



# Disaster Medicine in Taiwan

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This study aimed to examine scientific publications that were related to disaster medicine and were authored by emergency medicine physicians in Taiwan. This descriptive study utilized the electronic databases of PubMed, Scopus, and Web of Science. Academic works that were published between January 1, 1999, and December 31, 2018, were collected for review and analysis. Of the 53 articles included in the final analysis, 40 (75.5%) were original research, 3 (5.7%) were reviews, 1 (1.9%) was a brief report, and 9 (17.0%) were perspectives. The top 5 themes were disaster response systems (17, 32.1%), endemic diseases (11, 20.8%), emergency department (ED) overcrowding (10, 18.9%), earthquakes (10, 18.9%), and ED administration (9, 17.0%). Sixteen (30.2%) articles involved international collaborations. The median, interquartile range and range of the numbers of citations of the articles were 3, 1–11, and 0–65, respectively. Twenty-four (45.3%) articles were related to specific incidents: the Chi-Chi earthquake in 1999 (n = 5), the Singapore airline crash in 2000 (n = 1), Typhoon Nari in 2001 (n = 1), the outbreak of severe acute respiratory syndrome in 2003 (n = 7), Typhoon Morakot in 2009 (n = 1), the color party explosion in Formosa Fun Coast Park in 2015 (n = 4), and the Tainan earthquake in 2016 (n = 5). Regarding the study methods, 19 (35.8%) articles were quantitative studies; 10 (18.9%) were qualitative or semiquantitative studies; 8 (15.1%) used questionnaire surveys; 3 (5.7%) were literature reviews; 3 (5.7%) used computer simulations; and 10 (18.9%) were descriptive/narrative or other types of studies. Though the number of academic publications related to disaster medicine from the EDs in Taiwan is relatively limited, the quality and diversity of research seem promising. The research environment and education programs on disaster medicine in Taiwan deserve thoughtful consideration.

**Key words:** *disaster; disaster medicine, emergency medicine, Taiwan, review*

## Introduction

Disaster medicine stems from the coupling of disaster management and emergency medicine.<sup>1,2</sup> Enthusiasm and responsibility for the care of disaster victims have been borne by emergency medicine specialists throughout history. Disasters may result in varying injury and disease patterns. For example, typhoons can cause flood-related diseases and trauma from falling debris; earthquakes may cause entrapment and crush syndrome; and infectious disease outbreaks, either natural or intentional, can result

from many organisms. A prompt response to these disasters may require a comprehensive public health system and practical knowledge of injury and disease patterns. Providing care to the most victims possible, as dictated by the availability of resources, patients' conditions, and the likelihood of survival is one of the fundamental principles of disaster medicine.<sup>3</sup> Thus, disaster medicine also presents unique ethical situations that are rarely encountered in other areas of medicine.

Disaster medicine is a systems-oriented specialty. Because of the random nature of disasters, it is

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imperative for all practitioners in emergency health services to know about disaster medicine. Disaster medicine involves subject matter experts from various medical disciplines. Disaster medicine specialists are also required to be acquainted and interact with multiple responding jurisdictions and agencies. The evolution of a more formalized specialty of disaster medicine has enabled practitioners to participate in an overall disaster preparedness and response system.

Disaster medicine has become a distinct scientific discipline over only the past 50 years.<sup>1,4</sup> Emergency medicine has developed in Taiwan since the 1990s. The emergency medicine residency program in Taiwan was launched in 1991. The Taiwan Society of Emergency Medicine (TSEM) was founded in 1994, and the Emergency Medical Services Act was enacted in 1995. Thereafter, in 1998, emergency medicine was officially recognized as the 23rd medical specialty in Taiwan.<sup>5</sup> The importance of disaster medicine has emerged since the Chi-Chi earthquake in 1999, which was the deadliest disaster that had occurred in Taiwan in decades. The Disaster Prevention and Protection Act was enacted in 2000. In the same year, the Taiwan Society of Disaster Medicine (TSDM) was founded. In addition, the committee of disaster medicine in TSEM has been functioning since at least 2004.

The circumstances and challenges that disaster medicine specialists regularly confront mandate the continuous and vigorous pursuit of academic excellence in this young specialty. The *Annals of Disaster Medicine*, the official journal of the TSDM, was released biannually between 2002 and 2006. The TSEM inaugurated its official peer-reviewed journal, *Journal of Emergency Medicine, Taiwan*, in 1999, which was renamed *Journal of Taiwan Emergency Medicine* in 2003 and then *Journal of Acute Medicine* in 2011. The goals of conducting disaster research are to obtain evidence that can be used to decrease disaster risks and enhance the well-being and recovery of the affected population.<sup>6</sup> Academic publications may provide a dynamic perspective of the progress of medical specialties. This study aimed to examine scientific publications that were related to disaster medicine and were authored by emergency medicine physicians in Taiwan during the past two decades.

## Materials and Methods

### Study Design and Setting

This study was a retrospective, observational design analysis. Using a three-step procedure, scientific

articles on disaster medicine with authors affiliated with emergency departments (EDs) in Taiwan that were published in English between 1999 and 2018, were collected for review and analysis.

The initial step was to define the publication dates and author affiliations of the articles. A computerized search was conducted for peer-reviewed academic literature in three electronic databases: PubMed, Scopus, and Web of Science. Articles were included for initial review if they were (1) published in English, (2) published between January 1, 1999, and December 31, 2018, and (3) written by an author who was affiliated with departments of emergency medicine in Taiwan. For articles that were accepted for publication but were not formally published, the publication date was defined as the date of the first appearance online. This study excluded conference papers and posters.

The second step was to define the relevance of articles to disaster medicine. Entry terms related to disaster medicine were extracted using Medical Subject Heading (MeSH) terms and keywords. The MeSH terms and keywords used to define articles that were related to disaster medicine included “disasters,” “disaster victims,” “disaster medicine,” “disaster planning,” “safety management,” “cyclonic storms,” “earthquakes,” “mass casualty incidents,” “chemical hazard release,” “radioactive hazard release,” “terrorism,” “epidemics,” “pandemics,” “communicable diseases, emerging,” “ambulance diversion,” “surge capacity,” and “emergency department overcrowding.” Articles that fulfilled the first step criteria and the abovementioned MeSH terms and keywords were retrieved from the three databases and were imported into Endnote version X9 (Clarivate Analytics Inc., Philadelphia, PA, USA). Duplicate articles were removed from the list, and article abstracts were downloaded and reviewed individually by the investigator. Articles that were irrelevant to disaster medicine were subsequently excluded.

