

# Comparison of Emergency Management Strategies for Nosocomial Infections Between Two Earthquakes

Xi-xi Li<sup>1,3</sup>, Mei He<sup>2\*</sup>, Dong Wang<sup>2</sup>, Hai-Yan Wang<sup>1</sup>, Jia Pu<sup>1</sup>

<sup>1</sup>Nursing department, Mianyang Central Hospital, School of Medicine, University of Electronic Science and Technology of China, Mianyang 621000, Sichuan Province, China

<sup>2</sup>Director's office, Mianyang Central Hospital, Mianyang 621000, Sichuan Province, China

<sup>3</sup>Doctor of Philosophy in Nursing, Philippines Women's University, 1743 Taft Avenue, 1004 Manila, 0900, Philippines

\*Corresponding author: Mei He, xixiismeok@126.com

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**Abstract:** Aim: Based on the experience of the 5.12 Wenchuan Earthquake and the 8.8 Jiuzhaigou Earthquake, the emergency management strategies for nosocomial infections were compared between the two earthquakes. The experience shared in the present study provides a guideline for the emergency medical rescue of future earthquake. *Methods:* The patients involved in this study were those injured in the earthquake and admitted to the hospital for treatment. As an earthquake relief center, the hospital participated in the emergency rescue work of the two recent major earthquakes in western China. Review analysis was carried out in the hospital's infection control experience adopted in the two major earthquakes. It was emphasized that, targeting the characteristics and difficulties in the prevention and control of nosocomial infection, different innovative infection control emergency strategies were adopted by the frontline disaster relief hospitals, under the special circumstances and medical conditions in an earthquake disaster. *Results:* According to the different focus of infection control in the two earthquakes, different hospital infection control strategies were adopted, and the incidence of nosocomial infections was effectively controlled.

**Keywords:** Earthquake; Medical rescue; Emergency responders; Prevention of nosocomial infection

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## 1. Introduction

China is one of the countries with the strongest earthquakes in the mainland, and 33% of the global earthquakes occur in mainland China <sup>[1]</sup>. After the earthquake, the high wound contamination rate among the wounded, the overloaded work of medical staff, the dense distribution of patients, and the poor conditions for diagnosis and treatment, have resulted in the outbreak of nosocomial infections. Rizk *et al.* found that increased rates of multidrug-resistant microbes have been reported after earthquakes <sup>[2]</sup>. As a result, the emergency management of nosocomial infections during post-disaster rescue still encounters extremely severe challenges <sup>[3]</sup>. According

to the distribution of major earthquake zones in China, western Sichuan is an earthquake-prone zone. At 14:28 on May 12, 2008, a 7.8 magnitude earthquake occurred in Wenchuan County, Aba Prefecture of Sichuan Province. At 21:19 on August 8, 2017, a 7.0 magnitude earthquake happened in Zhangzha Town, Jiuzhaigou County, Aba Prefecture of Sichuan Province. The hospital is the third-level comprehensive hospital closest to the above two earthquake-stricken areas, which served as the treatment center for the critically injured people in these two earthquakes, and actively participated in the earthquake disaster treatment and infection control. In the current study, the different infection emergency management strategies adopted by the hospitals after the two earthquakes were compared to provide guideline for the infection prevention and control at disaster relief hospitals.

## 2. Comparison of disasters between the two earthquakes

After comparing the last two strong earthquakes in western Sichuan, it was discovered that there existed difference in terms of the scope of the earthquake, the affected area, and the situation of the wounded. It was obvious that the 5.12 Wenchuan Earthquake was severely damaging. It severely damaged a scope of over 100,000 square kilometers and was the most destructive earthquake since the founding of the People's Republic of China (PRC). By contrast, the Jiuzhaigou Earthquake was relatively less harmful. After the Wenchuan earthquake, the local disaster preparedness and mitigation capabilities were strengthened, which partially explained for the more orderly relief of the Jiuzhaigou earthquake. Given the frequent occurrence of earthquakes in recent years, various parts of the country and the news media have paid close attention to the situation of earthquake relief. More detailed comparisons between the two earthquakes are displayed in **Table 1**.

