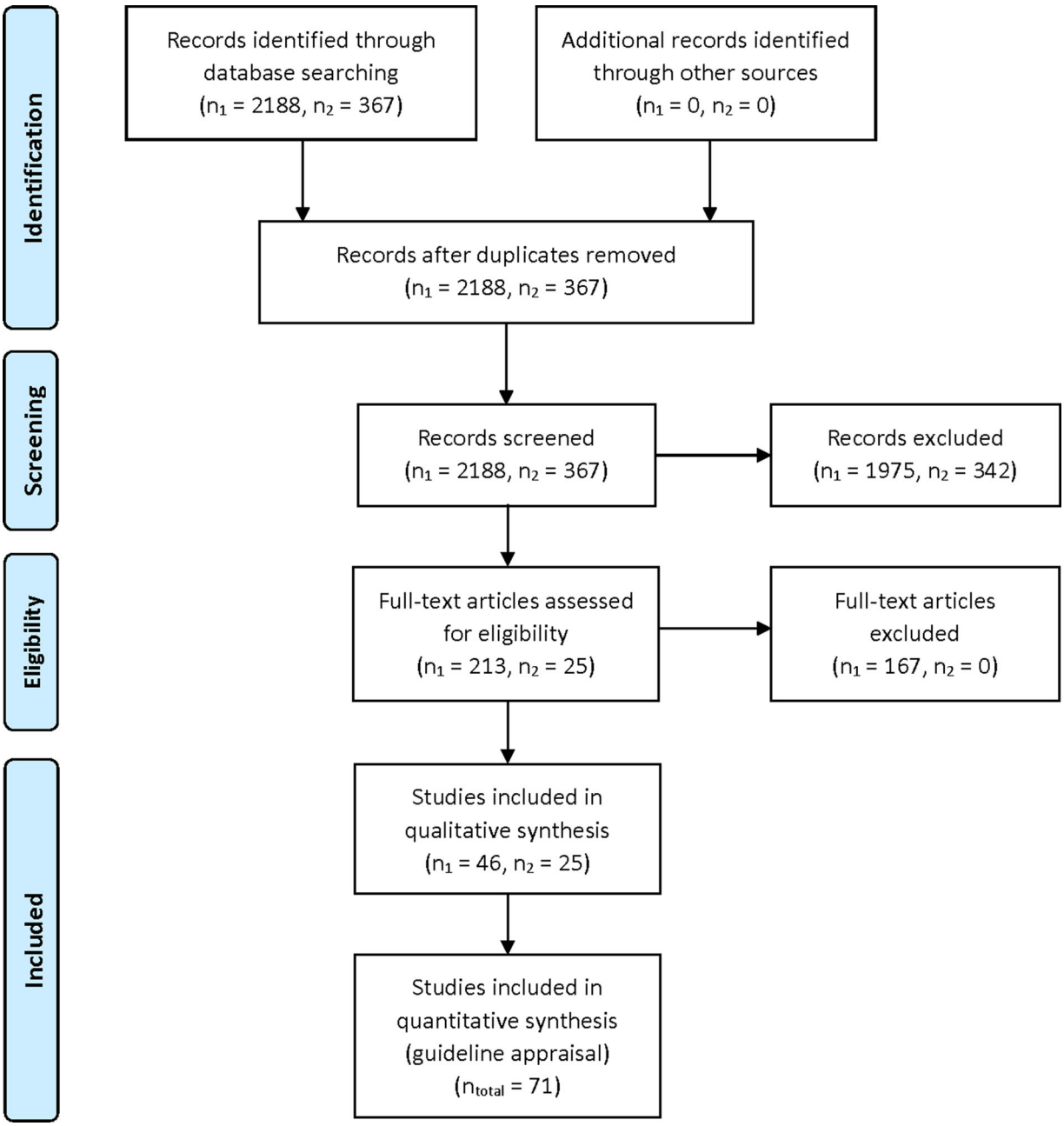

Figure 1. Preferred reporting items for Systematic Reviews and Meta-Analyses (PRISMA) Diagram for first and second searches.