The final phase was a focused-author search. Affiliations of the first author and corresponding authors of the articles included in the previous step were reviewed for associations with EDs in Taiwan. These articles were further searched for other publications in PubMed, Scopus, and Web of Science during the study period. Abstracts of their publications were reviewed by the investigator, and articles related to disaster medicine were included in the final analysis.

Full texts of articles included in the final analysis were retrieved and then reviewed.

## Measurements

The measurements in this study included: (1) publication year, (2) article types, (3) affiliations, (4) an international collaboration, (5) relation to specific incidents, (6) themes, (7) the number of citations, (8) journal categories, and (9) main study methods.

The trend in disaster medicine research was evaluated by categorizing articles into four groups by publication year: from 1999 to 2003, from 2004 to 2008, from 2009 to 2013, and from 2014 to 2018.

International collaboration on an article was defined as the article having at least one international coauthor. There could be multiple disaster types or focused topics of an article, as judged by the investigator. The number of citations of an article was retrieved from the Web of Science Core Collection (mainly), Scopus, or PubMed. The journal categories were adopted from the 2017 *Journal Citation Reports (JCR)*, which was published online in 2018.

## Data Analysis

The data were analyzed using Excel version 15 (Microsoft Inc., Washington, DC, USA). Descriptive statistics summarizing the characteristics of the study subjects were performed, including the numbers and frequency distributions (percentages) of the categorical variables and the medians, interquartile ranges (IQRs), and ranges of the continuous variables.

## Ethical Considerations

This study qualified for a waiver from the review of the Institutional Review Board of the National Cheng Kung University Hospital, Taiwan.

## Results

### Article Selection

Article selection was conducted on January 1, 2019. The initial search led to the identification of 3,251 articles from PubMed, 5,437 from Scopus, and 5,192 from Web of Science that was affiliated with departments of emergency medicine in Taiwan during the study period. Among them, the MeSH terms and keywords search yielded 53 (1.6%) articles from PubMed, 74 (1.4%) from Scopus, and 86 (1.7%) from Web of Science that were relevant to disaster medicine. Duplicate articles were removed via Endnote. The investigator reviewed the abstracts of the remaining 104 articles and subsequently excluded

70 articles because of their irrelevance to disaster medicine. Thus, only 34 articles were included in the final step for a focused-author search. Among the 34 articles, only 21 articles had first or corresponding authors who were affiliated with EDs in Taiwan. The focused-author search found an additional 19 articles in the electronic databases that were related to disaster medicine. In total, 53 articles were included in the final analysis.

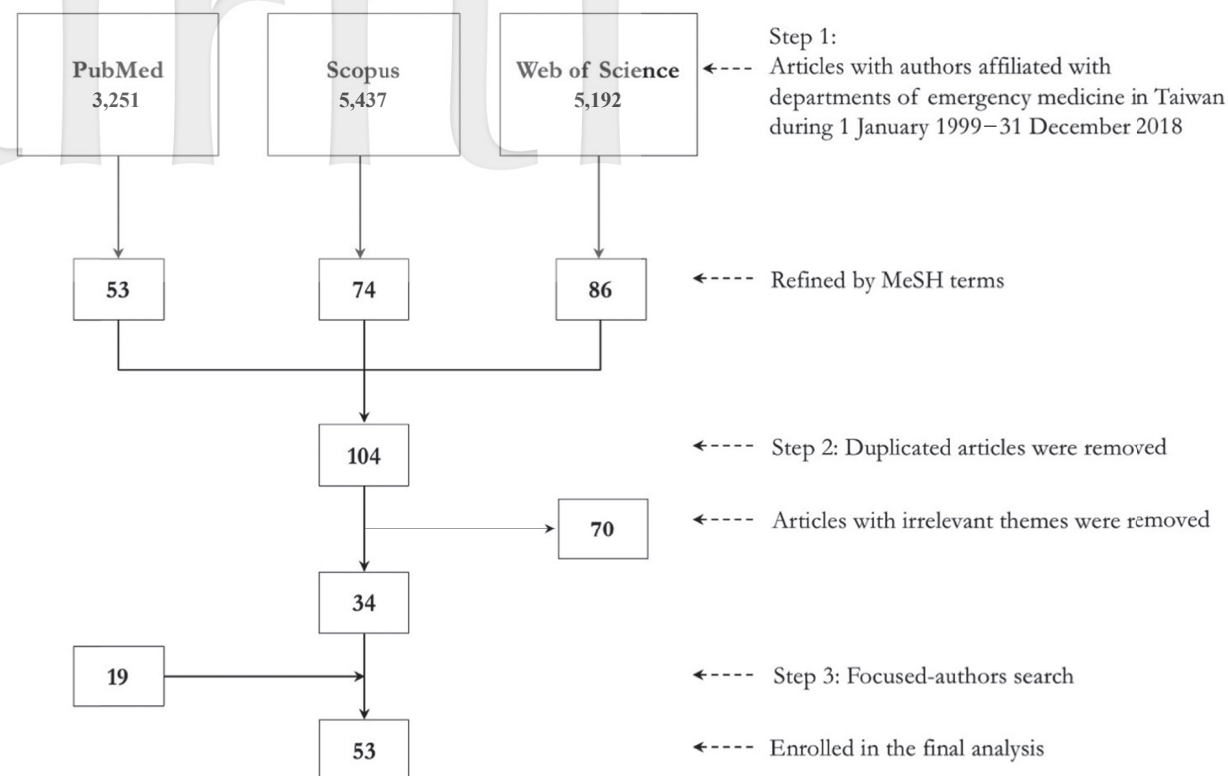
The overall flow chart of the article selection process for this study is depicted in Fig. 1.

