Quality Improvement Study

Medicine®

OPEN

An innovative emergency transportation scenario for mass casualty incident management

Lessons learnt from the Formosa Fun Color Dust explosion

Ming-Wei Lin, MS[a], Chih-Long Pan, PhD[b], Jet-Chau Wen, PhD[c,d,*], Cheng-Haw Lee, PhD[e], Zong-Ping Wu, PhD[f], Chin-Fu Chang, MD[g], Chun-Wen Chiu, MD[g]

Abstract

The purpose of this research is to analyze and introduce a new emergency medical service (EMS) transportation scenario, Emergency Medical Regulation Center (EMRC), which is a temporary premise for treating moderate and minor casualties, in the 2015 Formosa Fun Color Dust Party explosion in Taiwan. In this mass casualty incident (MCI), although all emergency medical responses and care can be considered as a golden model in such an MCI, some EMS plans and strategies should be estimated impartially to understand the truth of the successful outcome.

Factors like on-scene triage, apparent prehospital time (*app*PHT), inhospital time (IHT), and diversion rate were evaluated for the appropriateness of the EMS transportation plan in such cases. The patient diversion risk of inadequate EMS transportation to the first-arrival hospital is detected by the odds ratios (ORs). In this case, the effectiveness of the EMRC scenario is estimated by a decrease in *app*PHT.

The average *app*PHTs (in minutes) of mild, moderate, and severe patients are 223.65, 198.37, and 274.55, while the IHT (in minutes) is 18384.25, 63021.14, and 83345.68, respectively. The ORs are: 0.4016 (95% CI = 0.1032–1.5631), 0.1608 (95% CI = 0.0743–0.3483), and 4.1343 (95% CI = 2.3265–7.3468; $P < .001$), respectively. The *app*PHT has a 47.61% reduction by employing an EMRC model.

Due to the relatively high *app*PHT, diversion rate, and OR value in severe patients, the EMS transportation plan is distinct from a prevalent response and develops adaptive weaknesses of MCIs in current disaster management. Application of the EMRC scenario reduces the *app*PHT and alleviates the surge pressure upon emergency departments in an MCI.

Abbreviations: *app*PHT = apparent prehospital time, ED = emergency department, EMRC = Emergency Medical Regulation Center, EMS = emergency medical service, EMT = emergency medical technician, GIS = geographic information system, IHT = inhospital time, IRB = Institutional Review Board, MCI = mass casualty incident, MOHW = Ministry of Health and Welfare, OR = odds ratio, yo = years old.

Keywords: dust explosion, emergency medical regulation center (EMRC), emergency medical service (EMS), EMS transportation, mass casualty incident (MCI)

Editor: Ediriweera Desapriya.

This research was supported by the Ministry of Science and Technology (MOST) for the funding through grants: MOST 106-2915-I-224-501, MOST 106-2625-M-224-002, MOST 107-2625-M-224-002, and MOST 108-2625-M224-005. The funding agency had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; and preparation, review, or approval of the manuscript.

The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

[a] Graduate School of Engineering Science and Technology, [b] Bachelor Program in Interdisciplinary Studies, College of Future, [c] Department and Graduate School of Safety Health and Environmental Engineering, [d] Research Center for Soil & Water Resources and Natural Disaster Prevention (SWAN), National Yunlin University of Science & Technology, 123, Section 3, University Road, Douliu, Yunlin 640, [e] Department of Resources Engineering, National Cheng Kung University, 1, University Road, East District, Tainan city 701, [f] Graduate School of Disaster Management, Central Police University, 56, Shujen Road, Kueishan District, Taoyuan City 333, [g] Department of Emergency and Critical Care Medicine, Changhua Christian Hospital, 135, Nan-Hsiao Street, Changhua 500, Taiwan, ROC.

[*] Correspondence: Jet-Chau Wen, Department and Graduate School of Safety Health and Environmental Engineering, Research Center for Soil & Water Resources and Natural Disaster Prevention (SWAN), National Yunlin University of Science & Technology, 123, Section 3, University Road, Douliu, Yunlin 640, Taiwan, ROC (e-mail: wenjc@yuntech.edu.tw).

How to cite this article: Lin MW, Pan CL, Wen JC, Lee CH, Wu ZP, Chang CF, Chiu CW. An innovative emergency transportation scenario for mass casualty incident management: lessons learnt from the Formosa Fun Color Dust explosion. Medicine 2021;100:11(e24482).

Received: 17 April 2020 / Received in final form: 27 December 2020 / Accepted: 31 December 2020

http://dx.doi.org/10.1097/MD.0000000000024482

1. Introduction

Over the last few decades, natural and man-made disasters have become more intense and frequent,[1–4] as catastrophic mass casualty incidents (MCIs) are more frequent than before. The unexpectedly heavy caseload of casualties will force the emergency medical services (EMSs) system to plan an adequate strategy for saving the golden hours of the injured. Therefore, lessons learned from the MCIs will boost the improvement and adaptation of the EMS system.[5,6]

The EMS systems may be different depending on the action plans and the strategies in the model of transportation and the constitution of the EMS team in various countries.[7,8] In particular, for EMS transportation, the Anglo-American model is performed according to the "patient to doctor" plan, whereas the Franco-German model to the "doctor to patient" plan.[9–11] Different transportation models will produce different EMS teams, maybe consisting of emergency medical technicians (EMTs), doctors, and nurses for prehospital care in various settings. In Taiwan, the EMS system adopts the Anglo-American model, in which patients are transported to hospitals ordinarily by 2 EMTs.[12–14]

Planners and researchers are concerned about reducing the EMS transportation time as well as distance during MCIs.[5,14] Plans, such as the 3 phases of prehospital patient care following an earthquake, are being reviewed to diminish immediate mortality.[15] In addition, other investigators have applied the geographic information system (GIS) for a path design to implement effective and time-saving transportation.[16] Aero-transportation is another leading force during an MCI, which is recommended to address on-land transportation challenges.[17] However, there is much room for improvement in EMS transportation studies, especially on a systemic revolution aspect.