6, 8, 34, 41, 43–55, 57–65, 73, 75, 76, 81, 83, 84, 86), time/life critical conditions (N = 28, 39%) (23–26, 28, 31–36, 38, 41, 44, 45, 52, 56, 57, 70, 75–78, 80–83, 85), and medical emergencies (N = 22, 31%) (3, 26, 27, 29, 30, 33, 37, 39–41, 66–74, 78, 79, 82). There were N = 7 (10%) guidelines that provided content specific to pediatric patients (3, 42, 76–80). A minority of guidelines addressed non-clinical aspects of EMS medicine (N = 11, 15%), including special operations (N = 5, 7%) (75, 83–86), medical oversight (N = 5, 7%) (5, 7, 42, 68, 87), and quality improvement (N = 1, 1%) (88).

Guideline Appraisal

Results of the guideline appraisal process can be found in Table 3. When overall guideline scores are grouped into quartiles, most guidelines (N = 45, 63%) scored between 50-75%, with 9 (13%) guidelines scoring >75%, and 17 (24%) guidelines scoring <50%. When cumulative domain totals were averaged across guidelines, Domain 4 (Clarity of Presentation) scored the highest at 79.7% (±14.0), whereas Domain 5 (Applicability) scored the lowest at 35.1% (±19.1%) (Figure 2). Key items of Domain 4

TABLE 3. Appraisal of Guidelines for Research and Evaluation (AGREE) II Assessment.

Guideline	Domain 1	Domain 2	Domain 3	Domain 4	Domain 5	Domain 6	Domain Average
Adams 2003	33	28	20	59	4	17	26.8
Adelson 2003	80	44	70	89	26	44	58.8
Ahn 2011	89	44	69	87	17	22	54.7
Atkins 2015	83	50	57	89	40	61	63.3
Badjatia 2008	81	48	82	87	22	28	58.0
Battaloglu 2017	80	56	67	87	31	92	68.8
Belval 2018	67	41	10	59	22	39	39.7
Berlac 2008	74	54	48	87	35	0	49.7
Bhanji 2015	83	78	71	94	47	67	73.3
Boulanger 2018	85	98	84	94	74	100	89.2
Bowles 2017	76	67	18	72	24	69	54.3
British Trauma Society 2003	61	37	38	87	39	28	48.3
Brooks 2015	72	48	60	85	32	56	58.8
Brugger 2013	65	52	67	89	39	67	63.2
Bulger 2014	96	54	60	91	8	86	65.8
Callaway 2015	69	39	57	85	33	56	56.5
Chalkias 2009	69	24	13	57	15	22	33.3
Ching 2017	48	4	6	50	3	0	18.5
Connor 2013	46	31	18	61	32	81	44.8
Cotton 2009	85	35	68	94	17	42	56.8
de Caen 2015	78	46	63	81	39	64	61.8
Ellerton 2009	74	65	49	81	33	94	66.0
Elsensohn 2006	59	26	12	76	18	17	34.7
Furyk 2017	80	33	42	48	24	81	51.3
Gausche-Hill 2014	96	83	74	94	71	61	79.8
Gordon 2015	83	50	39	83	24	72	58.5
Harmsen 2017	76	50	36	67	35	69	55.5
Hebb 2007	78	39	33	70	40	25	47.5
Hock Ong 2013	93	70	54	69	49	64	66.5
Hossfeld 2016	57	52	34	69	21	94	54.5
Kanani 2017	96	89	92	91	67	72	84.5
Kleinman 2015	81	54	55	87	42	56	62.5
Kobayashi 2018	91	61	67	85	26	19	58.2
Kornhall 2017	94	72	85	94	56	97	83.0
Kreinest 2016	69	35	49	70	22	58	50.5
Kronick 2015	70	48	41	72	63	58	58.7
Kubica 2017	19	6	22	72	3	61	30.5
Lavonas 2015	76	46	60	91	39	61	62.2
Leech 2016	67	30	22	65	22	78	47.3
Link 2015	81	56	63	89	35	56	63.3
MacDonald 2006	74	39	53	80	19	28	48.8
Manoguerra 2005	94	72	79	87	26	72	71.7
Mayglothling 2012	96	30	71	100	11	44	58.7
Miller 2004	69	70	44	59	44	17	50.5
Millin 2013	65	50	44	80	28	56	53.8
Moss 2013	54	56	18	74	32	72	51.0
Neugebauer 2012	63	57	43	37	29	72	50.2
O'Connor 2015	80	57	65	85	40	58	64.2
O'Driscoll 2017	93	89	95	94	83	69	87.2
Patterson 2018	98	100	80	91	75	89	88.8
Powers 2018	96	63	75	96	43	83	76.0
Pre-Hospital Fibrinolysis 2004	70	56	46	70	49	86	62.8
Pride 2017	44	19	30	80	13	64	41.7
Quinn 2013	81	39	54	93	21	19	51.2
Rehn 2016	89	69	85	96	61	83	80.5
Sanello 2018	89	56	58	78	28	89	66.3
Sasser 2012	89	70	76	83	69	39	71.0
Savino 2015	96	61	56	91	26	47	62.8
Shah 2014	96	69	82	96	68	33	74.0
Silverman 2017	91	33	59	74	31	58	57.7
Singletary 2015	89	61	67	91	42	64	69.0
Stanton 2017	44	11	33	76	18	67	41.5

