Prehospital Emergency Care

ISSN: 1090-3127 (Print) 1545-0066 (Online) Journal homepage: http://www.tandfonline.com/loi/ipec20

# Response by Twin Italian Hub Hospitals in a Double Seismic Event: A Retrospective Observational Investigation

Alberto Barbieri, Gabriele Melegari, Valentina Lob, Lorenzo Mazzali, Luca D'Amelio, Andrea Giovannoni & Enrico Giuliani

**To cite this article:** Alberto Barbieri, Gabriele Melegari, Valentina Lob, Lorenzo Mazzali, Luca D'Amelio, Andrea Giovannoni & Enrico Giuliani (2018) Response by Twin Italian Hub Hospitals in a Double Seismic Event: A Retrospective Observational Investigation, Prehospital Emergency Care, 22:3, 353-360, DOI: 10.1080/10903127.2017.1394406

**To link to this article:** https://doi.org/10.1080/10903127.2017.1394406



Published online: 18 Jan 2018.

INTERNATIONAL EMS

# Response by Twin Italian Hub Hospitals in a Double Seismic Event: A Retrospective Observational Investigation

Alberto Barbieri, MD, Gabriele Melegari, MD, Valentina Lob, MBBS, Lorenzo Mazzali, MBBS, Luca D'Amelio, MBBS, Andrea Giovannoni, BSGeo, Enrico Giuliani, MD PhD

ABSTRACT

**Introduction**: The objectives of this study were to compare prevalence rates of different pathologies, ambulance system and emergency department management times, and patient survival and hazard ratios for codes 2 and 3 in two hub hospitals in Modena in the 36-month period across the stages of two major earthquakes in short sequence in Northern Italy in 2012. **Methods**: Clinical records pertaining to the emergency care of patients were analyzed and only those assigned status codes 2 and 3 by ambulance professionals were included (if the assessment was confirmed by emergency department triage). The statistical analysis of data was divided by three time periods studied: before, during/between, and after the earthquakes. **Results**: Among the 2,278 retained records, there were no statistically significant differences in the prevalence of the main pathologies presented at the two hubs in the studied period. A Cox regression model was used to analyze the survival of patients in the different stages of the emergency; there were no statistically significant differences in the hazard ratios of death before, during, and after the earthquake. The study found a significant increase in emergency department treatment times. **Discussion**: Redundancies in the Modena medical system were found to have compensated for damaged hospital facilities. In particular, they helped emergency systems reorganize themselves faster in order to bring medical assistance to people during and around seismic events with as a minimal amount of disruption as possible. **Conclusion**: The Modena medical system was redundant and ensured that disrupted emergency systems were reorganized and put back online while damaged hospital facilities were compensated for/reproduced elsewhere. **Key words:** earthquake; emergency response system; performances; management times

PREHOSPITAL EMERGENCY CARE 2018;22:353–360

Received July 7, 2017 from Dipartimento di Medicina Diagnostica Clinica e di Sanita Pubblica, Universita degli Studi di Modena e Reggio Emilia, Modena, Italy (AB, GM); Facolta di Medicina e Chirurgia, Universita degli Studi di Modena e Reggio Emilia, Modena, Italy (VL, LM, LD); Comitato di Modena, Croce rossa italiana, Modena, Italy (AG); Dipartimento di Scienze Biomediche Metaboliche e Neuroscienze, Universita degli Studi di Modena e Reggio Emilia, Modena, Italy (EG). Revision received October 11, 2017; accepted for publication October 11, 2017.

The authors disclose no conflict of interest.

A. Barbieri participated in the designing the study protocol, coordinated the study, took part in the interpretation of the results, and drafted and reviewed the manuscript. G. Melegari helped design the study protocol, coordinated the data collection, performed the statistical analysis, and participated in drafting the manuscript. V. Lob, L. Mazzali, and L, D'Amelio took part in the medical data collection and analyzed all relevant patients' records. A. Giovannoni took part in the geological and historical data collection, provided all the data regarding the management of the emergency system, and revised the manuscript. E. Giuliani participated in the designing the study protocol, took part in the analysis and interpretation of the results, and drafted and reviewed the manuscript. All authors read and approved the final manuscript.

We thank Dr. Carlo Serantoni (118 Ambulance Service, Modena), Dr. Antonio Luciani (Emergency Room Service, Policlinico, Modena), and Dr. Giovanni Pinelli (Emergency Room Service, NOCSAE, Modena) for their contribution to this research.

The study was funded by the Institutional funds for spontaneous research of the University of Modena and Reggio Emilia.

Address correspondence to Alberto Barbieri, Universita degli Studi di Modena e Reggio Emilia, Dipartimento di Medicina Diagnostica Clinica e di Sanita Pubblica, Modena, Italy. E-mail: alberto.barbieri@unimore.it

Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/ipec.



doi: 10.1080/10903127.2017.1394406

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study covers the entire population of code 2 and 3 patients that accessed the emergency system during the catastrophe, which gives the analysis strength.
- We used retrospective data that gives us no control over the homogeneity of the criteria used by the emergency medical personnel in the evaluation of the single cases.