### Publication Year

Among the 53 articles, 14 (26.4%) were published during 1999 and 2003. Shih et al. quantified the extent of ED overcrowding in Taiwan to identify possible solutions.<sup>7</sup> Chi et al. assessed the attitudes of emergency medical technicians toward tabletop drills to determine the effect of tabletop simulation on disaster preparedness and management.<sup>8</sup> Lee et al. designed a new training model of a local disaster medical system with tabletop exercises.<sup>9</sup> Tsai et al. discussed several issues related to terrorism.<sup>10-14</sup> Lee et al. reviewed the emergency medical preparedness and response for the Singapore airline crash in 2000.<sup>15</sup> Lai et al. discussed the strategies of disaster response in the healthcare system for Typhoon Nari in 2001.<sup>16</sup>

There were five articles related to the Chi-Chi earthquake in 1999. Wen et al. analyzed patients with chest injuries who were transferred to trauma centers.<sup>17</sup> Chen et al. evaluated the physician workforce and mobilization in an urban ED.<sup>18</sup> Liang et al. examined the mortality and morbidity associated with earthquakes.<sup>19</sup> Liao et al. determined the characteristics of psychological distress and its psychological predictors in rescue workers.<sup>20</sup> Hsu et al. determined whether medical assistance teams served a key role in assisting critically injured patients through the assessment of number and level of hospitals responding, training background, timeliness of response, and acuity of patient encounters.<sup>21</sup>

Twelve (22.6%) articles were published during 2004 and 2008. Several articles were extensively related to the outbreak of severe acute respiratory syndrome (SARS) in 2003. Chen et al. analyzed ED visits before and during the SARS epidemic.<sup>22</sup> Tsai et al. explained the implementation of the Hospital Emergency Incident Command System in a tertiary hospital.<sup>23,24</sup> Chen et al. evaluated patient characteristics in an urban ED during the outbreak of SARS.<sup>25</sup> Huang



**Fig. 1.** The overall flow chart of the article selection process.

et al. investigated the cost of ED visits in a designated SARS medical center.<sup>26</sup> Shih et al. described the challenges faced by hospital healthcare workers in using a syndrome-based surveillance system.<sup>27</sup>

Shih and Koenig discussed Taiwan's practices in managing surge needs.<sup>28</sup> Wu et al. described the challenges and steps in developing an ED-based syndromic surveillance system.<sup>29</sup> Yen and Shih elaborated the concept of transforming schools into predesigned alternative care sites for pandemic diseases.<sup>30</sup>

Five (9.4%) articles were published during 2009 and 2013. Lee et al. discussed the barriers to surge capacity of an overcrowded ED for a serious foodborne disease outbreak.<sup>31</sup> Liu et al. evaluated and classified the disaster response performance of hospitals.<sup>32</sup> Cheng et al. validated the ED occupancy rate against ambulance diversion status at an urban ED.<sup>33</sup> Lin et al. examined emergency healthcare demands across a series of tropical cyclones to build a predictive model to analyze a cyclone's potential effect.<sup>34</sup> Lin et al. evaluated the epidemiological characteristics of lower extremity cellulitis after Typhoon Morakot.<sup>35</sup>

Twenty-two (41.5%) articles were published from 2014 to 2018. Hsu and Huang evaluated the time

required for history taking through self-reporting of symptoms in food poisoning mass casualty incidents (MCIs).<sup>36</sup> Chen et al. assessed the service area of emergency medical services system after a disaster.<sup>37</sup> Lin et al. utilized a discrete event simulation model to evaluate the effectiveness of ambulance diversion in managing ED overcrowding in a single hospital or region.<sup>38,39</sup> Juang et al. used time series analysis in modeling and forecasting ED visits.<sup>40</sup> Lee et al. evaluated the effectiveness of high-turnover utility bed intervention in managing ED overcrowding.<sup>41</sup> Chiu et al. explored the association between clinical practice and ED overcrowding.<sup>42</sup> Hsu et al. conducted a quality improvement program to relieve ED overcrowding.<sup>43</sup> Yau et al. evaluated different practice models on ED patient flow.<sup>44</sup> Hsu et al. discussed strategies to prevent acute diarrhea and upper respiratory tract infection among disaster relief workers.<sup>45</sup> Hsu et al. developed a training program of public health crisis preparedness and disaster management for medical students.<sup>46</sup> Pan et al. discussed the significance of witness sensors for MCIs and epidemic outbreaks.<sup>47</sup>

Four articles were relevant to the color party explosion in Formosa Fun Coast Park in 2015. Chen

et al. examined the factors associated with ED length of stay.<sup>48</sup> Cheng et al. reported the challenges in burn care treatment and disaster preparedness in a single hospital.<sup>49</sup> Lin et al. described the insufficiency of the current field triage protocol in burn MCIs and encouraged the collaborative utilization of regional emergency medical services.<sup>50</sup> Ng et al. introduced a triage system in burn MCIs.<sup>51</sup>

Five articles addressed the 2016 Tainan earthquake. Lin et al. provided insights into the medical direction, occupational safety, and psychological health in disaster responses.<sup>52</sup> Ke et al. investigated the incidence and resilience of posttraumatic psychiatric disorders in healthcare providers.<sup>53</sup> Pan et al. explored the association of injury patterns and entrapment locations inside damaged buildings.<sup>54</sup> Wu et al. described respiratory symptoms among search and rescue workers in disasters and emphasized the importance of training programs regarding occupational health.<sup>55</sup> Chuang et al. used unmanned aerial vehicles and in-

ternet protocol cameras to reconstruct disaster scenes in 3-D during rescue operations in earthquakes.<sup>56</sup>

The full list of included articles is presented in Supplement Table 1.

### Article Types

Forty (75.5%) articles were original research, 3 (5.7%) were reviews, 1 (1.9%) was a brief report, and 9 (17.0%) were perspectives. An analysis of the included articles is summarized in Table 1.

### Affiliations

Among the 53 articles, the first authors of 33 (62.3%) articles and the corresponding authors of 31 (58.5%) articles were affiliated with EDs in Taiwan.

### International Collaboration

Among the 53 articles included, 16 (30.2%) involved international collaborations.