(*Continued*)

TABLE 3. (*Continued*).

Guideline	Domain 1	Domain 2	Domain 3	Domain 4	Domain 5	Domain 6	Domain Average
Stroke Foundation 2017	93	76	79	83	74	83	81.3
Strosberg 2016	72	41	15	39	65	67	49.8
Stuke 2011	63	44	53	67	33	25	47.5
Theodore, Arabi 2013	57	33	48	74	8	25	40.8
Theodore, Hadley 2013	69	41	56	94	21	28	51.5
Thomas 2014	96	89	71	94	50	42	73.7
Velopulos 2018	100	39	81	81	14	92	67.8
Wyckoff 2015	85	67	54	93	44	61	67.3
Zafren 2014	83	41	59	83	40	25	55.2

*All scores represent percentages.

include specific, unambiguous, and identifiable recommendations, and presentation of alternative options for management of the health condition. Key items of Domain 5 include facilitators and barriers to guideline application, tools for guideline implementation, resource implications, and monitoring/auditing criteria.

Evaluation of guidelines based on the NAM criteria for clinical guidelines revealed only 38% (N = 27) guidelines contained all recommended reportable elements (Table 4). Most guidelines contained a description of benefits, harms, and alternate care options (N = 69, 97%) and a summary of evidence synthesis (N = 63, 89%). The most commonly missing elements (N, % containing), were study selection (N = 35, 49%), synthesis of the evidence (N = 38, 54%), and a description of the search strategy (N = 39, 55%). Only N = 41 (58%) of guidelines contained a statement reporting the performance of a systematic review of the literature, or included all elements of a systematic review of the literature, which would similarly qualify as meeting this criterion (21).

DISCUSSION

We identified a limited number of published guidelines in the field of prehospital care when compared to the scope of EMS medicine. This is consistent with prior NAM findings of a limited amount of scientific evidence guiding EMS (1). However, we noted that 60 of 71 (85%) guidelines found in this review were published after 2007 when the NAM report promoting more evidence-based medicine in EMS was published. Of these guidelines, only 9 (13%) obtained a composite score of >75% in the appraisal process using AGREE II, demonstrating room for improvement across most guidelines available for EMS systems. Further, only 2 of 6 domain averages were >60%. Almost two thirds of EMS guidelines lacked detailed reporting recommended by the NAM and AHRQ, identifying important gaps in reporting within clinical guidelines for EMS medicine.

The areas in which guidelines scored highest were Domains 1 and 4, with average scores of 76.6% and 79.9%, respectively. Domain 1 (Scope and Purpose) involves a description of the objectives, health questions, and target population of the guideline, whereas Domain 4 (Clarity of Presentation) involves specific and identifiable recommendations that are presented with their alternatives. The intuitive nature of these items is what makes them commonplace; they require little to no prior experience in guideline development, external input or instruction, additional research or work, or specific knowledge beyond the subject at hand. However, they represent only 6 of the 23 AGREE II items.