## BACKGROUND

On May 20, 2012, at 02.03 hours Coordinated Universal Time (UTC), the provinces of Modena and Ferrara in Italy's Emilia-Romagna region, as well as Mantua in Lombardy, were hit by a local magnitude (LM) 5.9 earthquake. The 72 hours after the main shock were characterized by a sequence of 300 small subsequent seismic events. Then, on May 29 at 07.00 hours UTC, there was another large shock (5.8 LM), followed by 150 smaller shocks lasting until June 3 and intermittently thereafter (1, 2). A state of emergency was declared on May 22 to facilitate coordinated relief response.

The province of Modena has an area of 2690 $km^2$ with a population of 700,918 residents as of 2014; it is crossed by the main Italian highway, the E45. An important biomedical industrial district, producing roughly 1/3 of renal replacement therapy supplies used globally, is located in the northern part of the province, near the epicenters of both earthquakes: it suffered substantial damage in the quakes.

From a social, economic, and logistic impact point of view: 70% of the residential buildings in the crater were not habitable, 1,777 individuals with high level disability had to be evacuated from their homes (3). Structural damages have been estimated at €2.07 billion, with 25,874 workers from 2,414 companies that received temporary unemployment benefits.

There were eight hospitals active in the province at the time of the first shock: two hubs (Policlinico Hospital and Nuovo Ospedale S. Agostino Estense, or NOCSAE), located in the city of Modena at the center of the province, and six spokes, three (Sassuolo, Pavullo, and Vignola) in the south and three (Carpi, Mirandola, and Finale Emilia) in the north within the seismic crater.

NOCSAE, a 400-bed hospital with a trauma center, was not significantly damaged by the earthquakes due to its more recent construction and adoption of the most modern antiseismic technologies, while Policlinico, an older building active since 1963, was substantially involved, losing 1/3 of its 600-bed capacity, including pediatric and ob-gyn facilities. The northern hospitals of Carpi, Mirandola, and Finale Emilia were evacuated on the morning of May 20 and again on May 29, and the 260 patients there relocated. In all, a total of 619 patients were evacuated from damaged hospitals to other facilities in the region, to which can be added 2,120 elderly and physically disabled.

Figure 1 shows the reorganization of the hospital system of the Province of Modena during the seismic sequence of 2012.

This catastrophe also led to the death of 27 people and wounded 397; deaths were caused mostly by the collapse of industrial buildings.

Catastrophes are events that challenge the responsiveness and effectiveness of a territory's medical emergency response system by saturating its capacity and damaging its facilities. Consequently, it is vital to study the reaction of these systems to catastrophic events in order to identify criticalities and strengths, especially in relation to time-sensitive processes that require full functionality of key elements in the chain of survival, which makes these processes reliable and accurate indicators of the overall status of the system (4–8).

Emergency response time has been considered by Nehme and colleagues (9) a leading measure of the system's performance in developed countries. In another work by Cortez and colleagues (10) in evaluating the clinical differences between two sets of ambulance teams time was selected as objective measure of their interventions. Moreover, in a recently published paper (11), time was the primary outcome measure to assess the association between bystander resuscitation and survival.

As a result we selected the total management time, from ambulance dispatch to hospital referral (arrival time of the ambulance to the hospital), as a measure of the performance of the emergency medical response in the Province of Modena before, during and after the seismic events of 2012. A natural disaster, in fact, has the potential of disrupting the healthcare infrastructure significantly reducing the operative capacity of a system.

The primary objective of this study was to compare the management times for ambulance system codes 2 and 3 in the 36-month period across the earthquake.

## METHODS

### Data and Sample

After approval by the Institutional Ethics Committee (Comitato Etico Provinciale di Modena), this retrospective observational investigation was conducted on all patients managed by the Ambulance Service of the Province of Modena (118 Modena Soccorso) and the emergency departments of NOCSAE and Policlinico Hospital.

All clinical records pertaining to the emergency care of these patients were analyzed; only records assigned status codes 2 and 3 by the ambulance professionals, and where this assessment was confirmed by emergency department triage, were included (see Figure 2, the enrollment flow chart).