The MCIs wrought havoc in the EMS system due to an unexpected surge of casualties. Once the emergency response and mass casualty incident management cannot perform well in an MCI, it will delay the medication and put the patients in danger with a poor prognosis. Undoubtedly, no disaster can be repeated in a real scene for a drill and training. However, many historical case studies can provide plenty of data and experience to improve the EMS plans and the preparedness stage in disaster management. Unfortunately, valuable information is sometimes covered by the successful medical outcomes of animated controversies, such as the case discussed in this article.[18–22] The detailed EMS transportation plan was examined by the appropriateness and reasonable means to learn the lessons for facing an unpredictable MCI similar to the Formosa Fun Color Dust Party explosion.

Large casualty caseloads push EMS providers to brainstorm an appropriate adaptation. Once the overloaded patients in an MCI surge to the emergency departments (EDs) of the response hospitals, 2 questions will be asked: does the response ED have enough capacity to receive the patients? How can we reserve higher levels of medical resources for severely injured people? In order to resolve those questions, the Emergency Medical Regulation Center (EMRC) has been designed to accommodate moderate and mild cases to provide professional prehospital emergency medical care by physicians, while severe ones will be transferred to the EDs by first-line ambulances. It can prevent the competition of the medical center's resources between the urgent and non-urgent patients and release the surge pressure of EDs by employing the EMRC as a buffer space. EMRC is a transient location or building near the disaster area, while supported medical teams will provide first aid and stabilize conditions of moderate and mild patients. EMRC can be considered a conceptual term since its format is modified based on the demands of each incident. For example, in the Boston Marathon bombing in the USA,[23–25] the EMRC may have included tents and carpets, while during the Chi–Chi earthquake disaster in Taiwan,[26,27] schools and stadiums were provided to cover the patients' needs. In other words, EMRC can be considered as an innovative design for disaster response, emergency transportation, and patient distribution; therefore, the model will be scenarioing in the Formosa Fun Dust explosion MCI.

2. Methods

On 27th June 2015 in Taiwan, the Formosa Fun Color Dust Party explosion caused 499 people with different degrees of burn wounds to be transported to the hospitals via different means such as ambulances, taxis, private cars, and military vehicles. Due to the policy of the local health sectors, the casualties in situ were evacuated within 3.5 hours approximately. Although the emergency transportation strategy is far from regular guidance, a triage-based transportation practice, the mortality rate is quite low (about 3%). Therefore, it is worth evaluating the EMS transportation plan thoroughly in such a case to learn the lessons for a burn MCI revolution and try to develop an adaptive EMS transportation plan to reduce the deficiency and improve efficiency.

The patient's data of age, sex, on-scene triage, admitted hospitals, and ED arrival times were adopted from a previous study of the 2015 Formosa Fun Color Dust Party explosion. Real-time tracing of the patients' health status records was retrieved from the Emergency Medical Management System of the Ministry of Health and Welfare (MOHW) (http://ems.mohw.gov.tw/). The raw data was obtained by one of our team members who has legal access to the database. All acquisitions and applications have proceeded carefully according to the regulations of MOHW as in previous research.[20] The study was reviewed by the Institutional Review Board (IRB) at Changhua Christian Medical Center (IRB No. 200907), which judged it to be exempt from further review. The IRB waived the requirement for informed consent for this study.

Since the emergency conditions of the explosion site, records of ambulance arrivals and departures, transportation time, and on-scene time were missing; apparent prehospital time (*app*PHT) can be defined as the time from the initiation of the explosion until the time patients registered and admitted to the ED.

A*pp*PHT and inhospital time (IHT) for the 3 triage leveled patients are subjected to trimming the outliers by applying the *Z*-score method.[28–30] The outliers are trimmed beyond the range of $-3 < Z < 3$; therefore, the *app*PHT and IHT outliers will be excluded from both average time calculations. The percentage of outliers in *app*PHT and IHT is less than 3% for all cases.

Based on a general perspective, less *app*PHT means the patients transported to the EDs in a prior order, while the patients will be delayed to reach the hospitals with a long *app*PHT. Besides, the IHT can be defined as the time period from the patient's arrival in the hospital until the patient gets discharged regardless of the number of hospitals a patient has been transferred to.

A statistical method of odds ratio (OR) can be employed to evaluate the EMS transportation effects on patients with different medical conditions. According to standard EMS protocol, severely injured patients should be transferred to the medical centers, moderately injured to the regional hospitals, and patients with mild injuries to the district hospitals, based on the on-scene

Table 1

The definition of terms of the odds ratio analysis for the EMS transportation in the Formosa Fun Color Dust explosion.

	OR*	
	With diversions	Without diversions (as a reference)
First transportation to an inadequate hospital	D_E	H_E
First transportation to an adequate hospital (as a reference)	D_N	H_N

* OR: odds ratio; the equation is: $OR = \frac{D_E/H_E}{D_N/H_N}$.

triage. If the primary distribution of the patients is done adequately, then there is no need for other diversions. On the contrary, the diversions were unavoidable, and the risk exposure rates of the patients became high due to the extra extended transportation time, especially in the case of severe patients. The definition of terms in an OR table is shown in Table 1.

The OR values of patients with 3 different levels of on-scene triage are separately computed. Once a high OR value (>3, experientially) is observed, first inadequate emergency transportation will have a strong connection with secondary diversion. That is to say, the EMS transportation plans and strategies may argue a change in facing such an MCI.