The remaining domains, 2, 3, 5, and 6, scored significantly lower, with averages of 51.3%, 53.6%, 35.1%, and 56.2%, respectively. Although each domain contains multiple, unique items, one common theme that can be seen across these domains is the impact of funding and methodology, which are often closely related. First, Domain 2 (Stakeholder Involvement) generally requires the coordination and associated costs of large, national meetings, spanning multiple professions and disciplines. Second, Domain 3 (Rigor of Development) involves extensive manpower and time if a strict methodology like the Grading of Recommendations Assessment, Development and Evaluation (GRADE) (89, 90) is used. Further, a procedure for updating the guideline implies an ongoing effort with sustainable funding versus a stand-alone project, which is like the monitoring/auditing criteria of Domain 5 (Applicability). Domain 5 is also limited by the consideration of resource implications, which can involve performance of a cost-analysis and evaluation of the impact on existing resources, personnel, and local protocols.

The impact of funding and methodology is evident in the appraisals of the two highest scoring guidelines. The Canadian Stroke Best Practice Recommendations for Acute Stroke Management by

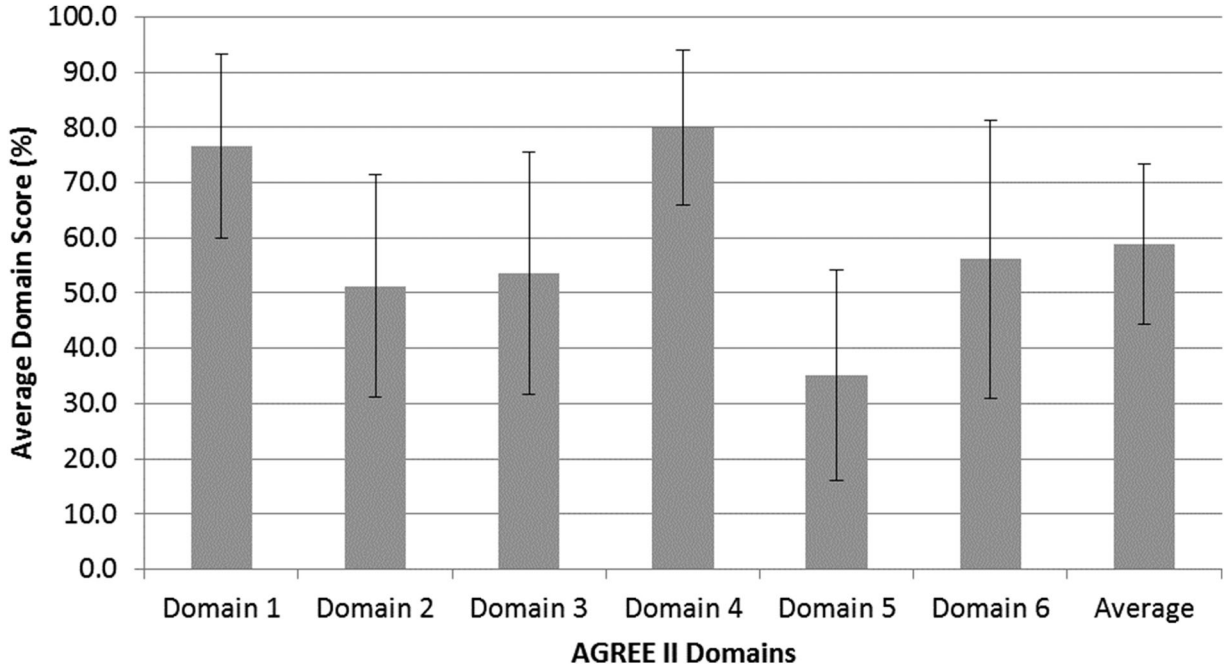

FIGURE 2. Average scores across AGREE II Domains. Caption: *Average of three appraisers ± standard deviation.

Boulanger et al. (66), had the highest average domain score of 89.2%. The Canadian Stroke Best Practice Recommendations, and their updates, are funded in their entirety by the Heart and Stroke Foundation, Canada. This is a well-funded, long-standing, national organization that advocates for stroke awareness and management across all levels of care. This organization possesses the resources to gather and support a large group of interdisciplinary experts, and the guideline development group used a rigorous framework adapted from the Practice Guidelines Evaluation and Adaptation Cycle (91). The second highest scoring guideline, with an average domain score of 88.8%, is the Evidence-Based Guidelines for Fatigue Risk Management in Emergency Medical Services by Patterson et al (7). Similarly, this guideline had robust funding from the U.S. Department of Transportation, National Highway Traffic Safety Administration and used GRADE methodology for evidence evaluation.