**Table 1.** Basic situation of the last two strong earthquakes in western Sichuan

Event	5.12 Wenchuan Earthquake	8.8 Jiuzhaigou Earthquake
Time	14:28 May 12, 2008	21:19 August 8, 2017
Earthquake level (Lee)	8.0	7.0
Intensity (degrees)	11	9
Sphere of influence	The 29 provinces (municipalities, autonomous regions) across the country have felt the earthquakes to varying degrees, with Sichuan, Gansu, and Shaanxi provinces experiencing the most severe earthquakes.	The quake was felt strongly in villages and townships within 5–20 kilometers, including Lanzhou, Chengdu, Chongqing, and Xi'an.
Affected area (km <sup>2</sup> )	50.0	1.8
Affected area	There are 10 counties (cities) in extremely severely stricken areas, 41 counties (cities, districts) in severely stricken areas, and 186 counties (cities, districts) in general disaster areas.	The scenic spot is the hardest hit area due to the concentration of population, and the villages in other areas are sparse, and the overall population density is low, so the impact is small.
Affected population (10,000)	4624	17.6
Number of deaths	69227	25
Number of injured	374643	525
Emergency response level	Level I	Level I
Earthquake early warning mechanism	No	Early warnings are sent through radio, television, and other media.

\*The data in the table comes from the website of China Earthquake Administration, <http://www.cea.gov.cn>

### **3. Comparison of the participation of the hospital in the two earthquakes as an earthquake relief center**

The following aspects were discovered when comparing the emergency rescue situation of our hospital between the two earthquakes.

- (1) The degrees of damage to hospital buildings and functions varied. The 5.12 Wenchuan earthquake caused serious damage to various medical emergency related houses and facilities, and over 1300 inpatients were forced to leave the inpatient building. Comparatively, the hospital buildings were not damaged in the 8.8 Jiuzhaigou earthquake.
- (2) The places for medical rescue were different. After the 5.12 Wenchuan earthquake, a large number of earthquake-wounded patients flew into the hospital within a short period of time. Temporary tents were set up on the square, as well as three temporary operating rooms. After the 8.8 Jiuzhaigou earthquake, bone injuries among the wounded accounted for 64.6% according to the preliminary assessment, and the leading team coordinated and vacated 60 beds in the orthopedic ward for the centralized treatment of the earthquake-wounded patients.
- (3) The number and composition of patients admitted were different. During the 5.12 Wenchuan earthquake, our hospital treated a total of 1941 injured people, including over 900 critically ill patients, and all of them were the local residents. During the 8.8 Jiuzhaigou earthquake, our hospital successively transferred and treated 5 batches of earthquake victims ( $n = 48$ ), including 10 local residents (20.83%), and 38 tourists (79.17%) from all over the country and abroad.

### **4. Comparison of the characteristics of nosocomial infections after the two earthquakes**

Insufficient awareness of the risk of infection may lead to improper application of preventive measures <sup>[4]</sup>. Consequently, after the two earthquakes, the hospital fully evaluated the risk of nosocomial infections. The challenges related to nosocomial infections encountered by the hospital in the 5.12 Wenchuan earthquake were as follows.

- (1) The debridement of open contaminated wounds was delayed, because the first life channel was opened at 79-hour after the earthquake, and the wounded were buried or rescued for a long time.
- (2) A large number of wounded were transported to the hospital within a short period of time after the earthquake, resulting in the relatively insufficient medical staff and medical supplies, making it difficult to implement routine measures at the early stage of treatment.
- (3) The simple outdoor ward was poor under the early post-earthquake conditions, with water shortage. Additionally, the wounded lived in a crowded area, where the infected and non-infected wounded were not treated strictly by district.
- (4) The hospital had poor response capacity to the earthquakes, the corresponding emergency equipment and drugs were lacking, and there were defects in the disinfection work procedures.