In this research, a new EMS transportation scenario was proposed and considered. There are 2 essential elements, the EMRC, and the two-stage transportation method, which shall be defined briefly for the idea. EMRC is a conceptual construction to accommodate the mild and moderate patients for providing a first aid treatment, while the two-stage transportation method categorizes the ambulances into 2 lines. First-line ambulances will reciprocate between the disaster area and an EMRC in a general situation, and the patients with the severe condition will be transported to the response EDs directly by the same first-line ambulances. Moreover, second-line ambulances are located in an EMRC on standby to receive orders from physicians to transport unstable patients to the recommended hospitals.

In our case, time efficiency can be determined by a reduction in *app*PHT through the EMRC scenario. Since the Formosa Fun Water Park can be selected as a competent location to set up an EMRC in the unaffected area of the Park, the mild and moderate patients will be retented in situ without any ambulance transportation. As a result, first-line ambulances are only transporting severe casualties to the EDs in this case. The *app*PHT of mild and moderate patients can be approached zero theoretically since these 2 kinds of patients will be sent and treated in the nearby EMRC. Therefore, the total *app*PHT in an EMRC model is calculated by the *app*PHT of severe patients majorly.

3. Results

The basic information on 499 casualties is shown in Table 1. The youth whose age is defined between 15 and 24 years old (yo) takes a large percentage of the injured population (64.13%); also, the average age was 23.37 ± 4.53 yo (maximum: 39 yo; minimum: 13 yo). The on-scene triage data is a critical factor for the subsequent analyses since it can provide persuasive medical evidence for selecting a competent response hospital for emergency transportation. In order to apprehend the EMS transportation policy in this dust explosion incident, the *app*PHT is assessed to differentiate patients with which level of injury will arrive at the hospitals within the shortest period. There is only a slight discrepancy in the *app*PHT under 40% of the population approximately in each triage level (Fig. 1). The EMS transportation has followed the "To see is to send" policy regardless of the on-scene triage results. The average *app*PHTs and IHTs for each category are listed in Table 2. Based on previous research, extended prehospital time will cause a poor prognosis and may prolong the IHT.[31–35]Figure 2 depicts the interaction between *app*PHT and IHT of the 3 on-scene triaged patients. The *app*PHTs of the mild and moderate patients scattered in a band-like range along the IHT axis; nevertheless, there are 2 obvious bands in the chart of the severe patients. This unusual phenomenon may exist in some unexplored practical meanings; therefore, it will get discussed in the subsequent section.

The detailed categorization of the patient is shown in Table 3 for further OR analysis to evaluate the diversion risk in the EMS transportation approach. The diversion rates of mild, moderate, and severe patients are 20.93%, 24.54%, and 46.46%, respectively. Similarly, the ORs for the 3 groups are 0.4016 (95% Cl, 0.1032–1.5631), 0.1608 (95% Cl, 0.0743–0.3483), and 4.1343 (95% Cl, 2.3265–7.3468) (Table 4).

The conceptual idea of the EMRC model is depicted in Figure 3. Based on patient retention capability, time efficiency has increased to 47.61% by reducing the *app*PHT of moderate and mild patients (Fig. 4).

4. Discussion

The case of the Formosa Fun Dust explosion is a classic focal disaster, noting its main difference with historical incidents is the age of the casualties involved. The indications in Figure 1 revealed that the EMS transportation in this calamity followed a "To see is to send" model; in other words, the on-scene triage may not be the main criterion for determining the priority patient transportation. The delay of the severely injured patient will cause pernicious consequences, which are well-discussed in other researches.[36–38] However, EMS transportation in such a burn MCI creates a space for further discussions.

Based on the results of IHT vs *app*PHT diagrams (Fig. 2), the IHT is independent of the *app*PHT among the 3 triaged groups. This phenomenon is quite different from the previous researches and practical evidence.[39–43] The key reason may be political interventions.[44] Since the incident was well-known headline news, the government of Taiwan exercises the public authority to take care of all the casualties by converging the medical workforce and resources, exempting the medical expenses, and providing indefinite IHT. Hence, the longer IHT is proposed due to the incapability of the IHT computation in a conventional manner. It can also explain the low mortality rate compared to other similar cases. Nevertheless, the average IHTs of mild, moderate, and severe patients correspond to their injured conditions.

Due to the policy of the local government, the central dogma of EMS response is the disaster area clearances as speedily as possible. Consequently, the patients in minor conditions