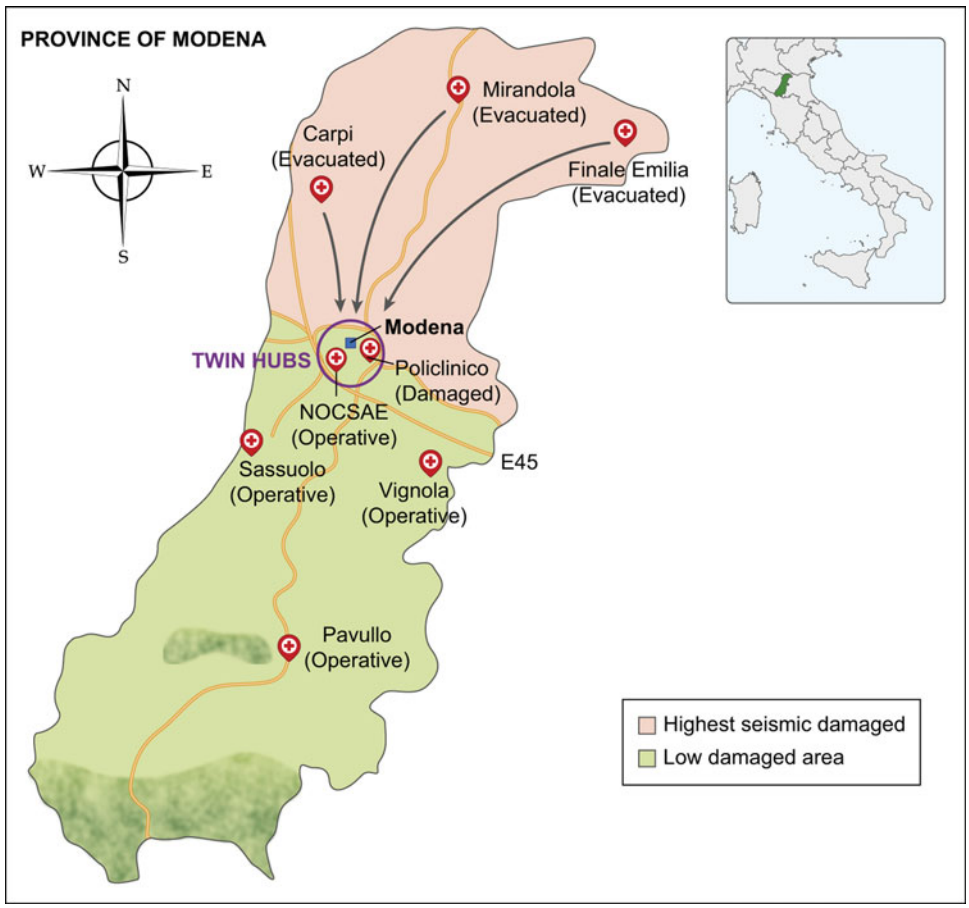


FIGURE 1. A map of the Province of Modena (Italy). The area marked in red was more severely damaged by the seismic sequence of 2012. Arrows show the reorganization of the hospital system during the catastrophe. © Alberto Barbieri. Reproduced by permission of Alberto Barbieri. Permission to reuse must be obtained from the rightsholder.

## Coding

In the Italian out-of-hospital emergency response system, named "118" after the emergency telephone number one dials to activate it, emergency professionals assign each patient a status code according to clinical severity: code 1 refers to a stable patient, where no rapid transport to hospital is required; code 2 groups all subjects who require referral to the emergency department; code 3 implies a life-threatening condition, which requires immediate admission to the emergency department; and code 4 refers to the death of the patient. Among, code 2s, due to their intermediate severity, further selection was conducted in order to identify only those who required advanced medical care, in particular patients who:

- Received ≥ 8 L/min of oxygen
- Required supraglottic devices; or
- Required other advanced airway management techniques.

Survival information was obtained from official hospital registries and patients were divided in the following categories according to their survival time: 24 and 72 hours; 7, 15, 30, 60, 75, 90, 180, and 365 days. Intervention times were calculated based on dispatch time and admission time to target emergency department, from ambulance and hospital records. This sample does not include patients with direct access without Emergency Room. The emergency department admission diagnosis was also noted.

Clinical variables (Cardiac arrest, Polytrauma, Traumatic brain injury, Myocardial infarction, Cardiac failure, Respiratory failure, Stroke, Septic shock) were recorded to identify whether the earthquake changed the case mix to reduce possible sources of bias.

Data regarding the number of civilians evacuated to emergency shelters due to extensive damage suffered by their homes and data regarding loss of bed capacity at hospitals were considered as measures of the severity of infrastructure compromise due to the earthquake.

Patients were initially divided into five groups according to the phase in which they contacted the emergency system:

- Pre-earthquake: January 1, 2011 to May 19, 2012 (phase 0)
- Earthquake: May 20 to May 29, 2012 (phase 1)
- Immediate aftermath: June and July 2012 (phase 2)