**Table 1.** Characteristics of the articles enrolled

Characteristic	1999–2003 n = 14 (%)	2004–2008 n = 12 (%)	2009–2013 n = 5 (%)	2014–2018 n = 22 (%)	All n = 53 (%)
<b>Article types</b>					
Original research	10 (71.4)	7 (58.3)	5 (100.0)	18 (81.2)	40 (75.5)
Review	2 (14.3)	1 (8.3)	0	0	3 (5.7)
Brief report	0	0	0	1 (4.5)	1 (1.9)
Perspective	2 (14.3)	4 (33.3)	0	3 (13.6)	9 (17.0)
<b>Affiliated with emergency departments in Taiwan</b>					
First authors	8 (57.1)	7 (58.3)	4 (80.0)	14 (63.6)	33 (62.3)
Corresponding authors	8 (57.1)	5 (41.7)	3 (60.0)	15 (68.2)	31 (58.5)
International collaboration	5 (35.7)	8 (66.7)	0	3 (13.6)	16 (30.2)
<b>Specific incidents</b>					
1999 Chi-Chi earthquake	5 (35.7)	0	0	0	5 (9.4)
2000 Singapore airline crash	1 (7.1)	0	0	0	1 (1.9)
2001 Typhoon Nari	1 (7.1)	0	0	0	1 (1.9)
2003 severe acute respiratory syndrome	0	6 (50.0)	0	1 (4.5)	7 (13.2)
2009 Typhoon Morakot	0	0	1 (20.0)	0	1 (1.9)
2015 color party explosion	0	0	0	4 (18.2)	4 (7.5)
2016 Tainan earthquake	0	0	0	5 (22.7)	5 (9.4)
<b>Numbers of being cited</b>					
Median	11	6	2	2	3
Interquartile range	4–16	3–12	1–4	0–3	1–11
Range	0–65	2–40	0–4	0–13	0–65
Articles that are cited at least once	13 (92.9)	12 (100.0)	4 (80.0)	7 (31.8)	36 (67.9)



## Specific Incidents

Twenty-four (45.3%) articles were primarily related to specific incidents. Among them, 5 (20.8%) articles were related to the Chi-Chi earthquake in 1999, 1 (4.2%) was related to the Singapore airline crash in 2000, 1 (4.2%) was related to Typhoon Nari in 2001, 7 (29.2%) were regarding the outbreak of SARS in 2003, 1 (4.2%) was related to Typhoon Morakot in 2009, 4 (16.7%) were regarding the color party explosion in Formosa Fun Coast Park in 2015, and 5 (20.8%) were regarding the Tainan earthquake in 2016.

## Number of Citations

The number of articles cited was retrieved on January 1, 2019. The median, IQR, and range of numbers of citations of the articles were 3, 1–11, and 0–65, respectively. The article entitled “ED overcrowding in Taiwan: facts and strategies” is the most cited literature in this study.<sup>7</sup>

## Themes

Table 2 summarizes the themes of the included articles. The top 5 themes were disaster response system (17, 32.1%), endemic diseases (11, 20.8%), ED overcrowding (10, 18.9%), earthquakes (10, 18.9%), and ED administration (9, 17.0%).

## Journal Categories

Four (7.5%) articles were published in journals that were not listed in the JCR. The remaining 49 articles were in nine different JCR categories. The articles were published in two categories of journals between 1998 and 2002, in three categories between 2003 and 2007, in three categories between 2008 and 2012, and eight categories between 2013 and 2018. The top three journal categories of the articles were emergency medicine (28, 52.8%), medicine, general and internal (8, 15.1%), and public, environmental, and occupational health (6, 11.3%). Table 3 lists the journal categories of the included articles.

**Table 2.** Themes of the articles enrolled

Theme	1999–2003 n = 14 (%)	2004–2008 n = 12 (%)	2009–2013 n = 5 (%)	2014–2018 n = 22 (%)	All n = 53 (%)
Emergency department overcrowding	1 (7.1)	0	2 (40.0)	7 (31.8)	10 (18.9)
Earthquake	5 (35.7)	0	0	5 (22.7)	10 (18.9)
Endemic disease	0	9 (75.0)	1 (20.0)	1 (4.5)	11 (20.8)
Mass casualty incident	3 (21.4)	0	1 (20.0)	4 (18.2)	8 (15.1)
Explosion/burn	2 (14.3)	1 (8.3)	0	4 (18.2)	7 (13.2)
Terrorism	4 (28.6)	2 (16.7)	0	0	6 (11.3)
Typhoon/flood	1 (7.1)	0	2 (40.0)	0	3 (5.7)
Traffic accidents	1 (7.1)	0	0	0	1 (1.9)
Emergency department administration	1 (7.1)	5 (25.0)	1 (20.0)	2 (9.1)	9 (17.0)
Public health	1 (7.1)	3 (25.0)	1 (20.0)	1 (4.5)	6 (11.3)
Incident command system	0	3 (25.0)	0	0	3 (5.7)
Triage	0	0	0	2 (9.1)	2 (3.8)
Trauma	1 (7.1)	0	0	1 (4.5)	2 (3.8)
Psychologic concerns	1 (7.1)	0	0	2 (9.1)	3 (5.7)
Education	2 (14.3)	0	0	1 (4.5)	3 (5.7)
Disaster exercise	2 (14.3)	0	0	0	2 (3.8)
Surveillance system	0	2 (16.7)	0	0	2 (3.8)
Information system	0	1 (8.3)	0	1 (4.5)	2 (3.8)
Occupational health	0	0	0	3 (13.6)	3 (5.7)
Disaster response system	5 (35.7)	3 (25.0)	2 (40.0)	7 (31.8)	17 (32.1)
Technology	0	0	0	1 (4.5)	1 (1.9)

## Study Methods

Nineteen (35.8%) articles were quantitative studies, 10 (18.9%) were qualitative or semiquantitative studies, 8 (15.1%) used questionnaire surveys; 3 (5.7%) were literature reviews, 3 (5.7%) used computer simulation, and 10 (18.9%) were descriptive/narrative or other types of studies. Table 4 presents the main study methods of the included articles.

## Discussion

The results of this study revealed that academic publications on disaster medicine from EDs in Taiwan were minimal. Only 53 articles were included in the final analysis, indicating that during the past 20 years, approximately 1% of articles from EDs in Taiwan focused on disaster medicine. This finding may deserve further exploration of the research environment and educational programs on disaster medicine in Taiwan.

A systemic review of the disaster literature from 1947 through 2017 found 9,433 related articles published in 918 multidisciplinary journals.<sup>60</sup> Although academic articles on disaster medicine from the EDs in Taiwan were limited in number, the increasing diversity of the journal categories of the articles through the publication years was observed. During 1999 and 2008, the articles were mainly published in journals that were mainly related to emergency medicine; however, the articles published from 2009 to 2018 were more likely to have been published in journals of other categories. This change may imply that researchers in Taiwan are gradually becoming more involved in different aspects of disaster medicine, thus enriching the research content.