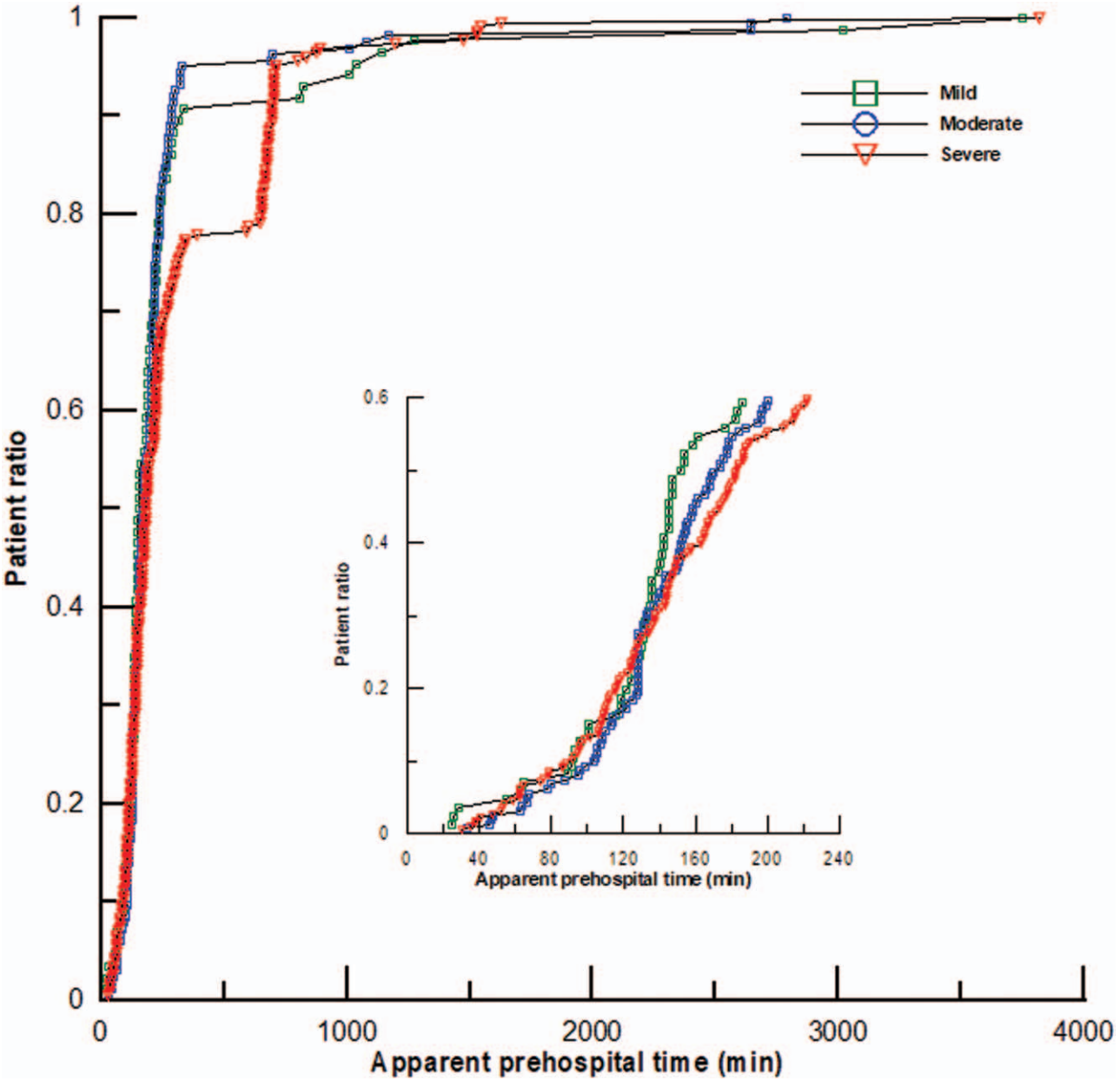

Figure 1. The prehospital time analyses for three-leveled patients. A zoom-in chart is shown inside the figure.

occupied the resources of high-level emergency response hospitals in the initial stage; hence the severe ones had no choice but to divert to other medical centers. Moreover, a portion of the severe patients had relevant extended *app*PHTs. A reasonable inference is that the severe patients near the explosion site cannot move to the ambulances by themselves, and the pathways are all blocked

Table 2

The background information of the 499 casualties in the Formosa Fun Color Dust explosion.

		On-scene triage		
	Total	**Mild**	**Moderate**	**Severe**
Number of casualties	499	86	163	226
Gender:				
Male	242	51	88	103
Female	233	31	75	123
Age	23.37 ± 4.52	24.15 ± 4.52	23.47 ± 5.12	22.98 ± 3.77
Average apparent prehospital time (min)	232.19	223.65	198.37	274.55
Average inhospital time (min)	54917.02	18384.25	63021.14	83345.68