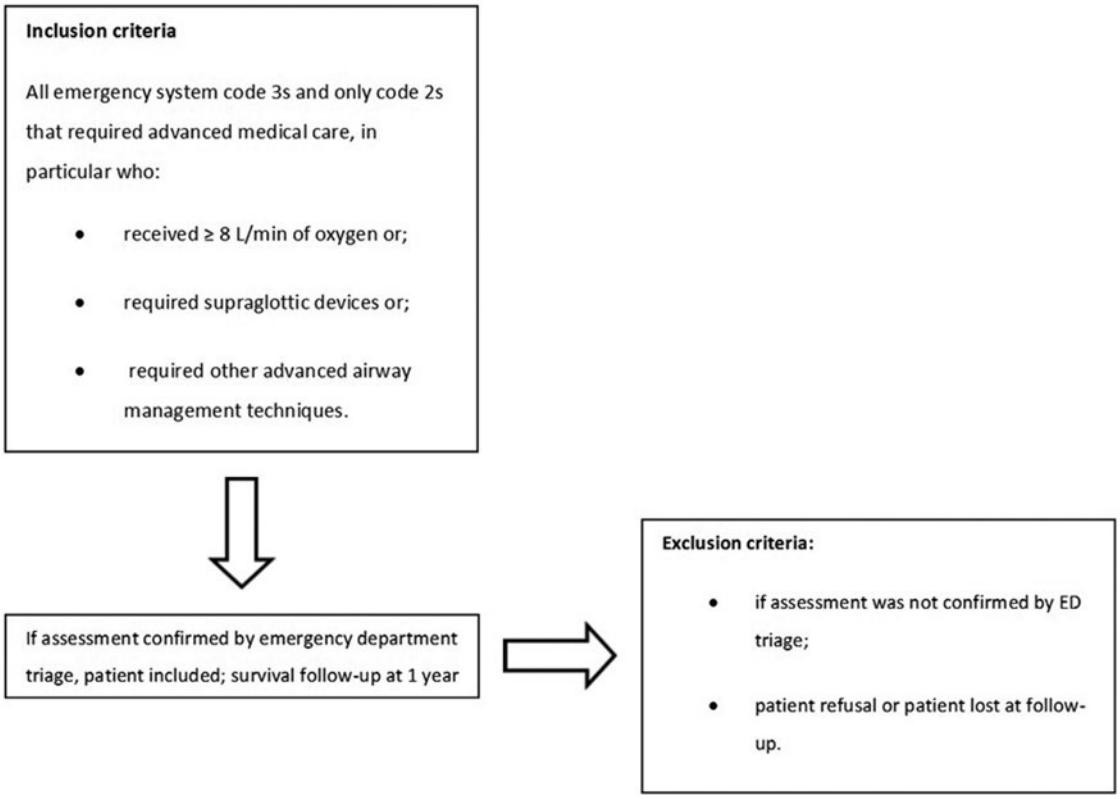


FIGURE 2. Enrollment flow chart: Inclusion and exclusion criteria.

- Early reorganization: August to October 2012 (phase 3)
- Normalization: November 2012 to December 2013 (phase 4)

In order to facilitate the analysis of mortality and intervention times, common characteristics were identified in the aforementioned phases and the study cohort was divided into three stages:

- Pre-earthquake (0): January 1, 2011 to May 19, 2012 (it includes phase 0)
- Earthquake (1): May 20 to November 3, 2012, when the Italian Red Cross declared the earthquake emergency over (it includes phase 1, 2 and 3)
- Post-earthquake (2): November 4, 2012, to December 31, 2013 (it includes phase 4)

Stage 0 represents pre-earthquake normal functionality, and stage 1 includes the whole management of the seismic emergency, while stage 2 covers the return to a new normal functionality. Figure 3 summarizes the temporal succession of phases and stages and their correlation.

All data were recorded in a digital database created specifically for the purpose.

## Statistical Analysis

Data were analyzed with Stata software (StataCorp, College Station, TX, USA). The Student's t-test was used for continuous variables, ANOVA to compare continuous variables among groups, paired Wilcoxon signed-rank test for longitudinal variables over time, and Cox regression model to study survival. All differences with p-values $\leq 0.05$ were considered statistically significant.

# RESULTS

## Characteristics of Study Subjects

A total of 2,278 patients presenting at Policlinico and NOCSAE in all phases (i.e., January 2011 to December 2013) were included in the study. Table 1 summarizes the referral rates of code 3s and code 2s to each emergency department.

As shown in Table 2, there were only a statistically significant differences in the prevalence of the main pathologies presenting at the two hubs in the studied period (as identified by the Wilcoxon signed-rank test): Stage 0 has a lower incidence than Stage 2, p-value 0.028.

## Main Results of the Analyses

A Cox regression model was used to analyze the survival of patients through the different stages of the emergency and surrounding period. There were no statistically significant differences in the hazard ratios of death before, during, and after the earthquake. Figure 4 shows the Kaplan–Meier survival estimate curves for this event.

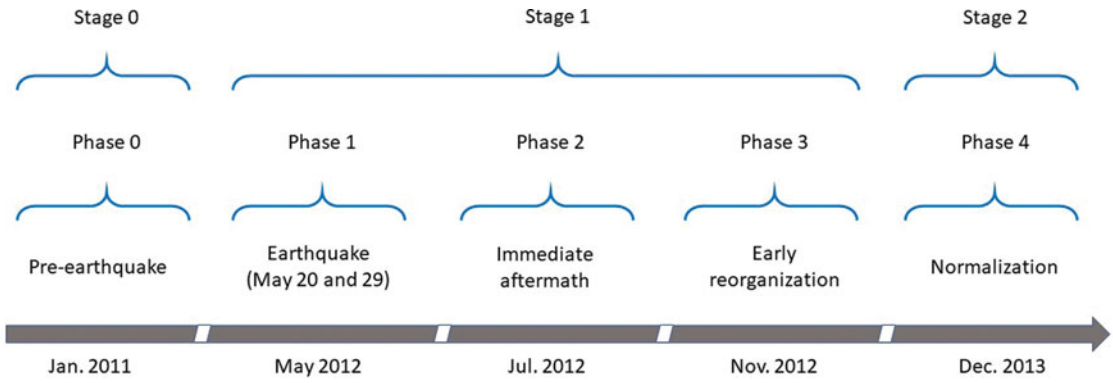


FIGURE 3. Temporal succession of phases and stages of the study. Phases: Pre-earthquake – from January 1, 2011 to May 19, 2012 – (phase 0), Earthquake – May 20 – May 29, 2012 – (phase 1), Immediate aftermath – June and July 2012 – (phase 2), Early reorganization – from August to October 2012 – (phase 3), Normalization – from November 2012 to December 2013 (phase 4); Stages: Pre-earthquake (0) – from January 1, 2011 to May 19, 2012 – (it includes phase 0), Earthquake (1) – from May 20 to November 3, 2012, when the Italian Red Cross declared the earthquake emergency over (it includes phase 1, 2 and 3), Post-earthquake (2) – from November 4, 2012, to December 31, 2013 (it includes phase 4).