In the 8.8 Jiuzhaigou earthquake, as the epicenter was located in a national-level scenic spot, the injured came from all parts of the country and even abroad, thus exerting a tremendous influence. Therefore, the state and governments at all levels paid great attention to this earthquake. The leaders were very concerned about this earthquake, and there were tremendous interviews from the news media. In addition, the medical experts at all levels for rounds and consultations, the supportive and coordinated medical logistic staff, caring staff and rescue workers from all walks of life, and volunteers resulted in the rapidly increasing density and mobility of personnel in the dedicated wards. This had brought severe challenges for the prevention and control of

nosocomial infections. The list of mobile personnel is shown in **Table 2**.

**Table 2.** Rough statistics on the total number of floating populations in dedicated wards one week after the earthquake

Personnel category		Frequency	Number of personnel
Medical expert team	Hospital level	80	300
	City level	15	45
	Provincial and above	6	16
Administrative logistics staff	Canteen	21	65
	Transshipment center	120	120
	Security guard	20	45
	Care workers	15	150
	Cleaning worker	15	50
News media		27	50
Leaders		30	100
Volunteer	Inside the hospital	15	80
	Outside the hospital	20	100
Social worker		10	20
Family members		-	96
Total		394	1237

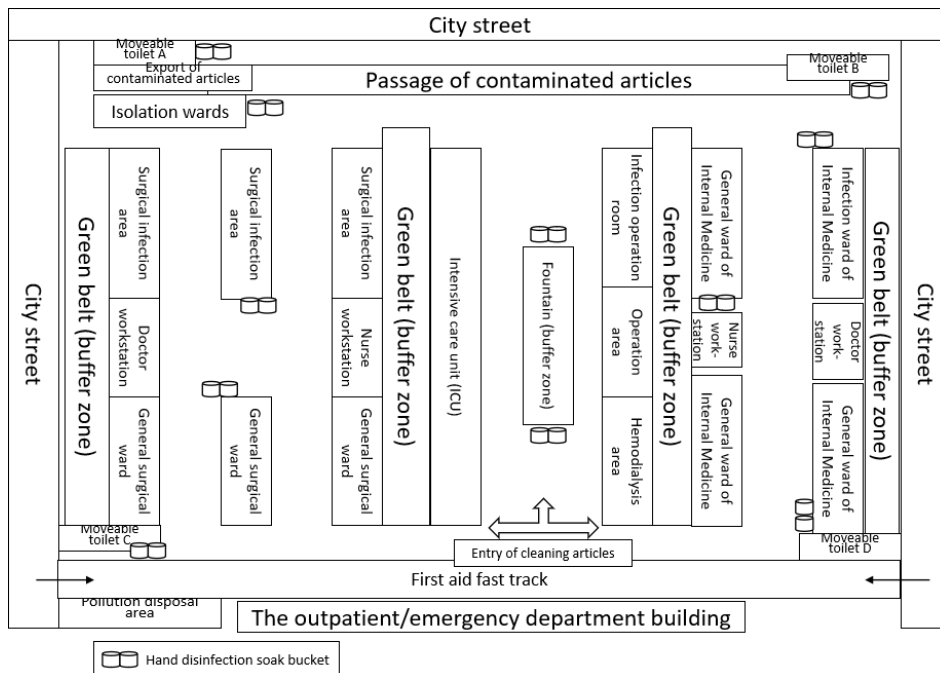
## 5. Comparison of the emergency management strategies for nosocomial infections after the two earthquakes

Different strategies were adopted for the emergency management of nosocomial infections after the two earthquakes. The special strategies for the emergency management of nosocomial infections after the 5.12 Wenchuan earthquake were as follows.