Yet funding from a national organization and use of structured methodology are not enough to achieve high scores across all domains. A variety of other guidelines appraised in this review reported either internal or external funding mechanisms. Appraisal across all domains suggests that future EMS guideline developers should be mindful of each individual domain identified by the AGREE II tool as a component of high guideline quality. Particular attention should be paid to domains, 2, 3, 5, and 6, which scored the lowest across EMS guidelines. Domain 6 (Editorial Independence) may specifically interact with the benefit of strong funding. It identifies the need for explicit statements regarding funding and potential competing interests. Specifically, it requires that the views of the funding body not influence the content of the guideline, and that any competing interests of the author group be recorded and addressed. The issue of bias is by no means a recent development in the world of research and guideline development, so it was surprising that many of the articles appraised failed to comment upon either issue. Smaller projects, specifically those that lack external funding, would be unlikely to have bias. Moreover, the individual requirements of this domain, and its items, call for a brief statement and attached document that addresses these concerns. This content can usually be found at the beginning or end of a guideline and involves minimal effort. Therefore, domain 6 appears to be an area where forthcoming guidelines can readily improve through simple improvements in reporting.

Several guidelines contained in this systematic review were created using the Model Process for EMS guideline development published by Lang et al. in 2012 (2). These include guidelines on pediatric prehospital seizure management (3), prehospital analgesia in trauma (8), air medical transportation of prehospital trauma patients (5), external hemorrhage control (6), and fatigue risk management (7). The Model Process stems from criteria for quality clinical guidelines put forth by the NAM (15), and strongly promotes the use GRADE methodology. The systematic and exhaustive approach utilized by

TABLE 4. Criteria for clinical practice guidelines assessment.

Guideline	Systematically Developed Recommendations	By an Association or Similar	Systematic Review	Description of Search Strategy	Study Selection	Synthesis of Evidence	Summary of Evidence Synthesis	Assessment of Benefits/ Harms and Alternative Care Options
Adams 2003	No	No	No	No	No	No	Yes	Yes
Adelson 2003	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ahn 2011	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Atkins 2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Badjatia 2008	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Battaloglu 2017	Yes	No	No	No	No	No	Yes	Yes
Belval 2018	No	Yes	No	No	No	No	Yes	Yes
Berlac 2008	No	Yes	Yes	No	No	No	Yes	Yes
Bhanji 2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Boulanger 2018	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bowles 2017	No	Yes	No	No	No	No	Yes	Yes
British Trauma Society 2003	Yes	Yes	No	No	No	No	Yes	Yes
Brooks 2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Brugger 2013	Yes	Yes	Yes	No	Yes	No	Yes	Yes
Bulger 2014	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Callaway 2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Chalkias 2009	No	No	No	No	No	No	Yes	Yes
Ching 2017	No	Yes	No	No	No	No	Yes	Yes
Connor 2013	Yes	No	No	No	No	No	No	Yes
Cotton 2009	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
de Caen 2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ellerton 2009	No	Yes	No	No	No	No	Yes	Yes
Elsensohn 2006	No	Yes	No	No	No	No	No	Yes
Furyk 2017	No	No	Yes	No	No	No	Yes	Yes
Gausche-Hill 2014	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Gordon 2015	No	No	No	Yes	No	No	Yes	Yes
Harmsen 2017	Yes	No	No	No	No	No	No	Yes
Hebb 2007	No	No	No	Yes	No	No	Yes	Yes
Hock Ong 2013	Yes	Yes	No	No	No	No	No	No
Hossfeld 2016	Yes	Yes	No	No	No	No	Yes	Yes
Kanani 2017	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleinman 2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kobayashi 2018	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Kornhall 2017	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kreinest 2016	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Kronick 2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kubica 2017	No	No	No	No	No	No	No	Yes
Lavonas 2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Leech 2016	No	Yes	No	No	No	No	Yes	Yes
Link 2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MacDonald 2006	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Manoguerra 2005	No	Yes	No	Yes	No	Yes	Yes	Yes
Mayglothling 2012	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Miller 2004	No	Yes	No	No	No	No	Yes	Yes
Millin 2013	Yes	Yes	No	No	No	Yes	Yes	Yes
Moss 2013	No	Yes	No	No	No	No	No	No
Neugebauer 2012	Yes	Yes	No	No	No	No	Yes	Yes
O'Connor 2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
O'Driscoll 2017	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Patterson 2018	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Powers 2018	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pre-Hospital Fibrinolysis 2004	No	Yes	No	No	No	No	Yes	Yes
Pride 2017	No	Yes	No	No	No	No	Yes	Yes
Quinn 2013	Yes	Yes	No	No	No	Yes	Yes	Yes
Rehn 2016	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Sanello 2018	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Sasser 2012	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