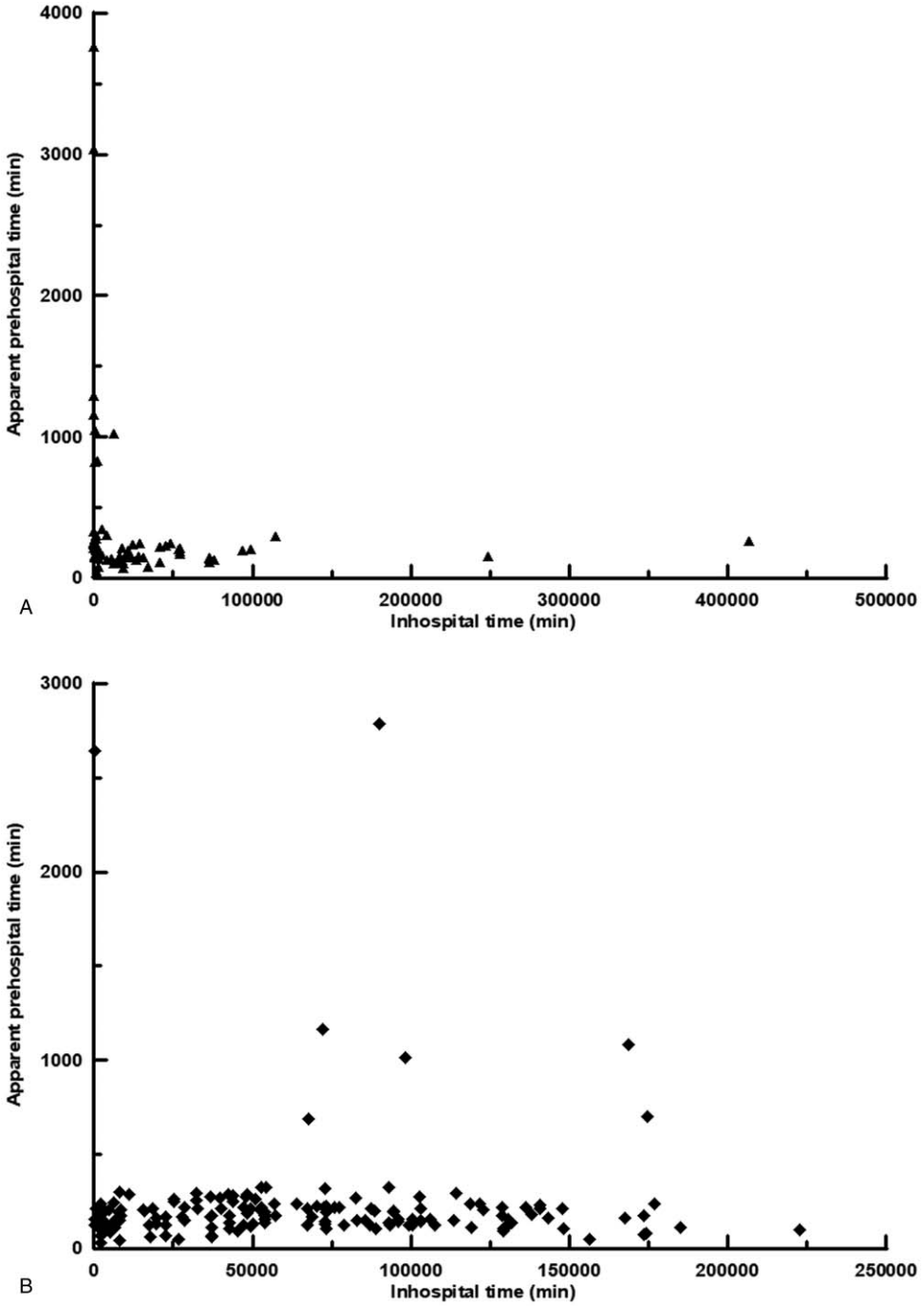

Figure 2. The interactions between apparent prehospital time and inhospital time in different triage levels. Panels A–C, indicates mild, moderate, and severe casualties, respectively.

by the patients and crowds. According to the OR results, inadequate emergency transportation will correspond to the diversion risk in severe patients. It clarifies that the EMS plan of "To see is to send" in this case should be improved, especially in an emergency transportation aspect.[44]

A more effective EMS transportation scenario is introduced in this research, combined with the ideas of the EMRC and the two-stage transportation method. In this case, we select the Park area to set up the EMRC since the in situ space is large enough to accommodate the casualties and the shortest distance between the disaster area and EMRC. The first-line ambulance transportation of mild and moderate patients can be saved for severe casualties, especially in OHCA cases. Moreover, severe patients can be transferred directly to the response hospitals without competition from the ED beds by moderate and mild patients. Since moderate and mild patients will get retained by EMRC, it can create extra time and space for response hospitals to release the patient surge pressure of an MCI. This will help alleviate the mental pressure of ED physicians and casualties such as burnout syndrome, disaster traumatic stress, anxiety depression, and social anxiety.[45,46] In

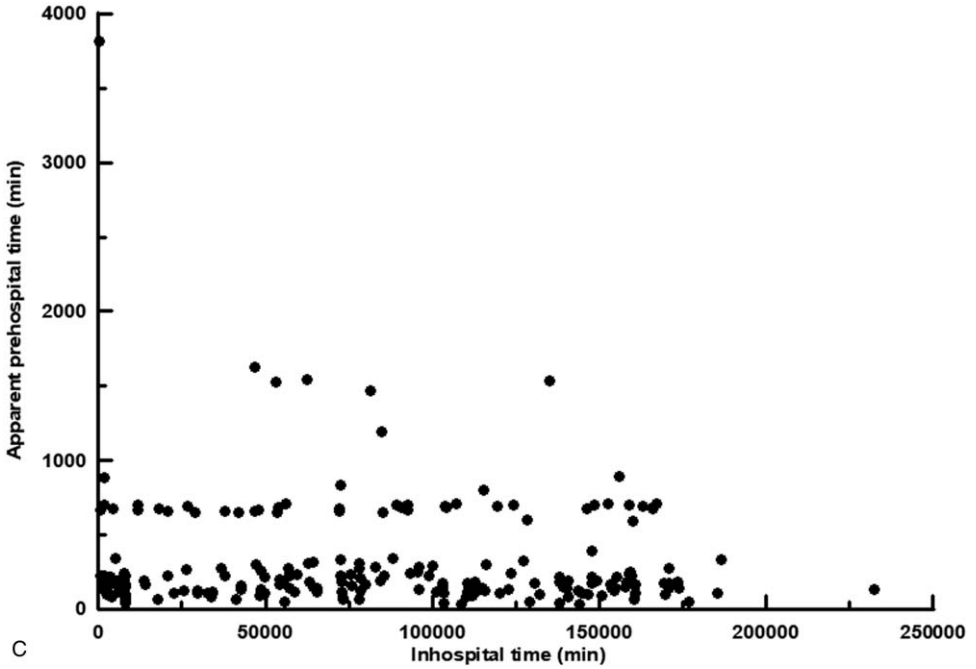

Figure 2. (Continued).

the case of an inexhaustible capacity of the EMRC for moderate and mild patients, the transportation time may have a 47.61% decrease than the EMS transportation action plan in this MCI.