The earthquake shifted the balance of patients referred to each hub hospital (before the earthquake almost evenly split between the two centers) toward NOCSAE, which thus had a higher workload than Policlinico after the earthquake. Table 3 shows the percentages of code 2 and 3 patients taken to each hospital before and after the emergency. There was a statistically significant increase in the number of patients treated by the NOCSAE hospital and a corresponding decrease at Policlinico Hospital.

Table 4 takes into consideration the average referral times to each hub center by the Ambulance Service and the emergency department treatment times for all stages of the earthquake emergency. Although there was no significant variation in ambulance times, there was a significant increase in emergency department treatment times.

## DISCUSSION

This study highlights a peculiar aspect of the 2012 earthquake as it affected health services in Modena: there was no surge in emergency department admissions during the emergency or in the following days.

The two major seismic events under consideration, in fact, had low mortality rates when compared to prior earthquake disasters in Italy (e.g., in Irpinia and Molise) and, since the disaster discussed herein, in

TABLE 1. Referral rates for status codes 2 and 3 to Nuovo Ospedale S. Agostino Estense (NOCSAE) and Policlinico hub hospitals from January 2011 to December 2013.

| Phase | Duration (Days) | Total Events | NOCSAE Events | Events/day Nocsae | Percentage | Policlinico Events | Events/day Policlinico | Percentage |
|---|---|---|---|---|---|---|---|---|
| 0 | 505 | 1073 | 630 | 1.25 | 58.71 | 443 | 0.88 | 41.29 |
| 1 | 9 | 22 | 10 | 1.11 | 45.45 | 12 | 1.33 | 54.55 |
| 2 | 62 | 133 | 83 | 1.34 | 62.41 | 50 | 0.81 | 37.59 |
| 3 | 97 | 179 | 120 | 1.24 | 67.04 | 59 | 0.61 | 32.96 |
| 4 | 422 | 871,00 | 558 | 1.32 | 64.06 | 313 | 0.74 | 35.94 |

The studied period was subdivided into 5 consecutive time phases: 0, before the earthquake; 1, during the earthquake; 2, in the immediate aftermath; 3, in the late summer early autumn of 2012; and 4, from November 2012 to December 2013.

TABLE 2. Case mix of admissions by stage: before the earthquake 0, during the earthquake 1, after the earthquake 2.

| Pathologies | Stage 0 | Percentage | Stage 1 | Percentage | Stage 2 | Percentage | total | Percentage |
|---|---|---|---|---|---|---|---|---|
| Cardiac arrest | 107 | 9.97 | 40 | 12.01 | 102 | 11.70 | 249 | 10.93 |
| Polytrauma | 132 | 12.30 | 48 | 14.41 | 107 | 12.27 | 287 | 12.60 |
| Traumatic brain injury | 137 | 12.77 | 40 | 12.01 | 106 | 12.16 | 283 | 12.42 |
| Myocardial infarction | 40 | 3.73 | 10 | 3.00 | 38 | 4.36 | 88 | 3.86 |
| Cardiac failure | 226 | 21.06 | 71 | 21.32 | 193 | 22.13 | 490 | 21.51 |
| Respiratory failure | 450 | 41.94 | 139 | 41.74 | 412 | 47.25 | 1001 | 43.94 |
| Stroke | 77 | 7.18 | 19 | 5.71 | 64 | 7.34 | 160 | 7.02 |
| Septic shock | 58 | 5.41 | 18 | 5.41 | 57 | 6.54 | 133 | 5.84 |
| Other | 202 | 18.83 | 73 | 21.92 | 195 | 22.36 | 470 | 20.63 |

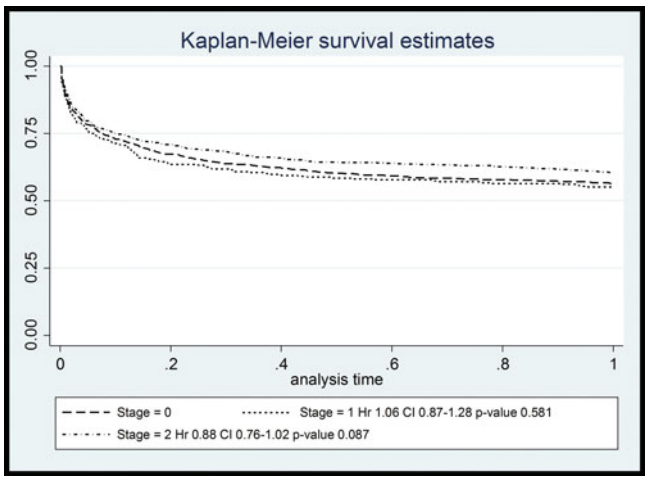


FIGURE 4. Kaplan–Meier survival estimate curves for survival before, during, and after the earthquake emergency (stages 0, 1, and 2, respectively). Figure reports hazard ratios and p-values.