(*Continued*)

TABLE 4. (*Continued*).

Guideline	Systematically Developed Recommendations	By an Association or Similar	Systematic Review	Description of Search Strategy	Study Selection	Synthesis of Evidence	Summary of Evidence Synthesis	Assessment of Benefits/ Harms and Alternative Care Options
Savino 2015	Yes	Yes	No	No	No	Yes	Yes	Yes
Shah 2014	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Silverman 2017	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Singletary 2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Stanton 2017	No	Yes	No	No	No	No	No	Yes
Stroke Foundation 2017	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Strosberg 2016	No	No	No	No	No	No	No	Yes
Stuke 2011	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Theodore, Arabi 2013	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Theodore, Hadley 2013	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Thomas 2014	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Velopulos 2018	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wyckoff 2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Zafren 2014	Yes	Yes	No	No	No	Yes	Yes	Yes

GRADE covers a large majority of the items in AGREE II. Each of these guidelines scored in the top third of all guidelines identified for EMS medicine, providing support for continued use of the Model Process, which has been recommended by NEMSAC and FICEMS (2).

Assessment of the NAM/AHRQ criteria for clinical practice guidelines revealed a variety of deficiencies in the methodology or reporting of EMS guidelines. Only 38% of guidelines reported all elements comprising these criteria. The most common elements missing included the reportable elements of a systematic review, including description of search strategy, study selection, and synthesis of evidence. Providing a description of the search strategy ensures readers know the databases searched, search terms used, and the time period covered by the literature search. This facilitates the identification of potential gaps in the literature search and is critical for updating guidelines using consistent methodology. Another key element is a description of study selection, including the number of studies identified, included, and excluded, along with the criteria used. These items further aid the reproducibility of the results and identifies why certain literature may or may not have been considered when framing the recommendations. A detailed description of the selected studies, such as the use of evidence tables was also missing in many guidelines, though most included a descriptive summary of the literature. Detailed reporting of the key elements of studies is important to best understand the basis for recommendations contained in a guideline.

Limitations of this systematic review include the potential for recommendations for prehospital care embedded in other clinical guidelines that may have been missed. Many clinical guidelines that address the spectrum of emergency care across disciplines by disease process were included, but our literature search may not have been exhaustive of such recommendations. Appraisals of guidelines by the AGREE II tool and for the NAM criteria may have variability based on subjective assessments. We used multiple reviewers and averaged scores across AGREE II domain reviews, as well as a consensus approach in assessing the NAM/AHRQ criteria to mitigate subjective assessments.

CONCLUSIONS

This systematic review of evidence-based guidelines identifies existing recommendations for a variety of topics within EMS medicine. We identified a wide range of quality and important gaps in guideline methodology and reporting based on the AGREE II tool and the NAM/AHRQ criteria for clinical practice guidelines. Future guideline developers in EMS should consider these important methodological and reporting elements when creating new guidelines in this growing field of medicine.