5. Limitations

The prime limitation of this research is the uncertain *app*PHT intervals. The general definition of total prehospital time includes response time, on-scene time, and transportation time.[47] Since the prehospital time data for the Formosa Fun Color Dust Party explosion case is missing due to the chaotic condition; the *app*PHT is defined as a time interval from the initiation of the explosion until the time patients registered and admitted to the ED. Therefore, the error cannot be excluded during the calculation of *app*PHT. Another limitation of this research is the establishment of EMRC. Several factors should be considered for a competent EMRC, such as the capacity, the site for set up, traffic flow between EMRC and EDs, and stampede management. In this study, we had selected the unaffected area of Formosa Fun Park as the EMRC; neverthe-

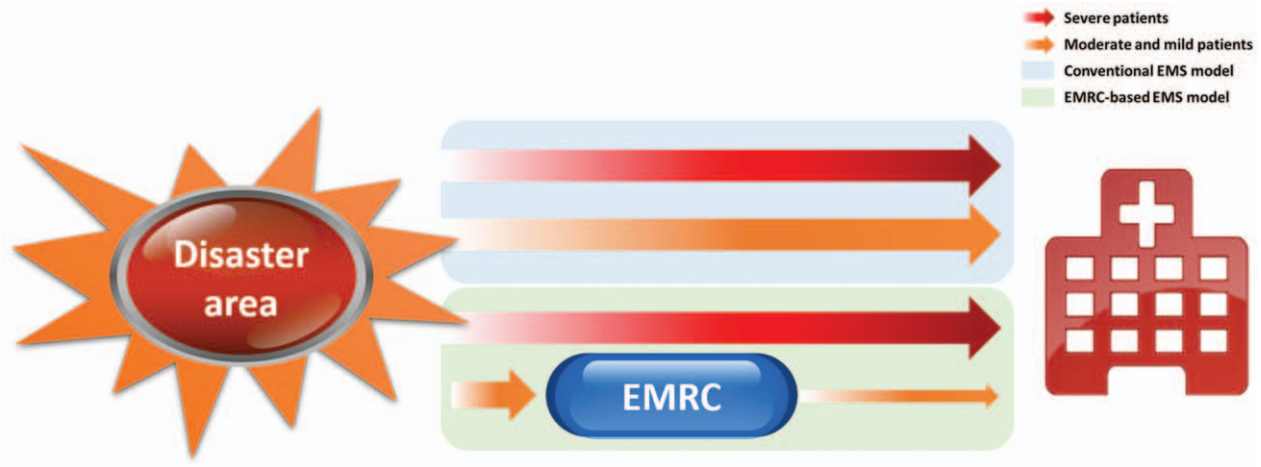

Figure 3. An EMRC scenario for the EMS transportation. All casualties will be transported to the response hospitals directly in conventional EMS transportation (light-blue background). The EMRC-based model will retented the moderate and mild patients for a first-aid treatment, while the unstable patients can be systemically transported to the response hospitals based on the orders of EMRC physicians. Nevertheless, the severe patients will be transferred straight from the disaster area to the response hospitals without any retention (light-green background). EMRC, Emergency Medical Regulation Center; EMS, emergency medical service.

Table 3

The primary and secondary distribution of different categorized patients in the Formosa Fun explosion event.

On-scene triage	Primary distribution	Secondary distribution
Severe (n = 226)	Medical center (n = 142)	Medical center (n = 31)
		Regional hospital (n = 16)
		District hospital (n = 1)
		No diversion (n = 94)
	Regional hospital (n = 77)	Medical center (n = 33)
		Regional hospital (n = 18)
		District hospital (n = 0)
		No diversion (n = 26)
	District hospital (n = 7)	Medical center (n = 4)
		Regional hospital (n = 2)
		District hospital (n = 0)
		No diversion (n = 1)
Moderate (n = 163)	Medical center (n = 105)	Medical center (n = 7)
		Regional hospital (n = 2)
		District hospital (n = 1)
		No diversion (n = 95)
	Regional hospital (n = 51)	Medical center (n = 17)
		Regional hospital (n = 5)
		District hospital (n = 3)
		No diversion (n = 26)
	District hospital (n = 7)	Medical center (n = 2)
		Regional hospital (n = 3)
		District hospital (n = 0)
		No diversion (n = 2)
Mild (n = 86)	Medical center (n = 51)	Medical center (n = 6)
		Regional hospital (n = 3)
		District hospital (n = 0)
		No diversion (n = 42)
	Regional hospital (n = 24)	Medical center (n = 3)
		Regional hospital (n = 2)
		District hospital (n = 0)
		No diversion (n = 19)
	District hospital (n = 11)	Medical center (n = 1)
		Regional hospital (n = 3)
		District hospital (n = 0)
		No diversion (n = 7)

n = number of patient(s).

less, the aptness of the EMRC in the Park should be evaluated by further research.

Equally important is to consider the arguments between on-scene triage and ED triage. We adopted the on-scene triage outcomes for the patient classification in this research since the on-scene triage is the principal reference for EMS transportation. However, an unpredictable error might exist when evaluating the diversion risk in an OR analysis.

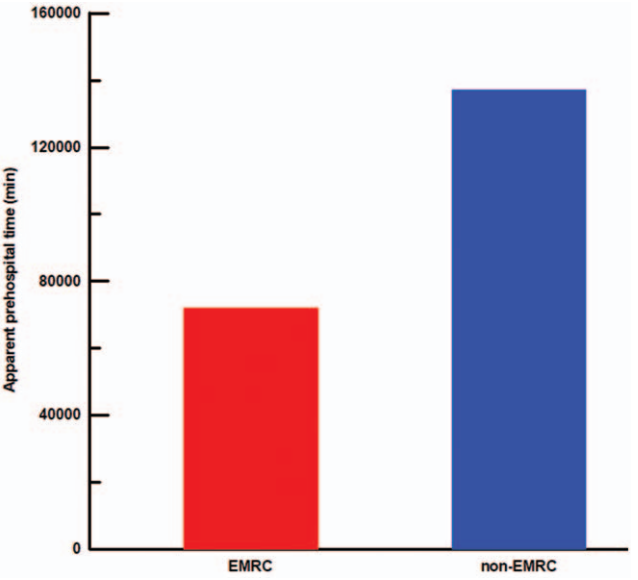

Figure 4. An apparent prehospital time analysis between EMRC- and non-EMRC-based EMS transportation. EMRC, Emergency Medical Regulation Center.