- (1) A 6000-square-meter “tent ward” was planned timely, which was divided into the first-class environment (including intensive care unit [ICU] area, surgery area, and hemodialysis area), second-class environment (surgical area and internal medicine area), third-class environment (the infected area), and fourth-class environment (the quarantine area), as presented in **Figure 1**.
- (2) The routine, temporary, and terminal disinfection managements were adopted for environmental sanitation in the tent ward. The fixed person was responsible for ground cleaning and tent disinfection, and the environment around the tent ward was sprayed with a disinfectant containing 500–1000 mg/L available chlorine for twice to thrice a day. When treating the wounded with obvious infections, the disinfection was temporarily strengthened. Besides, the tent doors and windows were opened for natural ventilation and air circulation.
- (3) The pre-check triage point was moved forward. The pre-hospital reception shed was set up at the station and the airport, and the pre-hospital pollution treatment area was set up at 50m away from the wounded resettlement area. Those contaminated wounds were cleaned with clean water and 3% hydrogen peroxide solution before admission to the hospital, replaced with the patient clothes or covered with clean sheets before they were sent to the ward.
- (4) Hand hygiene management of medical staff was strengthened. There was no running water in the tent ward. The nurse station and the treatment vehicle were equipped with a 500mL large package of quick-drying hand disinfectant. At the same time, there was a 100mL small package of quick-drying hand disinfectant on each door. Medical staff disinfected their hands immediately before and after

touching each of the wounded.

- (5) The Chinese medicine decoction for preventing respiratory and digestive tract infections were distributed among the wounded, their family members, and medical staff of the hospital every morning and afternoon.
- (6) Special management of medical wastes was executed. To be specific, all medical wastes and domestic wastes in the tent ward were included in the medical waste disposal. All garbage from patients with special infections were collected by special personnel into the double-layer medical waste bags with the warning signs of “Special Infection,” and treated specially. Afterwards, the medical wastes were sealed and transferred to the temporary storage point by special cars along the special routes.



**Figure 1.** Plan for “tent wards” in Mianyang Central Hospital

The following strategies were adopted for the management of nosocomial infections among the mobile workers after the 8.8 Jiuzhaigou earthquake.

- (1) The ward was semi-closed, and a visit registration system and a visit schedule were established. The dedicated ward for the earthquake wounded was managed in a semi-open manner, all social personnel who visited or sympathized with the wounded were reviewed and registered as required, and those with infections were not allowed to visit. In addition, visitors from news media units were coordinated and arranged by the hospital, and they shared news materials with the hospital’s news office to avoid repeated interviews.
- (2) A special reception office was set up in front of the hospital. A special receptionist was responsible for conducting health education, and infection control and education on various groups of people, while introducing the precautions during the accompany visits, so that the social visitors visited and comforted the earthquake victims in an orderly manner.
- (3) The circulation route of visitors was planned to limit the number and time of visit. There were a total of 6 fire passages and 12 elevators in the ward. One-way entrances and exits were set up to limit the flow of personnel. The number of visitors in each batch was limited as required, and good doctor-patient communications were made.

- (4) Relatives of the wounded were properly placed in a nearby hotel for rest, and caregivers and volunteers were also deployed as needed. Unless otherwise specified, no more than one family member or companion was left in each period. The appropriate number of nursing staff and volunteers were allocated according to the self-care ability of the wounded evaluated by the nurses using a scale, aiming to prevent excessive accompanying staff.

## 6. Implementation results

During the 5.12 Wenchuan earthquake, a total of 1557 patients with earthquake injuries were treated in the hospital, including 137 with community acquired infections (9.67%). In the tent operating room and debridement room, a total of 989 emergency operations were performed for the earthquake-stricken and non-earthquake-wounded patients. Among them, cesarean section, ectopic pregnancy, and other operations all achieved grade A healing. In addition, more than 950 contaminated surgeries were carried out. One case was diagnosed with *Bacillus gasoformans* infection and treated as gas gangrene infection. Fortunately, the infection was effectively controlled after surgery and isolation treatment. There was no epidemic or local outbreak of nosocomial infection, and no cross-infection was observed among the wounded. Among the 48 earthquake victims admitted to the hospital during the 8.8 Jiuzhaigou earthquake, 40 were seriously injured (83.33%). Meanwhile, 2 out of the 45 cases with open fractures had community acquired infections and were effectively treated. In addition, 32 operations were performed, and no postoperative site infection occurred. No other patient had nosocomial or specific infection, and there was no nosocomial infection or local outbreak in the hospital.