The previous studies revealed that the published articles for emergency planning were heavily dominated by anecdotal and descriptive reports on specific disasters (up to 74%).<sup>60,61</sup> Nearly half of the articles

**Table 3.** Journal categories of the articles enrolled

Journal category	1999–2003 n = 14 (%)	2004–2008 n = 12 (%)	2009–2013 n = 5 (%)	2014–2018 n = 22 (%)	All n = 53 (%)
Emergency medicine	12 (85.7)	7 (58.3)	2 (40.0)	7 (31.8)	28 (52.8)
Medicine, general and internal	1 (7.1)	2 (16.7)	0	5 (22.7)	8 (15.1)
Public, environmental, and occupational health	0	3 (25.0)	0	3 (13.6)	6 (11.3)
Multidisciplinary sciences	0	0	1 (20.0)	1 (4.5)	2 (3.8)
Statistics and probability	0	0	1 (20.0)	0	1 (1.9)
Materials science, characterization and testing	0	0	0	1 (4.5)	1 (1.9)
Surgery	0	0	0	1 (4.5)	1 (1.9)
Medicine, research and experimental	0	0	0	1 (4.5)	1 (1.9)
Medical informatics	0	0	0	1 (4.5)	1 (1.9)
Not listed	1 (7.1)	0	1 (20.0)	2 (9.1)	4 (7.5)

**Table 4.** Main study methods of the articles enrolled

Study method	1999–2003 n = 14 (%)	2004–2008 n = 12 (%)	2009–2013 n = 5 (%)	2014–2018 n = 22 (%)	All n = 53 (%)
Quantitative study	3 (21.4)	5 (41.7)	4 (80.0)	7 (31.8)	19 (35.8)
Qualitative or semi-qualitative study	3 (21.4)	1 (8.3)	1 (20.0)	5 (22.7)	10 (18.9)
Questionnaire survey	3 (21.4)	2 (16.7)	0	3 (13.6)	8 (15.1)
Literature review	2 (14.3)	1 (8.3)	0	0	3 (5.7)
Computer simulation	0	0	0	3 (13.6)	3 (5.7)
Descriptive/narrative or others	3 (21.4)	3 (25.0)	0	4 (18.2)	10 (18.9)

(45.3%) enrolled in this study were related to specific disasters in Taiwan; however, only 18.9% of articles primarily used descriptive or narrative methods. This could be because of the language factor since only English language journals were included in this study.

High-level evidence within the existing disaster management literature was quite scarce.<sup>60,62</sup> Although 77.4% of articles enrolled in this study were original research, none of them utilized a prospective, controlled study design. The unpredictable and uncontrolled nature of disaster renders conducting high-quality research difficult. Since controllable real-world scenarios through which to study disaster management are generally unavailable, the development of an evidence-based approach to support practices, performance measures, and standards for disasters could be challenging. The traditional hierarchy of evidence applied to clinical research is not necessarily applicable in the field of disaster medicine research.<sup>60</sup> Developing novel data sources and measures based on small-scale, frequent events or controllable educational programs and exercises could be a feasible alternative for translating research into practice.<sup>63-65</sup>

The numbers of articles cited by other articles may reflect the impact of research in an academic field. Nearly 70% of the articles included in this study were cited by other articles at the time of this study. Therefore, the quality of disaster medicine research in Taiwan seems promising. International collaborations account for 30.2% of current studies is noteworthy and can help facilitate the ability to construct, scrutinize, debate, and share opinions and experience, which is essential for academic and scientific advancement. International partnerships among academic organizations could be encouraged for further research collaborations.

Many articles in *Journal of Acute Medicine and Annals of Disaster Medicine* were not included in PubMed, Scopus, or Web of Science electronic databases and therefore were not included in this study. Notably, of the 89 original articles that were published in the *Journal of Acute Medicine* during 2011 and 2018, only one (1.1%) was relevant primarily to disaster medicine. *Annals of Disaster Medicine* is aimed at presenting academic literature on disaster medicine. The contents in *Annals of Disaster Medicine* deserve a further survey, and interested readers may find extensive information through the online resources of the TSDM.

The lack of standards for collecting and reporting

data could be a significant challenge in research studies on disaster medical management.<sup>63,66</sup> Standardized reporting of data related to disaster medical response could facilitate the interpretation of results, comparisons between emergency response systems, and quality improvement in the medical management.<sup>66,67</sup> The Task Force on Quality Control of Disaster Management of World Association for Disaster and Emergency Medicine published guidelines in 2003 for evaluation and research on health disaster management.<sup>68</sup> The Utstein-style template for uniform data reporting of acute medical response in disasters was proposed by Emergency Management and Disaster Medicine Academy in 2012.<sup>65</sup> The template, including 15 data elements with indicators, might enable better completion of reports on emergency management and the provision of further scientific evidence.<sup>65</sup> The frameworks for disaster research and evaluation were also developed in 2014 to organize the information and research of the health aspects of disasters.<sup>6</sup> The investigators on disaster medicine may utilize these templates and frameworks in future studies.

## Limitations

This study has several limitations. First, this study focused on peer-reviewed, English language literature, and thus, was unable to include academic contributions that were published in Chinese or other languages. Language could be an important barrier for local researchers to publish the findings of their studies. Publications in Chinese could be tailored to local needs and more understandable for local readers, and hence might be more likely to generate a direct and responsive impact, especially on local systems. Although English language literature might have more readers internationally and enhance academic collaborations, articles that are published in Chinese or local journals are valuable and should be reviewed thoughtfully. Second, articles that were not included in the PubMed, Scopus, or Web of Science electronic databases were not enrolled in this study. Third, to describe the historical trend of academic performance on disaster medicine, the articles that were included in this study were divided into four groups by their publication years. Since the articles covered only 20 years, the grouping method used in this study could be too arbitrary to provide a sophisticated analysis of overall performance. A genealogical method or a dynastic method could be considered to appraise the



historical evolution of the disaster medicine literature for more extended periods, and more publication material could be covered in the review process. Finally, the involvement of multidisciplinary domains and expertise in disaster medicine makes a comprehensive search for related articles methodologically challenging. To overcome the obstacles, the research protocol in this study involved a three-step process, including a MeSH terms/keywords search and a focused-author search, to find relevant articles as comprehensively as possible.

## Conclusions

Though the number of academic publications related to disaster medicine from EDs in Taiwan is relatively limited, the quality and diversity of research seem promising. The research environment and education programs on disaster medicine in Taiwan deserve thoughtful consideration.