6. Conclusions

Injuries, illnesses, and also deaths have resulted from floods, storms, fires, droughts, heatwaves, and other natural and man-made disasters that are on the increase. Therefore, the EMS providers should scheme out an adaptive plan to face the unpreventable MCIs. In this MCI, although all the evaluation data using the mortality or patient clearance time as indexes showed remarkable success in the EMS action, some weaknesses in the EMS transportation plans should be emphasized to improve patient safety in future actions. However, an innovative scenario of EMRC is introduced in this research to enhance the efficiency of emergency transportation and reduce the surge pressure on response EDs. In order to obtain the optimized efficiency of the EMRC-based emergency transportation model, issues such as command system establishment, site selection, medical staff, supplies requests, information network, ambulance allocation, and surge capacity analyses should be considered in the additional studies.

Acknowledgments

The authors would like to thank Mr. Rajankumar Gohil for his great input in editing and finalizing the precision of the manuscript.

Table 4

The odds ratios of EMS transportation strategies cause a next diversion for the three-leveled patients.

	On-scene triage		
	Severe	Moderate	Mild
Diversion rate*	46.46%	24.54%	20.93%
Odds ratio (95% CI)	4.1343† (2.3265–7.3468)	0.1608 (0.0743–0.3483)	0.4016 (0.1032–1.5631)

CI = confidence interval, EMS = emergency medical service.

* Among different hospital levels.

† $P < .0001$.

Author contributions

All listed authors meet their authorship requirements. M-WL and C-LP conceived the study. Z-PW, C-FC, and C-WC collected the data and shared their experience in the matters of the emergency medical response during a disaster. Their contribution and ideas were extremely important to understand the real conditions of the case study. J-CW supervised all the details of this research. MWL, C-LP, C-HL, and J-CW performed a literature review and drafted the initial manuscript. All authors thoroughly revised the manuscript. J-CW takes responsibility for the paper as a whole.

Conceptualization: Ming-Wei Lin, Chih-Long Pan, Jet-Chau Wen.
Data curation: Zong-Ping Wu, Chin-Fu Chang, Chun-Wen Chiu.
Formal analysis: Chun-Wen Chiu.
Funding acquisition: Jet-Chau Wen, Chih-Long Pan.
Methodology: Zong-Ping Wu, Chin-Fu Chang.
Project administration: Jet-Chau Wen.
Resources: Zong-Ping Wu, Chin-Fu Chang, Chun-Wen Chiu.
Supervision: Jet-Chau Wen.
Validation: Jet-Chau Wen.
Writing – original draft: Jet-Chau Wen, Ming-Wei Lin, Chih-Long Pan, Cheng-Haw Lee.
Writing – review & editing: Jet-Chau Wen, Ming-Wei Lin, Chih-Long Pan, Cheng-Haw Lee.