## 7. Discussion

The earthquake not only changes the ecological environment, but also alters the conditions for treatment<sup>[5]</sup>. Combined with multiple fractures or multidrug-resistant pathogens, infection has become one of the most common causes of death among the earthquake victims<sup>[6]</sup>. As confirmed in a large number of studies, after the earthquake disaster, the early intervention of infection control, assessment of infection risk, improvement of medical conditions, strict bedside isolation, reinforcement of monitoring management and ward management of nosocomial infections, and strengthening of disinfection and sterilization effect monitoring are the key to prevent nosocomial infections<sup>[7,8]</sup>. In the two earthquake emergency rescue processes that our hospital participated in, the following countermeasures were implemented with reference to the above nosocomial infection control principles and related policies. Firstly, immediately after the earthquake, the director of the hospital set up a working team to enhance the nosocomial infection management. The control and management of nosocomial infections were carried out while giving intensive treatment for the earthquake injuries. A temporary diagnosis and treatment team composed of infection professionals went into the ward every day to investigate cases with fever over 38°C and diarrhea. Moreover, the “Daily Report on Earthquake Nosocomial Infection Information” was compiled, and the hospital infection information was also compiled and recorded daily. Secondly, division and classification management of the wounded were implemented. The wounded were separated according to the presence of mild or severe injuries, before or after surgery, suspected infected wounds or general wounds, and ordinary or infected for specially infected wounds. In addition, contact isolation measures were also strictly implemented. Thirdly, the layout of treatment environment, the flow of people, and the logistics from cleaning to pollution were planned. Meanwhile, the infected areas, medical waste disposal areas, and toilets were kept away from the clean areas. Fourthly, meals for the earthquake victims and their

relatives were provided by the cafeteria. Supervision of diet hygiene was strengthened to ensure the food safety and hygiene and to prevent the spread of intestinal infectious diseases. Lastly, eye-catching and easy-to-understand hand hygiene signs and procedures were posted at the entrance and exit of the ward, and a special person was in charge of supervising the hand hygiene among the personnel in and out.

Environment and the organizational behaviors are complex and constantly changing. This inherent property has added to the difficulties in effective management, as a result, there is no uniform theory or method for all situations<sup>[9]</sup>. After a large earthquake occurs, the management environment and conditions have changed. To ensure the implementation of management objectives, the management plan, model, and method will change accordingly. For example, during the 5.12 Wenchuan earthquake, the entire operating system of the hospital was almost paralyzed. In the emergency state, the quick-drying hand disinfectant was temporarily in short supply. To compensate for the temporary lack of hand disinfectant, several 10cm × 10cm sanitized gauze or paper towels were soaked with 75% alcohol and placed into a clean container with a lid, so that the medical staff were able to wipe and disinfect their hands before and after the wound diagnosis and treatment, which overcame the problem of rapid hand disinfection. As the front-line portal hospital for treating the wounded during the “5.12 Wenchuan Earthquake,” the hospital building was damaged by the earthquake and the good medical environment and conditions were destroyed. In the meantime, considering the large number of wounded and sick people, together with the necessity to construct the temporary new wards, the “tent ward” infection management sanitation process and program were planned to control the outbreak of infection, which were praised by the professionals from all sides<sup>[10]</sup>. However, the experience of each earthquake medical emergency rescue cannot be duplicated or repeated. Different from the “tent ward” program of the 5.12 Wenchuan earthquake, a dedicated ward with open environment was adopted for the wounded in the post-disaster treatment of the 8.8 Jiuzhaigou earthquake. There were many visitors in the hospital, causing insufficient air circulation due to the relatively small ward space. Besides, the high-density mobile populations also prompted various pathogenic microorganisms to attach to the fine dust and flow with the air. In addition, most of the 48 earthquake victims admitted to our hospital had open wounds and were associated with a high risk of nosocomial infections. Nosocomial infection management broke away from the conventional model of hospital ward prevention and control, bringing new problems to nosocomial infection management. At present, there is no report on the targeted hospital management for a large number of mobile people in a ward after the disaster. Based on the valuable experience of nosocomial infection prevention and control in the previous earthquake rescue, the principle and flexibility were adhered to actively explore and innovate the corresponding measures. In the disaster rescue together with infection prevention and control of the 8.8 Jiuzhaigou earthquake, a series of positive measures were taken, such as semi-closed management of dedicated wards, establishment of a visit registration system, founding of a dedicated reception office, sharing of news materials with the media, assignment of special personnel responsible for education and sensory control, planning of the visitor circulation, evacuation of the stranded people in the ward, along with deploying carers and volunteers as needed. These measures effectively reduced the flow of people in the ward and ultimately controlled the occurrence of nosocomial infections. These were praised by the international medical help team as a miracle in fighting the disaster.