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Supplementary Table 1. Search Terms of Systematic Review

#	Search
1	exp Emergency Medical Service Communication Systems/
2	Exp “Transportation of Patients”/
3	(pre-hospital or prehospital).ti,kw.
4	Emergency Medical Services/
5	emergency medical service*.ti,kw.
6	patient transport*.ti,kw.
7	(ems or emt).ti,kw.
8	Emergency Medical Technicians/
9	Emergency Medical Technician*.ti,kw.
10	exp Ambulances/
11	ambulance*.ti,kw.
12	emergency mobile unit*.ti,kw.
13	(air medical or air medicine).ti,kw.
14	(aeromedical or aeromedicine or aero-medical or aero-medicine) .ti,kw.
15	(paramedic* or para-medic*).ti,kw.
16	exp Patient Transfer/
17	((interhospital or inter-hospital or interfacility or inter-facility or intrafacility or intra-facility) adj3 (transfer or transport)).ti,kw.
18	transport* medicine.ti,kw.
19	emergency health service*.ti,kw.
20	out-of-hospital.ti,kw.
21	or/1-20
22	guideline*.ti,kw.
23	consensus.ti,kw.
24	recommendation*.ti,kw.
25	*consensus/
26	*Practice Guidelines as Topic/
27	22 or 23 or 24 or 25 or 26
28	21 or 27
29	limit 28 to english language
30	remove duplicates from 29

Supplementary Table 2. Evidence-Based Guidelines Mapped to the Core Content of EMS Medicine

AMERICAN BOARD OF EMERGENCY MEDICINE CORE CONTENT IN EMS MEDICINE	PUBLISHED EVIDENCE-BASED GUIDELINES
1.0 CLINICAL ASPECTS OF EMS MEDICINE	
1.1 Time / Life-Critical Conditions	
1.1.1 Cardiac Arrest	Atkins 2015 Brooks 2015 Brugger 2013 Callaway 2015 Ching 2017 de Caen 2015 Elsensohn 2006 Gordon 2015 Hock Ong 2013 Kleinman 2015 Lavonas 2015 Millin 2013 Wyckoff 2015 Zafren 2014
1.1.2 Airway Compromise / Respiratory Failure	Adelson 2003 Ahn 2011 Badjatia 2008 Berlac 2008 Hossfeld 2016 Kanani 2017 Mayglothling 2012 Moss 2013 O'Driscoll 2017 Rehn 2016
1.1.3 Hypotension and Shock	de Caen 2015 Kanani 2017 Neugebauer 2012 Singletary 2015
1.1.4 Altered Mental Status	Sanello 2018
1.2 Injury	
1.2.1 Trauma	Ahn 2011 Battaloglu 2017 British Trauma Society 2003 Bulger 2014 Cotton 2009 Chalkias 2009 Connor 2013 Ellerton 2009 Gausche-Hill 2014 Harmsen 2017 Kanani 2017

	Kornhall 2017 Kreinest 2016 Leech 2016 Millin 2013 Neugebauer 2012 Quinn 2013 Singletary 2015 Sasser 2012 Stanton 2017 Strosberg 2016 Stuke 2011 Theodore, Arabi 2013 Theodore, Hadley 2013 Thomas 2014 Velopulos 2018
1.2.2 Orthopedics	Battaloglu 2017 Ellerton 2009 Singletary 2015
1.2.3 Traumatic Brain Injuries	Adelson 2003 Badjatia 2008 Hebb 2007
1.2.4 Assault – Domestic / Sexual / Elder Abuse / Child Abuse	
1.2.5 Environmental	Belval 2018 Brugger 2013 Gordon 2015 MacDonald 2006 Zafren 2014
1.3 Medical Emergencies	
1.3.1 Respiratory	O'Driscoll 2017 Singletary 2015
1.3.2 Cardiovascular	Adams 2003 Atkins 2015 Bowles 2017 Ching 2017 Kubica 2017 O'Connor 2015 Pre-Hospital Fibrinolysis 2004 Savino 2015 Singletary 2015
1.3.3 Neurological	Boulanger 2018 Furyk 2017 Kobayashi 2018 Powers 2018 Pride 2017 Sanello 2018 Shah 2014 Silverman 2017

