

## **Field Study in Kure City, Hiroshima Prefecture, After Torrential Rains Triggered Massive Flooding and Landslides in Western Japan In 2018**

**Youichi Yanagawa\* MD, PhD, Hiroki Nagawasa MD, Ikuto Takeuchi MD, Kei Jitsuiki MD, Shunsuke Madokoro MD, Hiromichi Ohsaka MD. PhD, Kouhei Ishikawa MD.PhD, Kazuhio Omori MD.PhD, Renpei Yanagawa MD.PhD, Toshiya Ogawa MD.PhD**

Department of Acute Critical Care Medicine, Shizuoka Hospital, Juntendo University, Kure Hospital, Self Defense Force

### **Original Research Article**

**\*Corresponding author**

*Youichi Yanagawa*

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**Abstract:** Heavy rain in July 2018 resulted in the highest rain accumulation in western Japan in meteorological observation history, and these torrential storms triggered massive flooding and landslides in western Japan, with Hiroshima Prefecture hit the worst. A member of the Shizuoka Medical Research Center for Disaster visited Kure City, which reported the most fatalities in Hiroshima Prefecture, to perform a field study to identify medical issues and aid in relief efforts. This member collected information on medical organizations and problems associated with the Emergency Medical Information System established by the Ministry of Health, Labour and Welfare and interviewed staff at Kure Hospital as well as members of the Japan Self Defense Force and Kure City Hall employees. The local headquarters of the disaster medical assistance team (DMAT) in Kure City was established at Chugoku Rosai Hospital. As there were no outstanding medical demands at the disaster base hospitals of Kure City or in the medical facilities or refugee sites, aside from requests for psychological first aid, the local headquarters of the DMAT in Kure City was dissolved on July 9, 2018. The main issue reported by medical facilities was the water supply in Kure City being cut off, which forced most medical facilities to reduce their medical services. However, the Self Defense Forces Kure Hospital, which had its own water source, was not damaged by these heavy rains. As a result, the Self Defense Forces Kure Hospital provided standard medical services after the disaster. The Hiroshima prefectural government carefully managed the water resources in Kure City, allowing the medical facilities to use the minimum level of water supply from industries. The present survey showed that damage to the water supply by landslides can have a profound influence on the function of hospitals, even if the hospitals themselves are undamaged. The disruption and reduction of hospital functions in the event of a disaster may be minimized by ensuring the proper maintenance of water supply facilities and/or enacting agreements regarding water supply and formulating strategic water allocation plans in preparation for a long-term interruption of water services.

**Keywords:** rain; landslide; water supply.

### **INTRODUCTION**

The relationship between climate change and its potential effects on the stability of slopes remains an open issue [1]. Global warming-induced extreme climatic changes have increased the frequency of severe typhoons, bringing heavy rains, floods and landslides [2]. On July 6, 2018, the Japan Meteorological Agency issued a special warning for heavy rain with the possibility to induce floods and landslides, as back-building storms induced by a seasonal rain front stimulated by typhoon N0.7, 2018 carried a risk of causing torrential rain in western Japan. This storm resulted in the highest rain accumulation in western Japan in meteorological observation history (**Figure 1**), receiving the name "Heavy Rain in July 2018" from the Japan Meteorological Agency. This torrential rain

triggered massive flooding and landslides in western Japan, with some 27,000 households in 29 prefectures hit by flooding, and the death toll has risen to 219, with 22 people still missing according to the report from the National Police Agency and Ministry of Internal Affairs and Communications issued on July 15, 2018. The fatalities were concentrated in western Japan (**Figure 2**). Worst hit was Hiroshima Prefecture, followed by Okayama and Ehime Prefectures. The most common causes of death were drowning, suffocation due to mud and crushing due to a collapsed house. On July 15, 2018, a member of the Shizuoka Medical Research Center for Disaster visited Kure City, which reported the most fatalities in Hiroshima Prefecture, to perform a field study to identify medical issues and aid in relief efforts.

## **METHODS**

The protocol of this study was approved by our institutional review board, and the examinations were conducted according to the standards of good clinical practice and the Helsinki Declaration.

This member collected information on medical organizations and problems associated with the Emergency Medical Information System established by the Ministry of Health, Labour and Welfare and interviewed staff at Kure Hospital as well as members of the Japan Self Defense Force and Kure City Hall employees.