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**Supplement Table 1.** The full list of the articles enrolled in this study

Publication year	Journal	Journal category	Title	Authors	First author (affiliated with emergency departments in Taiwan)	Corresponding author (affiliated with emergency departments in Taiwan)	Article type	Disaster types or focused topics	International collaboration	Numbers of being cited
1999	<i>American Journal of Emergency Medicine</i>	Emergency medicine	ED overcrowding in Taiwan: facts and strategies <sup>7</sup>	Shih FY et al.	Yes	Yes	Original research	Emergency department overcrowding; disaster response system	No	65
2000	<i>American Journal of Emergency Medicine</i>	Emergency medicine	Chest injuries transferred to trauma centers after the 1999 Taiwan earthquake <sup>17</sup>	Wen YS et al.	Yes	Yes	Original research	Chi-Chi earthquake (1999); earthquake; trauma; mass casualty incident	No	4
2001	<i>American Journal of Emergency Medicine</i>	Emergency medicine	Emergency medical technicians' disaster training by tabletop exercise <sup>8</sup>	Chi CH et al.	Yes	Yes	Original research	disaster exercise; education	No	16
2001	<i>Annals of Emergency Medicine</i>	Emergency medicine	Were there enough physicians in an emergency department in the affected area after a major earthquake? an analysis of the Taiwan Chi-Chi earthquake in 1999 <sup>18</sup>	Chen WK et al.	Yes	Yes	Original research	Chi-Chi earthquake (1999); earthquake; emergency department administration	No	16

Publication year	Journal	Journal category	Title	Authors	First author (affiliated with emergency departments in Taiwan)	Corresponding author (affiliated with emergency departments in Taiwan)	Article type	Disaster types or focused topics	International collaboration	Numbers of being cited
2001	<i>Annals of Emergency Medicine</i>	Emergency medicine	Disaster epidemiology and medical response in the Chi-Chi earthquake in Taiwan <sup>19</sup>	Liang NJ et al.	No	No	Original research	Chi-Chi earthquake (1999); earthquake; public health; disaster response system	No	48
2002	<i>Academic Emergency Medicine</i>	Emergency medicine	Emergency medical preparedness and response to a Singapore airline crash <sup>15</sup>	Lee WH et al.	Yes	Yes	Original research	Singapore airline crash (2000); traffic accident; disaster response system	No	16
2002	<i>Journal of the Formosan Medical Association</i>	Medicine, general and internal	Association of psychological distress with psychological factors in rescue workers within two months after a major earthquake <sup>20</sup>	Liao SC et al.	No	No	Original research	Chi-Chi earthquake (1999); earthquake; psychologic concerns	No	39
2002	<i>Prehospital and Disaster Medicine</i>	Emergency medicine	Emergency medical assistance team response following Taiwan Chi-Chi earthquake <sup>21</sup>	Hsu EB et al.	No	No	Original research	Chi-Chi earthquake (1999); earthquake; disaster response system	Yes	3



Publication year	Journal	Journal category	Title	Authors	First author (affiliated with emergency departments in Taiwan)	Corresponding author (affiliated with emergency departments in Taiwan)	Article type	Disaster types or focused topics	International collaboration	Numbers of being cited
2003	<i>Academic Emergency Medicine</i>	Emergency medicine	Strategies of disaster response in the health care system for tropical cyclones: experience following Typhoon Nair in Taipei City <sup>16</sup>	Lai TI et al.	Yes	Yes	Perspective	Typhoon Nari (2001); typhoon; disaster response system	No	11
2003	<i>Chang Gung Medical Journal</i>	Not listed	Designation of a new training model of a local disaster medical system with tabletop exercises <sup>9</sup>	Lee WH et al.	Yes	Yes	Original research	Disaster exercise; education	No	1
2003	<i>Prehospital and Disaster Medicine</i>	Emergency medicine	Terrorism in Taiwan, Republic of China <sup>10</sup>	Tsai MC et al.	Yes	Yes	Perspective	Terrorism	Yes	0
2003	<i>Prehospital and Disaster Medicine</i>	Emergency medicine	A proposed universal medical and public health definition of terrorism <sup>11</sup>	Arnold JL et al.	No	No	Original research	Terrorism	Yes	5

Publication year	Journal	Journal category	Title	Authors	First author (affiliated with emergency departments in Taiwan)	Corresponding author (affiliated with emergency departments in Taiwan)	Article type	Disaster types or focused topics	International collaboration	Numbers of being cited
2003	<i>Prehospital and Disaster Medicine</i>	Emergency medicine	Mass-casualty, terrorist bombings: epidemiological outcomes, resource utilization, and time course of emergency needs (part I) <sup>12</sup>	Arnold JL et al.	No	No	Review	Terrorism; explosion; mass casualty incident	Yes	11
2003	<i>Prehospital and Disaster Medicine</i>	Emergency medicine	Mass-casualty, terrorist bombings: implications for emergency department and hospital emergency response (part II) <sup>14</sup>	Halpern P et al.	No	No	Review	Terrorism; explosion; mass casualty incident	Yes	10
2004	<i>Emergency Medicine Journal</i>	Emergency medicine	Impact of a severe acute respiratory syndrome outbreak in the emergency department: an experience in Taiwan <sup>22</sup>	Chen TA et al.	Yes	Yes	Original research	Severe acute respiratory syndrome (2003); endemic disease; emergency department administration	No	3

Publication year	Journal	Journal category	Title	Authors	First author (affiliated with emergency departments in Taiwan)	Corresponding author (affiliated with emergency departments in Taiwan)	Article type	Disaster types or focused topics	International collaboration	Numbers of being cited
2004	<i>Emergency Medicine Journal</i>	Emergency medicine	Impact of an outbreak of severe acute respiratory syndrome on a hospital in Taiwan, ROC <sup>23</sup>	Tsai MC et al.	Yes	Yes	Original research	Severe acute respiratory syndrome (2003); endemic disease; emergency department administration	Yes	13
2004	<i>Annals of Emergency Medicine</i>	Emergency medicine	Mass casualty terrorist bombings: a comparison of outcomes by bombing type <sup>13</sup>	Arnold JL et al.	No	No	Review	terrorism; explosion; public health	Yes	11
2004	<i>Prehospital and Disaster Medicine</i>	Emergency medicine	Information-sharing in out-of-hospital disaster response: the future role of information technology <sup>57</sup>	Arnold JL et al.	No	No	Perspective	Disaster response system; information system	Yes	4
2005	<i>Medical Care</i>	Public, environmental, and occupational health	The impact of the SARS outbreak on an urban emergency department in Taiwan <sup>25</sup>	Chen WK et al.	Yes	Yes	Original research	Severe acute respiratory syndrome (2003); endemic disease; emergency department administration	No	13