References

[1] Below R, Wallemacq P. Annual Disaster Statistical Review 2017. Brussels, Belgium: CRED; 2018.
[2] Akter S, Wamba SF. Big data and disaster management: a systematic review and agenda for future research. Ann Oper Res 2017;1–21.
[3] Marmot M. Man-made disaster. The Lancet 2018;391:113–4.
[4] IPCCClimate Change 2014: Impacts, Adaptation, and Vulnerability. Cambridge, UK and NY, USA: Cambridge University Press; 2014. 37–75.
[5] Pan C-L, Chiu C-W, Wen J-C. Adaptation and promotion of emergency medical service transportation for climate change. Medicine 2014;93: e186.
[6] Pan C-L, Lin C-H, Lin Y-R, et al. The significance of witness sensors for mass casualty incidents and epidemic outbreaks. J Med Internet Res 2018;20:e39.
[7] Arnold JL. International emergency medicine and the recent development of emergency medicine worldwide. Ann Emerg Med 1999;33:97–103.
[8] Cone DC, Brooke Lerner E, Band RA, et al. Prehospital care and new models of regionalization. Acad Emerg Med 2010;17:1337–45.
[9] Dick WF. Anglo-American vs. Franco-German emergency medical services system. Prehosp Disaster Med 2003;18:29–37.
[10] Dykstra EH. International models for the practice of emergency care. Am J Emerg Med 1997;15:208–9.
[11] VanRooyen MJ, Thomas TL, Clem KJ. International emergency medical services: assessment of developing prehospital systems abroad. J Emerg Med 1999;17:691–6.
[12] Chiang W-C, Ko PC-I, Wang H-C, et al. EMS in Taiwan: past, present, and future. Resuscitation 2009;80:9–13.
[13] Bullard MJ, Liaw S-J, Chen J-C. Emergency medicine development in Taiwan. Ann Emerg Med 1996;28:542–8.
[14] Lin M-W, Wu C-Y, Pan C-L, et al. Saving the on-scene time for out-of-hospital cardiac arrest patients: the registered nurses' role and performance in emergency medical service teams. BioMed Res Int 2017;5326962.
[15] Schultz CH, Koenig KL, Noji EK. A medical disaster response to reduce immediate mortality after an earthquake. N Engl J Med 1996;334: 438–44.
[16] Peters J, Hall GB. Assessment of ambulance response performance using a geographic information system. Soc Sci Med 1999;49:1551–66.
[17] Nakagawa Y, Inokuchi S, Morita S, et al. Long-distance relay transportation of a patient with twin-twin transfusion syndrome requiring early delivery by Doctor-Helicopters. Tokai J Exp Clin Med 2010;35:118–21.
[18] Wang T-H, Jhao W-S, Yeh Y-H, et al. Experience of distributing 499 burn casualties of the June 28, 2015 Formosa Color Dust Explosion in Taiwan. Burns 2017;43:624–31.
[19] Pan C-L, Lin M-W, Wu Z-P, et al. Towards a reliable paradigm shift in emergency medical service for improving mass burn casualty response. Burns: J Int Soc Burn Injuries 2017;43:1821.
[20] Lin C-H, Lin C-H, Tai C-Y, et al. Challenges of burn mass casualty incidents in the prehospital setting: lessons from the Formosa Fun Coast Park Color Party. Prehosp Emerg Care 2019;23:44–8.
[21] Chuang S, Cheng C-H, Chen H-C, et al. Coping with communication challenges after the Formosa Fun Coast Dust Explosion. Paper presented at: 2018 Resilience Week (RWS). IEEE 2018;5–10.
[22] Chuang S, Chang K-S, Woods DD, et al. Beyond surge: coping with mass burn casualty in the closest hospital to the Formosa Fun Coast Dust Explosion. Burns 2019;45:964–73.
[23] Gates JD, Arabian S, Biddinger P, et al. The initial response to the Boston marathon bombing: lessons learned to prepare for the next disaster. Ann Surg 2014;260:960.
[24] Biddinger PD, Baggish A, Harrington L, et al. Be prepared—the Boston Marathon and mass-casualty events. N Engl J Med 2013;368:1958–60.
[25] Kellermann AL, Peleg K. Lessons from Boston. N Engl J Med 2013; 368:1956–7.
[26] Ma KF, Lee CT, Tsai YB, et al. The Chi–Chi, Taiwan earthquake: large surface displacements on an inland thrust fault. EOS Trans Am Geophys Union 1999;80:605–11.
[27] Liang N-J, Shih Y-T, Shih F-Y, et al. Disaster epidemiology and medical response in the Chi–Chi earthquake in Taiwan. Ann Emerg Med 2001;38:549–55.
[28] Shiffler RE. Maximum Z scores and outliers. Am Stat 1988;42:79–80.
[29] Wilcox RR. Applying Contemporary Statistical Techniques. 2003;Gulf Professional Publishing:76–84.
[30] Pan C-L, Chang C-F, Chiu C-W, et al. What can emergency medicine learn from kinetics: introducing an alternative evaluation and a universal criterion standard for emergency department performance. Medicine 2016;95:
[31] Mayer JD. Emergency medical service: delays, response time and survival. Med Care 1979;17:818–27.
[32] Newgard CD, Schmicker RH, Hedges JR, et al. Emergency medical services intervals and survival in trauma: assessment of the "golden hour" in a North American prospective cohort. Ann Emerg Med 2010;55:235–46.e234.
[33] Bigdeli M, Khorasani-Zavareh D, Mohammadi R. Pre-hospital care time intervals among victims of road traffic injuries in Iran. A cross-sectional study. BMC Public Health 2010;10:1–7.
[34] Funder KS, Petersen JA, Steinmetz J. On-scene time and outcome after penetrating trauma: an observational study. Emerg Med J 2011;28: 797–801.
[35] Takahashi M, Kohsaka S, Miyata H, et al. Association between prehospital time interval and short-term outcome in acute heart failure patients. J Card Fail 2011;17:742–7.
[36] Spaite DW, Criss EA, Valenzuela TD, et al. Analysis of prehospital scene time and survival from out-of-hospital, non-traumatic, cardiac arrest. Prehosp Disaster Med 1991;6:21–7.
[37] Vukmir RB. Survival from prehospital cardiac arrest is critically dependent upon response time. Resuscitation 2006;69:229–34.
[38] Feero S, Hedges JR, Simmons E, et al. Does out-of-hospital EMS time affect trauma survival? Am J Emerg Med 1995;13:133–5.
[39] Kereiakes DJ, Gibler WB, Martin LH, et al. Group CHPSRelative importance of emergency medical system transport and the prehospital electrocardiogram on reducing hospital time delay to therapy for acute myocardial infarction: a preliminary report from the Cincinnati Heart Project. Am Heart J 1992;123:835–40.
[40] Kereiakes DJ, Weaver WD, Anderson JL, et al. Time delays in the diagnosis and treatment of acute myocardial infarction: a tale of eight cities report from the Pre-hospital Study Group and the Cincinnati Heart Project. Am Heart J 1990;120:773–80.
[41] Van der Velden M, Ringburg A, Bergs E, et al. Prehospital interventions: time wasted or time saved? An observational cohort study of management in initial trauma care. Emerg Med J 2008;25:444–9.
[42] Pedley DK, Bissett K, Connolly EM, et al. Prospective observational cohort study of time saved by prehospital thrombolysis for ST elevation myocardial infarction delivered by paramedics. BMJ 2003;327:22–6.
[43] Akan Z, Baskurt B, Asliyuksek H, et al. Environmental radioactivity and high incidence rates of stomach and esophagus cancer in the Van Lake region: a causal relationship? Asian Pac J Cancer Prev 2014;15:375–80.

[44] Yilmaz A, Kilinc F, Usman M, et al. The prevalence of diabetes mellitus, dysglycaemia and factors that affect them in public employees of Kahramanmaras. Turk J Family Med Prim Care 2015;9:99–103.
[45] Yilmaz A. Burnout, job satisfaction, and anxiety-depression among family physicians: a cross-sectional study. J Family Med Prim Care 2018;7:952–6.
[46] Kibrisli E, Bez Y, Yilmaz A, et al. High social anxiety and poor quality of life in patients with pulmonary tuberculosis. Medicine 2015;94: e413.
[47] Brown JB, Rosengart MR, Forsythe RM, et al. Not all prehospital time is equal: influence of scene time on mortality. J Trauma Acute Care Surg 2016;81:93–100.