## **RESULTS**

In response to this heavy rain, the Hiroshima prefectural government established the main headquarters of medical health adjustment (Figure 3). The main headquarters consisted of a disaster medical assistance team (DMAT) and a medical measures party. The DMAT is a medically trained team consisting of doctors, nurses and co-medical personnel dispatched to an affected area immediately after a disaster to provide acute care to victims[3]. The members of the DMAT usually work at a disaster base hospital, which plays an important role in preparing for and managing disasters. Such facilities are required to have a quake-resistant construction and firm lifelines, as they will become the center for accepting patients or dispatching necessary personnel when a disaster occurs.

The main headquarters of the DMAT in Hiroshima Prefecture included an Action Coordination Totality (ACT) Disaster Psychiatric Assistance Team (DPAT), activity conductors presiding over the Hiroshima as well as Kure and Bisan areas, refugee sites, hemodialysis equipment, and supplies and communication resources. The medical measures party included the Japan Medical Association Team (JMAT), Japan Red Cross team and Japan Rehabilitation Assistance Team (JRAT). In the acute phase, the disaster hospitals in Hiroshima hospital treated the some wounded patients who had been rescued from collapsed houses. However, most victims were founded dead in collapsed houses due to landslides, with their lives being impossible to save by medical treatment. Accordingly, no marked increase in medical demands was recognized by the Hiroshima prefectural government aside, from requests for psychological first aid at refugee sites.

Kure City, which reported the most fatalities in Hiroshima Prefecture, temporarily became inaccessible

by land because the main roads were cut off by landslides (Figure 4). Kure Line, belonging to the Japan Railway Company, was also stopped by landslides (Figure 5). However, such landslides were limited inside Kure City itself, and most citizens were able to go about life as usual aside for having a restricted water supply. The local headquarters of the DMAT in Kure City was established at Chugoku Rosai Hospital and consisted of staff members of Chugoku Rosai Hospital and Kure Kyosai Hospital.

As there were no outstanding medical demands at the disaster base hospitals of Kure City or in the medical facilities or refugee sites, aside from requests for psychological first aid, in the acute phase of the disaster, the local headquarters of the DMAT in Kure City was dissolved on July 9, 2018, followed by the dissolution of the main headquarters of the DMAT by the Hiroshima prefectural government. Because demands for psychological first aid at refugee sites in Kure City persisted, the DPAT was asked to respond by the Hiroshima prefectural government.

The main issue reported by medical facilities was the water supply in Kure City being cut off. As the main water pipes had been damaged by landslides and the transportation of water using trucks was impossible due to the roads being cut off, the people in Kure City—including the medical facilities—struggled with water shortages shortly after the disaster. Among 101 medical facilities, at least 46, including the 3 disaster base hospitals, faced water shortages. As a result, most medical facilities were forced to reduce their medical services, as many aspects of patient care were now impossible (e.g. toilet usage, bathing patients, cleaning surgical instruments, endoscopy, hemodialysis, and infection control) and drinking water for the staff was unavailable. However, the Self-Defense Forces Kure Hospital, which had been established in 1898 at Kure Naval Base and experienced two world wars, had its own water source supplied by rigid water pipes running deep underground to prevent damage by bombing runs and had therefore not been damaged by the heavy rains. As a result, the Self-Defense Forces Kure Hospital provided standard medical services after the disaster, and Kure Naval base provided water and bath services to Kure City citizens. The Hiroshima prefectural government carefully managed the water resources in Kure City, allowing the medical facilities to use the minimum level of water supply from industries.