Publication year	Journal	Journal category	Title	Authors	First author (affiliated with emergency departments in Taiwan)	Corresponding author (affiliated with emergency departments in Taiwan)	Article type	Disaster types or focused topics	International collaboration	Numbers of being cited
2005	<i>The Journal of Emergency Medicine</i>	Emergency medicine	Implementation of the Hospital Emergency Incident Command System during an outbreak of severe acute respiratory syndrome (SARS) at a hospital in Taiwan, ROC <sup>24</sup>	Tsai MC et al.	Yes	Yes	Original research	Severe acute respiratory syndrome (2003), endemic disease; incident command system	Yes	10
2005	<i>Prehospital and Disaster Medicine</i>	Emergency medicine	Recommended modifications and applications of the Hospital Emergency Incident Command System for hospital emergency management <sup>88</sup>	Arnold JL et al.	No	No	Perspective	Incident command system	Yes	3

Publication year	Journal	Journal category	Title	Authors	First author (affiliated with emergency departments in Taiwan)	Corresponding author (affiliated with emergency departments in Taiwan)	Article type	Disaster types or focused topics	International collaboration	Numbers of being cited
2006	<i>Journal of the Formosan Medical Association</i>	Medicine, general and internal	Declining emergency department visits and costs during the severe acute respiratory syndrome (SARS) outbreak <sup>26</sup>	Huang HH et al.	Yes	Yes	Original research	Severe acute respiratory syndrome (2003); endemic disease; emergency department administration	No	6
2006	<i>Academic Emergency Medicine</i>	Emergency medicine	Improving surge capacity for biothreats: experience from Taiwan <sup>28</sup>	Shih FY et al.	Yes	No	Perspective	Endemic disease; terrorism; disaster response system	Yes	6
2007	<i>Infection Control and Hospital Epidemiology</i>	Public, environmental, and occupational health; infectious diseases	Challenges faced by hospital healthcare workers in using a syndrome-based surveillance system during the 2003 outbreak of severe acute respiratory syndrome in Taiwan <sup>27</sup>	Shih FY et al.	Yes	No	Original research	Severe acute respiratory syndrome (2003); endemic disease; surveillance system	Yes	3



Publication year	Journal	Journal category	Title	Authors	First author (affiliated with emergency departments in Taiwan)	Corresponding author (affiliated with emergency departments in Taiwan)	Article type	Disaster types or focused topics	International collaboration	Numbers of being cited
2008	<i>BMC Public Health</i>	Public, environmental, and occupational health	Establishing a nationwide emergency department-based syndromic surveillance system for better public health responses in Taiwan <sup>29</sup>	Wu TS et al.	No	No	Original research	Endemic diseases; emergency department administration; public health; surveillance system	Yes	40
2008	<i>Journal of the Formosan Medical Association</i>	Medicine, general and internal	Transforming schools into pre-designed alternative care sites as part of preparedness plan for pandemic H5N1 influenza <sup>30</sup>	Yen MY et al.	No	No	Perspective	Endemic diseases; disaster response system; public health	No	2
2010	<i>Emergency Medicine Journal</i>	Emergency medicine	Barriers to surge capacity of an overcrowded emergency department for a serious foodborne disease outbreak <sup>31</sup>	Lee WH et al.	Yes	Yes	Original research	Endemic disease; Mass casualty incident; emergency department overcrowding	No	2

Publication year	Journal	Journal category	Title	Authors	First author (affiliated with emergency departments in Taiwan)	Corresponding author (affiliated with emergency departments in Taiwan)	Article type	Disaster types or focused topics	International collaboration	Numbers of being cited
2011	<i>Quality &amp; Quantity</i>	Statistics and probability	The disaster response performance of hospitals in Taiwan: evaluation and classification <sup>32</sup>	Liu FHF. et al.	No	No	Original research	Disaster response system	No	1
2012	<i>Journal of Acute Medicine</i>	Not listed	Using ambulance diversion status to validate occupancy rate at an academic emergency department in Taipei, Taiwan <sup>33</sup>	Cheng P. et al.	Yes	Yes	Original research	Emergency department overcrowding; disaster response system	No	0
2013	<i>The Journal of Emergency Medicine</i>	Emergency medicine	The effect of tropical cyclones (typhoons) on emergency department visits <sup>34</sup>	Lin CH et al.	Yes	No	Original research	Typhoon; emergency department administration	No	4
2013	<i>PLOS One</i>	Multidisciplinary sciences	Epidemiological characteristics of lower extremity cellulitis after a typhoon flood <sup>35</sup>	Lin PC et al.	Yes	Yes	Original research	Typhoon Morakot (2009); typhoon; public health	No	4

Publication year	Journal	Journal category	Title	Authors	First author (affiliated with emergency departments in Taiwan)	Corresponding author (affiliated with emergency departments in Taiwan)	Article type	Disaster types or focused topics	International collaboration	Numbers of being cited
2014	<i>Prehospital and Disaster Medicine</i>	Emergency medicine	Does self-reporting facilitate history taking in food poisoning mass-casualty incidents? <sup>36</sup>	Hsu YI et al.	Yes	Yes	Original research	Mass casualty incident; emergency department administration	No	0
2015	<i>Journal of Testing and Evaluation</i>	Materials science, characterization and testing	Ambulance service area considering disaster-induced disturbance on the transportation infrastructure <sup>37</sup>	Chen AY et al.	No	No	Original research	Disaster response system	No	2
2015	<i>Journal of the Formosan Medical Association</i>	Medicine, general and internal	Managing emergency department overcrowding via ambulance diversion: a discrete event simulation model <sup>38</sup>	Lin CH et al.	Yes	No	Original research	Emergency department overcrowding	No	11