	Singletary 2015 Stroke Foundation 2017
1.3.4 Diabetic Emergencies	Singletary 2015
1.3.5 Renal	
1.3.6 Obstetric and Gynecologic Emergencies	Battaloglu 2017 Lavonas 2015
1.3.7 Poisoning / Toxicologic Emergencies	Singletary 2015 Manoguerra 2005
1.3.8 Dermatology	
1.3.9 Communicable Diseases	
1.3.10 Behavioral Emergencies	
1.4 Special Clinical Considerations	
1.4.1 Airway Management in Adverse Conditions	Brugger 2013 Zafren 2014
1.4.2 Procedures	Ahn 2011 Battaloglu 2017 Berlac 2008 British Trauma Society 2003 Brugger 2013 Chalkias 2009 Ching 2017 Connor 2013 Cotton 2009 de Caen 2015 Ellerton 2009 Hossfeld 2016 Kanani 2017 Kobayashi 2018 Kornhall 2017 Kreinest 2016 Leech 2016 Link 2015 Mayglothling 2012 Moss 2013 Neugebauer 2012 O'Connor 2015 Quinn 2013 Rehn 2016 Savino 2015 Stanton 2017 Stuke 2011 Theodore, Arabi 2013 Theodore, Hadley 2013 Velopulos 2018 Zafren 2014
1.4.3 Pain Assessment and Management in the Field	Gausche-Hill 2004 Kanani 2017

1.4.4 Flight Physiology	MacDonald 2006
1.4.5 Pediatrics	Adelson 2003 Atkins 2015 de Caen 2015 Furyk 2017 Hebb 2007 Miller 2004 Shah 2014 Wyckoff 2015
1.4.6 Geriatrics	
1.4.7 Bariatric Issues	
1.4.8 End-of-Life Issues	
1.4.9 Social Issues	
1.5 Special Considerations for Evaluation, Treatment, Transport, and Destinations	
1.5.1 Time-Life Critical Conditions	Lavonas 2015
1.5.2 Special Patient Populations	
2.0 MEDICAL OVERSIGHT OF EMS	
2.1 Medical Oversight	
2.1.1 Medical Oversight of EMS Systems	
2.1.2 Legal Issues	
2.2 EMS Systems	
2.2.1 Public Safety Answering Points	
2.2.2 Design of System Components	
2.2.3 Delivery Systems with Special Considerations	Thomas 2014
2.3 EMS Personnel	
2.3.1 Scope of Practice Models	
2.3.2 Education	Bhanji 2015 Miller 2004 Powers 2018
2.3.3 EMS Provider Health and Wellness	Patterson 2018
2.4 System Management	
2.4.1 System Finance	
2.4.2 Legislation and Government	
2.4.3 Public Health	
2.4.4 System Status Management	
3.0 QUALITY MANGEMENT AND RESEARCH	
3.1 Quality Improvement Principles and Programs	
3.1.1 Data Collection, Management, and Analysis	
3.1.2 Quality Improvement Programs	Kronick 2015
3.1.3 Evidence-based Practice	
3.2 Research	
3.2.1 Data Collection, Management, and Analysis	
3.2.2 Fundamental Knowledge of Biostatistics and Epidemiology	
3.2.3 EMS Research Design	
4.0 SPECIAL OPERATIONS	

4.1 Mass Casualty Management	
4.1.1 Incident Command System (ICS)	
4.1.2 Triage	
4.1.3 Patient Care in Mass Casualty Events / Scene Management	
4.2 Chemical / Biological / Radiological / Nuclear / Explosive (CBRNE)	
4.2.1 Toxic Exposure / Poisoning / Hazardous Materials (HAZMAT)	
4.2.2 Explosive Incidents	
4.2.3 Weapons of Mass Destruction and Related Injury	
4.3 Mass Gathering	
4.3.1 Planning and Operations	
4.3.2 Personnel Needs	
4.3.3 Training and Drills	
4.3.4 Design of Temporary Treatment Facilities	
4.3.5 Equipment	
4.3.6 Communications	
4.4 Disaster Management	
4.4.1 National Incident Management System (NIMS) & National Response Framework	
4.4.2 Catastrophic Events	
4.4.3 Health and Medical Resources	
4.4.4 Special Response Considerations	
4.5 EMS Operations	
4.5.1 Tactical	
4.5.2 Technical Rescue	
4.5.3 Wilderness EMS Systems	Brugger 2013 Ellerton 2009 Elsensohn 2006 Quinn 2013 Zafren 2014
4.5.4 Mobile Integrated Healthcare / Community Paramedicine	