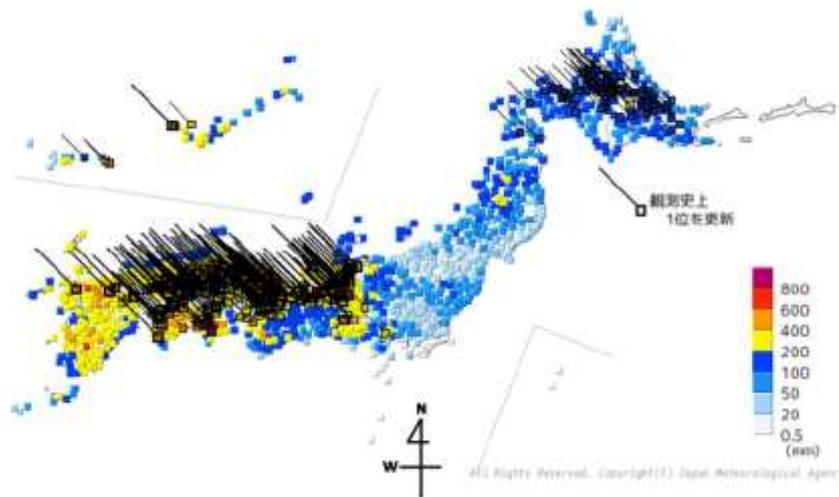


Fig-1: Maximum amount of rainfall over 72 h from June 28 to July 8, 2018. In western Japan, many places recorded the largest volume of rain accumulation in meteorological observation history (bar: place of the largest volume of rain accumulation). Data from Japan Meteorological Agency ([https://www.jma.go.jp/jma/press/1807/09b/20180709\\_sankou.pdf](https://www.jma.go.jp/jma/press/1807/09b/20180709_sankou.pdf))

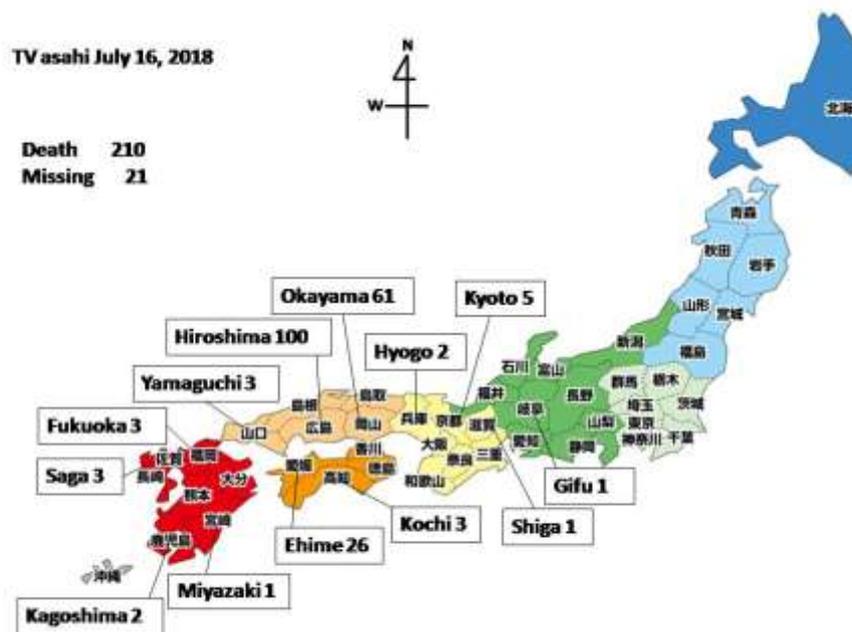
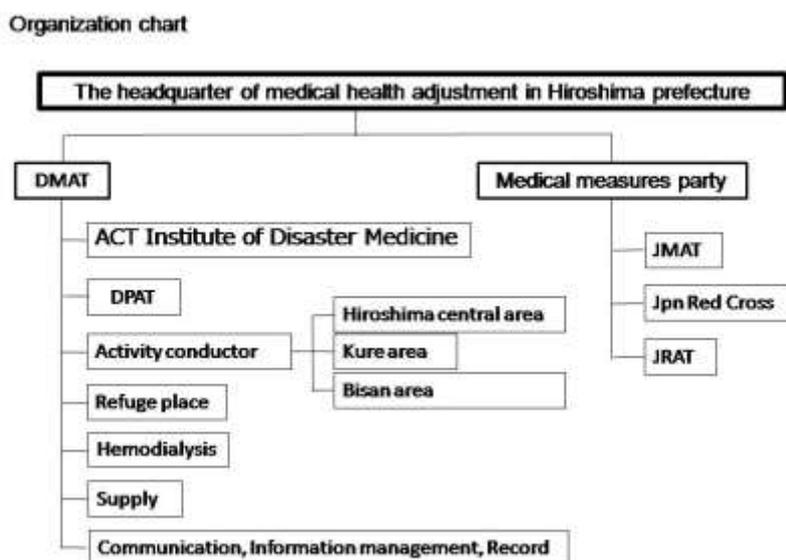