Any hidden danger of infection may induce the outbreak of nosocomial infections and cause secondary damage to the earthquake. In the medical treatment during the earthquake, it is extremely important to control nosocomial infections and prevent infectious disease epidemics, which are as important as the treatment of earthquake injuries. The earthquake will not take the lives of the survivors, let alone allow the pathogenic bacteria to devour the lives of the wounded. The infection control is mainly carried out to prevent death<sup>[11]</sup>. In a major earthquake disaster, under the special circumstances and medical conditions, nosocomial infection

management professionals must respond to the local conditions in a flexible manner. A series of effective and efficient emergency strategies for infection control should be created under the principle of science, and used to actively prevent and control infection outbreaks in the process of earthquake relief in order to ensure the medical safety.

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## Disclosure statement

The authors declare no conflict of interest.

## Author contributions

X.L. conceived the initial idea of the paper and wrote the draft. M.H. designed and implemented the study. D.W. critically revised the initial drafts. H.Y.W. collected and analyzed the data. J.P. retrieved the document.

## References

- [1] Pan WJ, Zhai GF, 2022, The Whole Process of Urban Earthquake Risk Management. *Disaster Prevention Expo*, 6(4): 101–104.
- [2] Rizk A, Abou Fayad A, Haraoui LP, 2023, Antimicrobial-Resistant Infections after Turkey/Syria Earthquakes, 2023. *Emerging Infectious Diseases*, 29(6): 1273–1275. <https://doi.org/10.3201/eid2906.230316>
- [3] Reina Ortiz M, Le NK, Sharma V, *et al.*, 2017, Post-Earthquake Zika Virus Surge: Disaster and Public Health Threat Amid Climatic Conduciveness. *Scientific Reports*, 7(1): 15408.
- [4] Khan AA, 2020, Emergency Medical Services Providers' Experiences and Attitudes Toward Infection Prevention and Control Measures in Saudi Arabia: a Qualitative Study. *Disaster Medicine and Public Health Preparedness*, 14(6): 713–718.
- [5] Suneja A, Gakh M, Rutkow L, 2018, Burden and Management of Noncommunicable Diseases After Earthquakes and Tsunamis. *Health Security*, 16(1): 30–47.
- [6] Xie H, Min TU, Dongyun AI, 2008, Prevention and Control Strategies of Nosocomial Infection in Earthquake Wounded Ward. *Journal of Nursing Science*, 23(18): 18–19.
- [7] Anshori F, Kamal AF, Prabowo Y, *et al.*, 2023, The Outcome of Orthopedics Treatment of Lombok Earthquake Victim 2018: A Cohort of One-Year Follow-Up Study-Lesson Learned After Lombok Earthquake. *Orthopedic Research and Reviews*, 2023(15): 91–103. <https://doi.org/10.2147/ORR.S387625>
- [8] Liu-Yi LI, Ying-Hong WU, Yang XS, 2013, Infection Control in the Early Stage of Treatment of Earthquake Victims. *Chinese Journal of Nosocomiology*, 23(17): 4225–4227.
- [9] Izumikawa K, 2018, Infection Control After and During Natural Disaster. *Acute Medicine & Surgery*, 6(1): 5–11.



- [10] Feng Q, Wang D, Yang W, *et al.*, 2008, Prevention and Control of Nosocomial Infection in Medical Treatment Process After “5.12” Wenchuan Earthquake. *Chinese Journal of Infection Control*, 7(4): 225–228.
- [11] Liu CG, 2021, Prevention and Control of Orthopedic Surgical Incision Site Infection. *Chinese Science and Technology Journal Database (full text version) Medicine and Health*, 2021(1): 42–45.

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