TABLE 3. Percentages of code 2 and 3 patients taken to each hospital before and after the earthquake.

| Stage | Policlinico | NOCSAE | Total |
|---|---|---|---|
| 0 | 453 (51.65%) | 638 (45.54%) | 1091 (47.89%) |
| 1 and 2 | 424 (48.35%) | 763 (54.46%) | 1187 (52.11%) |
| Total | 877 | 1401 | 2,278 |
| | *p-value 0.004* | | |

Analysis performed using chi-squared test.

Amatrice, Accumoli, Pescara del Tronto, and the entire central Italy. The 27 deaths were caused by the collapse of buildings, mainly industrial facilities; however, the vast majority of structures, albeit often severely damaged, allowed the evacuation of the occupants to safe zones (12–14).

The main impacts of this earthquake were social, economic, and logistic: the populations of the towns located within the crater found themselves without homes at the beginning of a very warm season and mostly without jobs as well, as most industrial sites suffered blocks or delays to their activities; they also lacked medical services, since as mentioned, the spoke facilities at Carpi, Mirandola, and Finale Emilia have been taken out of commission (15).

Due to the peculiar characteristics of this natural disaster, with low mortality rates and higher infrastructure damages, it was necessary to measure the impact of the seismic events on the emergency response system with a more sensitive method: the management time of a case, from ambulance dispatch to hospital referral, can be considered a measure of the system's operative capacity, as already demonstrated in similar contexts (9–11).

Data suggest that before the earthquake, the management of code 2 and 3 cases was evenly divided between the two hub hospitals; whereas, after the second shock, on May 29, there was a steady rise in emergency department admissions at NOCSAE. This catastrophe has led to the reorganization of the local healthcare system to rely progressively more on the hub that was less involved in the seismic event, which is likely one of the key factors in keeping mortality and performance stable (16–19).

While the ambulance system was largely untouched by the earthquake, as shown by the unchanged intervention times, the reorganization of services that diverted a larger flow of code 2 and 3 patients to NOCSAE slightly lengthened emergency department treatment times. In fact, before the earthquakes, spoke hospitals received code 2 and 3 from their respective territories while afterward this traffic was diverted toward Policlinico and especially NOCSAE, as Policlinico was damaged.

Ambulance intervention times did not change significantly during the Stage 1, as much of the evacuation was carried out by dedicated rescue personnel that were not involved in the management of medical problems. There was a prompt response by Civil Protection, Army, Scouts, Veterans association, Red Cross that shared the burden of aiding civilians leaving ambulances, and medical personnel only for health-related issues. Moreover, roads were mostly intact and more in general, being a densely populated industrial region, in case a roadway was blocked alternative routes could easily be identified. Ambulance referral times,

TABLE 4. Ambulance referral times (ES) and emergency department treatment times (ED) in each hub hospital during the phases of the earthquake emergency including first line life-saving treatments and diagnostic procedures.

| Stage | Policlinico obs | Mean time ES | St.er | NOCSAE obs | Mean time ES | St.er |
|---|---|---|---|---|---|---|
| 0 | 415 | 46.78 | 4.90 | 608 | | 4.14 |
| 1 | 114 | 37.92 | 4.59 | 201 | 43.27 | 5.87 |
| 2 | 297 | 47.14 | 6.55 | 528 | 45.80 | 4.73 |
| *p-value* | | | 0.6693 | | | 0.9376 |
| Stage | Policlinico obs | Mean time ED | St.er | NOCSAE obs | Mean time ED | St. er |
| 0 | 280 | 293.18 | 17.80 | 413 | 334.12 | 14.19 |
| 1 | 65 | 414.80 | 40.40 | 121 | 411.48 | 27.26 |
| 2 | 159 | 412.77 | 24.16 | 317 | 443.77 | 24.16 |
| *p-value* | | | 0.0001* | | | 0.0000* |

Policlinico obs and NOCSAE obs refer to the number of patients admitted to/treated by Policlinico and NOCSAE with codes 2 and 3. St.er - Standard error.

moreover, did not increase significantly due to a likely reduction of the commercial vehicular traffic in the earthquake crater, which may have compensated the longer distances that had to be covered by the ambulances. The effect of the closure of spoke hospitals can be seen in the longer emergency department times, which accounts for the higher workload the two hub hospitals had to bear during the emergency.

Although the economic and social consequences of the earthquakes of 2012 in Emilia-Romagna were lasting and severe, the number of injured and killed was, fortunately, relatively low. The Kaplan–Meier survival estimate shows that there was no rise in mortality correlated with the seismic events of May 2011, because most of the collapses involved industrial buildings that at the time of the shocks were, in the large majority of cases, either empty or already evacuated. The healthcare system responded adequately, providing continuity in essential services and maintaining the same level of performance as before the event.

As the present results show, placing two hubs in a heavily populated territory and allowing for a certain degree of flexibility such that one can take over in case the other is damaged is a possible strategy to limit the consequences of such catastrophes. In this regard, the geographical placement of the hubs is important in order to minimize the chance of damage to both facilities.