Fig-2: Distribution of fatalities due to heavy rain in July 2018 in each prefecture in Japan. The fatalities are concentrated in western Japan, with the worst in Hiroshima Prefecture, followed by Okayama and Ehime Prefectures



**Fig-3: Organization chart showing the headquarters of medical health adjustment in Hiroshima Prefecture. The main headquarters consisted of a disaster medical assistance team (DMAT) and a medical measures party. The DMAT includes an Action Coordination Totality (ACT) Disaster Psychiatric Assistance Team (DPAT), activity conductors presiding over the Hiroshima as well as Kure and Bisan areas, refugee sites, hemodialysis equipment, and supplies and communication resources. The medical measures party included the Japan Medical Association Team (JMAT), Japan Red Cross team and Japan Rehabilitation Assistance Team (JRAT).**

DMAT: Disaster Medical Assistance Team  
 ACT: Action Coordination Totality  
 DPAT: Disaster Psychiatric Assistance Team  
 JMAT: Japan Medical Association Team  
 JRAT: Japan Rehabilitation Assistance Team



**Fig-4: Landslide in Kure City. A landslide damaged the town**



**Fig-5: Landslide in Kure City. Kure Line, belonging to the Japan Railway Company, was also stopped by landslides**

## DISCUSSION

This study shows that landslides can damage water pipes, resulting in the loss of the water supply and adversely influencing the work of medical facilities.

Extreme weather can cause substantial adverse socio-economic effects by damaging and disrupting the infrastructure services that underpin modern society[4]. Major causative factors for floods and landslides are heavy and continuous rainfall, outburst floods, infrastructure failure, and deforestation[5]. Water-induced disasters can kill hundreds of people and affect thousands directly[5]. Kure City experienced no outburst floods, infrastructure failure, or deforestation, only suffering heavy and continuous rainfall—likely due to global warming—that triggered landslides. Not only water pipelines but also power and telephone lines were damaged by the landslides. However, the power lines were easily restored using poles, and a temporary telephone relay center was used to replace the damaged telephone lines; as such, electrical power and communication were restored relatively quickly. However, the reconstruction of water pipelines requires digging and placing pipelines underground, so such repairs can take some time to complete. As a result, securing the water supply became a serious problem in Kure City following the heavy rains of July 2018.

Water shortages can strongly influence hospital management practices. In addition to a shortage of drinking water for admitted patients and medical facility staff members, surgical instruments and endoscopes could not be sterilized, so operations and endoscopy examinations could not be performed. These problems have already been recognized in association with chemical pollution of water sources[6]. In addition, in the Great East Japan Earthquake of 2011, even Japanese disaster base hospitals were unable to

draw well water for a brief period, and hospitals whose water supply facilities were damaged experienced significant disruption to dialysis, sterilization equipment, meal services, sanitation, and outpatient care services[7].

Continuing dialysis for patients with end-stage renal disease and managing patients suffering from crush syndrome following earthquakes is a serious problem, as hemodialysis, a life-sustaining therapy for patients with acute or chronic renal failure, requires a large amount of water. However, many dialysis centers were unable to perform dialysis treatment due to damage caused by the Great East Japan Earthquake. A survey conducted by the Japanese Society for Dialysis Treatment after the Great East Japan Earthquake showed that failure of lifelines, such as electric power and water supply, was the leading cause of malfunction of dialysis treatment[8]. One hospital in Shizuoka Prefecture, which is predicted to be at risk of a large earthquake in the near future, has not only constructed earthquake-resistant buildings and facilities, but also adopted back-up electric and water lifelines by introducing emergency generators and well water supply systems. Hospital emergency preparedness planning can be enhanced by specifying alternative sources of potable water sufficient for hemodialysis, infection control, and hospital processing and cleaning needs. Physicians cannot prevent all disasters, and global warming is a political issue, but the extent of a disaster can be curbed by proper preparation, including preparations for landslides[9].

## CONCLUSION

The present survey showed that damage to the water supply by landslides can have a profound influence on the function of hospitals, even if the hospitals themselves are undamaged. The disruption

and reduction of hospital functions in the event of a disaster may be minimized by ensuring the proper maintenance of water supply facilities and/or enacting agreements regarding water supply and formulating strategic water allocation plans in preparation for a long-term interruption of water services.

#### **CONFLICT OF INTEREST STATEMENT**

The authors declare no conflicts of interest in association with this study.

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