Publication year	Journal	Journal category	Title	Authors	First author (affiliated with emergency departments in Taiwan)	Corresponding author (affiliated with emergency departments in Taiwan)	Article type	Disaster types or focused topics	International collaboration	Numbers of being cited
2015	<i>PLOS One</i>	Multidisciplinary sciences	The impact of ambulance and patient diversion on crowdedness of multiple emergency departments in a region <sup>39</sup>	Kao CY et al.	No	Yes	Original research	Emergency department overcrowding	No	2
2015	<i>Disaster Medicine and Public Health Preparedness</i>	Public, environmental, and occupational health	Is there a case for quarantine? perspectives from SARS to Ebola <sup>59</sup>	Barbisch D et al.	No	No	Perspective	Severe acute respiratory syndrome (2003); Endemic disease; disaster response system	Yes	13
2016	<i>American Journal of Emergency Medicine</i>	Emergency medicine	Factors associated with ED length of stay during a mass casualty incident <sup>48</sup>	Chen SY et al.	Yes	Yes	Original research	Color party explosion (2015); explosion; emergency department administration	No	3

Publication year	Journal	Journal category	Title	Authors	First author (affiliated with emergency departments in Taiwan)	Corresponding author (affiliated with emergency departments in Taiwan)	Article type	Disaster types or focused topics	International collaboration	Numbers of being cited
2016	<i>Plastic and Reconstructive Surgery</i>	Surgery	Management of the Formosa Color dust Explosion: lessons learned from the treatment of 49 mass burn casualty patients at Chang Gung Memorial Hospital <sup>49</sup>	Cheng MH et al.	No	No	Original research	Color party explosion (2015); explosion; disaster response system; public health	No	10
2016	<i>Lancet</i>	Medicine, general and internal	Medical response to 2016 earthquake in Taiwan <sup>52</sup>	Lin CH et al.	Yes	Yes	Perspective	Tainan earthquake (2016); earthquake; disaster response system; occupational health; psychologic concerns	No	3



Publication year	Journal	Journal category	Title	Authors	First author (affiliated with emergency departments in Taiwan)	Corresponding author (affiliated with emergency departments in Taiwan)	Article type	Disaster types or focused topics	International collaboration	Numbers of being cited
2017	<i>BMJ Open</i>	Medicine, general and internal	Application of time series analysis in modelling and forecasting emergency department visits in a medical centre in Southern Taiwan <sup>40</sup>	Juang WC et al.	Yes	No	Original research	Emergency department overcrowding	No	0
2017	<i>Biomed Research International</i>	Medicine, research and experimental	Posttraumatic psychiatric disorders and resilience in healthcare providers following a disastrous earthquake: an interventional study in Taiwan <sup>53</sup>	Ke YT et al.	No	Yes	Original research	Tainan earthquake (2016); earthquake; psychologic concerns	No	0
2017	<i>Journal of Acute Medicine</i>	Not listed	Strategies to prevent acute diarrhea and upper respiratory tract infection among disaster relief workers <sup>45</sup>	Hsu IL et al.	Yes	Yes	Original research	Occupational health	No	0

Publication year	Journal	Journal category	Title	Authors	First author (affiliated with emergency departments in Taiwan)	Corresponding author (affiliated with emergency departments in Taiwan)	Article type	Disaster types or focused topics	International collaboration	Numbers of being cited
2017	<i>Journal of the Chinese Medical Association</i>	Medicine, general and internal	A new strategy for emergency department crowding: high-turnover utility bed intervention <sup>41</sup>	Lee IH et al.	Yes	Yes	Original research	Emergency department overcrowding; disaster response system	No	3
2018	<i>American Journal of Emergency Medicine</i>	Emergency medicine	The influence of crowding on clinical practice in the emergency department <sup>42</sup>	Chiu IM et al.	Yes	Yes	Original research	Emergency department overcrowding; disaster response system	No	2
2018	<i>Journal of Medical Education</i>	Not listed	Development of a public health crisis preparedness and disaster management training program for medical students <sup>46</sup>	Hsu HC et al.	Yes	Yes	Original research	Education	No	0
2018	<i>Journal of the Formosan Medical Association</i>	Medicine, general and internal	Emergency department overcrowding: quality improvement in a Taiwan Medical Center <sup>43</sup>	Hsu CM et al.	Yes	Yes	Original research	Emergency department overcrowding	No	0

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2018	<i>Journal of Medical Internet Research</i>	Medical informatics	The significance of witness sensors for mass casualty incidents and epidemic outbreaks <sup>47</sup>	Pan CL et al.	No	No	Perspective	Mass casualty incident; Information system	No	0
2018	<i>American Journal of Emergency Medicine</i>	Emergency medicine	Can different physicians providing urgent and non-urgent treatment improve patient flow in emergency department? <sup>44</sup>	Yau FF et al.	Yes	Yes	Original research	Emergency department overcrowding	No	0
2018	<i>Journal of the Formosan Medical Association</i>	Medicine, general and internal	Association of injury pattern and entrapment location inside damaged buildings in the 2016 Taiwan earthquake <sup>54</sup>	Pan ST et al.	Yes	Yes	Original research	Tainan earthquake (2016); earthquake; trauma	Yes	0
2018	<i>Occupational and Environmental Health</i>	Public, environmental, and occupational health	Respiratory symptoms among search and rescue workers who responded to the 2016 Taiwan earthquake <sup>55</sup>	Wu CL et al.	No	Yes	Original research	Tainan earthquake (2016); earthquake; occupational health	Yes	0

Publication year	Journal	Journal category	Title	Authors	First author (affiliated with emergency departments in Taiwan)	Corresponding author (affiliated with emergency departments in Taiwan)	Article type	Disaster types or focused topics	International collaboration	Numbers of being cited
2018	<i>Prehospital Emergency Care</i>	Emergency medicine	Challenges of burn mass casualty incidents in the prehospital setting: lessons from the Formosa Fun Coast Park color party <sup>50</sup>	Lin CH et al.	Yes	Yes	Brief report	Color party explosion (2015); explosion; triage; disaster response system; mass casualty incident	No	0
2018	<i>Prehospital Emergency Care</i>	Emergency medicine	Combining unmanned aerial vehicles, and internet protocol cameras to reconstruct 3-D disaster scenes during rescue operations <sup>56</sup>	Chuang CC et al.	Yes	Yes	Original research	Tainan earthquake (2016); technology	No	0
2018	<i>World Journal of Emergency Surgery</i>	Emergency medicine	Introduction of a mass burn casualty triage system in a hospital during a powder explosion disaster: a retrospective cohort study <sup>51</sup>	Ng CJ et al.	Yes	Yes	Original research	Color party explosion (2015); explosion; triage; mass casualty incident	Yes	0

ED: emergency department; SARS: severe acute respiratory syndrome.