Redundancy is a well-known principle in the design of intrinsically safe devices, but it comes at the price of having to invest resources in not-directly-needed replication of similar structures in two different portions of the same system and establishing a standard set of rules for their activation. The healthcare system can be, to a certain extent, considered a very complex—possibly the most complex—medical device, and redundancy has to be considered when planning for essential structures in densely populated areas (20–25).

Cost concerns often limit the degree to which this approach can be applied, however, making a system less resilient to unpredictable events. One possible approach to increasing the adaptability of systems in this context is investing in a form of flexible redundancy, where multipurpose facilities can be easily converted to a needed function with minimal effort. NOCSAE and Policlinico developed in tandem along these lines into a *Gestalt* system, with an essentially different mix of departments that share a common core around basic health needs (26).

One critical point in terms of this division of functions is the fact that Policlinico, which has the only neonatal intensive care unit in the province, also has maternal and child health departments, which are duplicated at the centers of Carpi, Mirandola and Sassuolo (i.e., both in the north, within the seismic crater, and in the south). Duplicating these services multiple times in the same territory may be impractical not only due to cost, but also due to the high level of specificity of these specializations. The risk of a medical system's involvement in a catastrophe greatly degrading its ability to provide health services can be mitigated by creating regional networks for the smooth referral of patients should one center be rendered largely or completely inoperative (27).

Another preventive measure is the hardening of structures to make them more resistant in case of earthquake. Policlinico hospital is a large complex of buildings that has been constantly growing since 1963, year of its opening. Renovation works were already in progress when the earthquake struck and were essential in preventing further damages. Structural safety of older buildings is a complex challenge, especially in contexts where critical society functions are located in facilities built when safety criteria were significantly different.

A limitation is the fact that hospital data was used to assess mortality, which may bias the estimate because it fails to identify community deaths that did not contact the emergency response system.

Another limitation of this study was by not including codes 1 and 4 in the analysis, because their sheer number can saturate the treatment capacity of an emergency department during a catastrophe distracting precious resources from codes 2 and 3. Systems for the assessment of mass casualties can in such circumstances help healthcare personnel prioritize cases. Fortunately, the 2012 earthquake had a low mortality; therefore, no mass casualty scenario arose.

However, in this regard, it is also important to note that Policlinico managed to reorganize its structures in the aftermath of the 2012 earthquakes to ensure adequate service, even if most of its structures were damaged. Renovation and structural hardening of Policlinico are currently in the process to ensure optimal safety for patients; most departments have experienced a reduction of beds. NOCSAE and Policlinico have merged at the end of 2016 from a management standpoint while maintaining their independence as structures.

The Carpi Hospital, main spoke facility, that served the northern part of the province, reopened the first departments 85 days after the earthquake and progressively returned to normal activity in the following months. An advanced medical post had been activated soon after the event to treat immediate casualties. The Mirandola Hospital reactivated the A&E and Radiology departments after approximately 45 days. The Finale Emilia Hospital was reopened approximately one year after the earthquake as an outpatient facility.

Finally, in considering the results of this study we should remember that, luckily, Emilia-Romagna's earthquake was different from other more catastrophic earthquakes in recent years, such as Irpinia, Abruzzo, and recently Amatrice, Accumoli, and Pescara del

Tronto: it had relatively low mortality, even as it undermined the provincial infrastructure in Modena, especially buildings, industry, and hospitals. The Modena medical system was redundant and ensured that disrupted emergency systems were reorganized and put back online while damaged hospital facilities were compensated for/reproduced elsewhere. This is fortunate, as human lives are not redundant.

## FUNDING

Institutional funds for spontaneous research of the University of Modena and Reggio Emilia.

## References


1. Scognamiglio L, Margheriti L, Mele FM, Tinti E, Bono A, De Gori P, et al. The 2012 Pianura Padana Emiliana seismic sequence: locations, moment tensors and magnitudes. Ann Geophys. 2012;55:549–59.
2. Forcellini D, Tarantino AM. Assessment of stone columns as a mitigation technique of liquefaction-induced effects during Italian earthquakes (May 2012). Sci World J. 2014;2014:216–78. doi:10.1155/2014/216278.
3. Botturi D, Caranci N, Pacelli B, Rodella S, Carrozzi G, Goldoni C. Il sisma del 2012 in Emilia. Una proposta di metodo per studiare l'impatto dei disastri naturali sulla salute [A method proposal to study the impact of disasters natural to health]. Agenzia sanitaria e sociale regionale dell'Emilia-Romagna [Regional Health and Social Agency Emilia-Romagna]. 2016. http://assr.regione.emilia-romagna.it.
4. Noji E. Disaster epidemiology. Emerg Med Clin North Am. 1996;14:289–300. doi:10.1016/S0733-8627(05)70252-2. PMID: 8635409
5. Waeckerle J. Disaster planning and response. N Eng J Med. 1991;324:815–21. doi:10.1056/NEJM199103213241206.
6. Hauf der Heide E. The importance of evidence-based disaster planning. Ann Emerg Med. 2006;47:34–49. doi:10.1016/j.annemergmed.2005.05.009. PMID:16387217
7. Lindell MK. Disaster studies. Curr Sociol. 2013;61:797–825. doi:10.1177/0011392113484456.
8. Nasiri M, Heidari M, Shahbazi S, Ansari E. Correlation of human resource strategies based on Allen Ylsy Model with organizational performance staff in Aiat Allah Kashani Hospital. J Health Promot Manag. 2013;2:36–44.
9. Nehme Z, Andrew E, Smith K. Factors influencing the timeliness of emergency medical service response to time critical emergencies. Prehosp Emerg Care. 2016;20:783–91. doi:10.3109/10903127.2016.1164776. PMID:27487018
10. Cortez E, Panchal A, Davis J, Keseg DP. The effect of ambulance staffing models in a metropolitan, fire-based EMS system. Prehosp Disaster Med. 2017;32:175–9. doi:10.1017/S1049023X16001539. PMID:28095934
11. Rajan S, Wissenberg M, Folke F, Hansen SM, Gerds TA, Kragholm K, et al. Association of bystander cardiopulmonary resuscitation and survival according to ambulance response times after out-of-hospital cardiac arrest. Circulation. 2016;134:2095–104. doi:10.1161/CIRCULATIONAHA.116.024400. PMID:27881566
12. Stabile T, Satriano C, Orefice A, Festa G, Zollo A. Anatomy of a microearthquake sequence on an active normal fault. Sci Rep. 2012;2:410. doi:10.1038/srep00410. PMID:22606366
13. Pacelli B, Caranci N, Carozzi G. Prima e dopo il sisma dell'Aquila: Le esperienze di sorveglianza epidemiologica post-terremoto in Italia [Before and after the earthquake of Aquila: Epidemiological Surveillance Experiences post-earthquake in Italy]. Epidemiol Prev. 2016;40:66–7. PMID:27291212
14. Ochi S, Nakagawa A, Lewis J, Hodgson S, Murray V. The Great East Japan Earthquake disaster: distribution of hospital damage in Miyagi Prefecture. Prehosp Disaster Med. 2014;29:245–53. doi:10.1017/S1049023X14000521. PMID: 24909238
15. Masedu F, Valenti M. I dati sulla mortalità all'Aquila: Poche evidenze, molte criticità [The Aquila mortality data: There are few evidences, many critical issues]. Epidemiol Prev. 2016;40:68–9. PMID:27291213
16. Ardagh MW, Richardson SK, Robinson V, Than M, Gee P, Henderson S, et al. The initial health-system response to the earthquake in Christchurch, New Zealand, in February, 2011. Lancet. 2012;379:2109–15. doi:10.1016/S0140-6736(12)60313-4. PMID:22510397
17. Schluter PJ, Hamilton GJ, Deely JM, Ardagh MW. Impact of integrated health system changes, accelerated due to an earthquake, on emergency department attendances and acute admissions: a Bayesian change-point analysis. BMJ Open. 2016;6:e010709. doi:10.1136/bmjopen-2015-010709. PMID:27169741
18. Babaje J, Moslehi S, Ardalan A. Rapid health needs assessment experience in 11 August 2012 East Azerbaijan Earthquake: a qualitative study. PLoS Curr Disasters. 2014;6(1).
19. Matsuoka T, Yoshioka T, Oda J, Tanaka H, Kuwagata Y, Sugimoto H, Sugimoto T. The impact of a catastrophic earthquake on morbidity rates for various illnesses. Pub Health. 2000;114:249–53. doi:10.1016/S0033-3506(00)00339-5.
20. Popovic M, Petrovic D. After the earthquake. Lancet. 1964;2:1169–71. doi:10.1016/S0140-6736(64)92690-X. PMID:14213587
21. Beinin L. An examination of health data following two major earthquakes in Russia. Disasters. 1981;5:142–6. doi:10.1111/j.1467-7717.1981.tb01097.x. PMID:20958491
22. Quarantelli EL. Organizational behavior in disasters and implications for disaster planning. Newark, DE: Disaster Research Center, University of Delaware; 1985. Report series 18.
23. Kaji AH, Waeckerle JF. Disaster medicine and the emergency medicine resident. Ann Emerg Med. 2003;41:865–70. doi:10.1067/mem.2003.10. PMID:12764344
24. Bambrick AT, Passman DB, Torman RM, Livinski AA, Olsen JM. Optimizing the use of chief complaint & diagnosis for operational decision making: an EMR case study of the 2010 Haiti Earthquake. PLoS Curr Disasters. 2014;6(1).
25. Lin L, Ashkenazi I, Dorn BC, Savoia E. The public health system response to the 2008 Sichuan province earthquake: a literature review and interviews. Disasters 2014;38:753–73. doi:10.1111/disa.12079. PMID:25196335
26. Babcock C, Theodosis C, Bills C, Kim J, Kinet M, Turner M, Millis M, Olopade O, Olopade C. The academic health center in complex humanitarian emergencies: lessons learned from the 2010 Haiti earthquake. Acad Med. 2012;87:1609–15. doi:10.1097/ACM.0b013e31826db6a2. PMID: 23018336
27. Chen B, Halliday TJ, Fan VY. The impact of internal displacement on child mortality in post-earthquake Haiti: a difference-in-differences analysis. Int J Equity Health. 2016;15:114–22. doi:10.1186/s12939-016-0403-z. PMID: 27435004