CASE REPORT

Wilderness Mass Casualty Incident (MCI): Rescue Chain After Avalanche at Everest Base Camp (EBC) In 2015

Ken Zafren, MD; Anne Brants, MD; Katie Tabner, BMBS; Andrew Nyberg, MD; Matiram Pun, MBBS; Buddha Basnyat, MD; Monika Brodmann Maeder, MD

From Department of Emergency Medicine, Stanford University Medical Center, Stanford, CA (Dr Zafren); Department of Emergency Medicine, Alaska Native Medical Center, Anchorage, AK (Dr Zafren); Himalayan Rescue Association, Kathmandu, Nepal (Drs Zafren and Basnyat); Department of Emergency Medicine, Canisius-Wilhelmina Hospital, Nijmegen, The Netherlands (Dr Brants); Outdoor Medicine, Woudrichem, The Netherlands (Dr Brants); NHS Education for Scotland, Caledonian Programme, Inverness, Scotland (Dr Tabner); Department of Emergency Medicine, Intermountain Park City Hospital, Park City, UT (Dr Nyberg); Intermountain Heber Valley Hospital, Heber City, UT (Dr Tabner); Mountain Medicine Society of Nepal, Kathmandu, Nepal (Dr Pun); Division of Mountain Medicine and High Altitude Physiology, Department of Physiology and Pharmacology, University of Calgary, Calgary, Canada (Dr Pun); Oxford Clinical Research Unit – Nepal, Kathmandu, Nepal (Dr Basnyat); Department of Emergency Medicine, University Hospital Inselspital, Bern, Switzerland (Dr Brodmann Maeder); EURAC Research, Institute of Mountain Emergency Medicine, Bolzano, Italy (Dr Brodmann Maeder); and the Pasang Lhamu - Nicole Niquille Hospital, Lukla, Nepal (Dr Brodmann Maeder).

The Nepal Earthquake of 2015 killed over 8000 people and injured over 20,000 in Nepal. Moments after the earthquake, an avalanche of falling ice came down from above Everest Base Camp (EBC). The air blast created by the avalanche flattened the middle part of EBC, killing 15 people and injuring at least 70. The casualties were initially triaged and treated at EBC and then evacuated by air to Kathmandu for definitive care. There were intermediate stops at the villages of Pheriche and Lukla during which the casualties were offloaded, retriaged, treated, and loaded again for further transport. Most of the authors of this article helped to provide primary disaster relief at EBC, Pheriche, or Lukla immediately after the earthquake. We describe the process by which an ad hoc rescue chain evacuated the casualties. We discuss challenges, both medical and nonmedical, what went well, and lessons learned. We make recommendations for disaster planning in the Khumbu (Everest) region, an isolated high altitude roadless area of Nepal.

Keywords: disaster, helicopter emergency medical services, avalanche, trauma, air medical transport

Introduction

At 1156 local time on April 25, 2015, a major (magnitude 7.8) earthquake with an epicenter near the town of Gorkha ([Figure 1](#)), shook much of Nepal and adjacent countries. In Nepal, the Great Earthquake of 2015 killed over 8000 people and injured over 20,000. Hundreds of thousands of homes and other buildings were damaged or destroyed. More exact statistics are not available. Moments after the earthquake, an avalanche of falling ice came down from above Everest Base Camp (EBC) (5360 m/17,600 ft). The air blast created by the avalanche flattened the middle part of EBC, killing 15 people and

injuring at least 70 more. There is no historical record of an avalanche reaching Everest Base Camp.

Most of the authors of this article helped to provide primary disaster relief at EBC, Pheriche, or Lukla immediately after the earthquake. Together with others, they became part of an ad hoc rescue chain that provided medical care for the casualties at EBC on the day of the earthquake and during the evacuation of the injured on the following day. The rescue chain began by moving casualties from the destroyed middle part of EBC to the unaffected lower part. An improvised field clinic was set up in which patients were triaged and received treatment. The next day, helicopters transported the injured patients to Pheriche (4300 m/14,100 ft), the site of the closest undamaged medical facility, the Himalayan Rescue Association (HRA) Clinic. ([Figure 2](#)) At Pheriche, patients were triaged again and treated before being loaded again onto helicopters and flown to the nearest

Corresponding author: Ken Zafren, MD, 10181 Curvi St, Anchorage, AK 99507; e-mail: kenzafren@gmail.com.

Submitted for publication September 2017.

Accepted for publication March 2018.

Figure 1. Epicenter and intensity of the Nepal Earthquake of April 25, 2015. The zones of intensity are arbitrary and do not correlate with the amount of damage.

airport at Lukla (2860 m/9400 ft), which was also the location of the closest hospital, the Pasang Lhamu - Nicole Niquille (PLNN) Hospital. From Lukla patients were flown by helicopter and fixed wing aircraft to the capital, Kathmandu, for definitive care.

Methods

The first author contacted all of the doctors who could be identified who were at EBC, Pheriche, or Lukla at the time of the evacuation of casualties from EBC to Kathmandu. All of them were invited to be authors. Two additional authors who were in Kathmandu during the evacuation were recruited in order to give an account of events in Kathmandu and throughout Nepal on April 25 and April 26, 2015. All accounts of events and weather conditions at EBC, Pheriche, and Lukla were based on observations by the authors. There are no weather stations in the area. Fact checking was done by memory and by examining time-stamped photographs from EBC, Pheriche, and Lukla. We constructed a timeline of events based on known times and time-stamped photographs (Figure 3: Timeline of the rescue chain).

Everest Base Camp

THE SETTING

During the spring climbing season in April and May, EBC (5360 m/17,600 ft) is a small city at the base of the Khumbu Icefall on the normal climbing route on the Nepal side of Mt. Everest. EBC is accessible only by trail or by helicopter. The camp stretches for hundreds of meters along a rising part of the Khumbu Glacier just below the icefall. Because EBC is situated on a moving rock-covered glacier, there are no permanent structures. Most people sleep in free-standing tents. Small individual camps make up EBC. In 2015, over 40 expedition teams were at EBC for the season. At the time of the earthquake approximately 1200 people were living in EBC. Nearly 200 of them were on the mountain, leaving at least 1000 in the camp.

MEDICAL RESOURCES

The HRA operates the EBC Clinic, also known as “Everest ER.” The HRA EBC Clinic operates in a large tent, located in the middle part of EBC. At the time of the avalanche there were 3 doctors and 1 medical assistant in residence. Some expeditions had brought their own medical staff and guides

Figure 2. Map of the Everest Base Camp trek.

with varying amounts of medical training. There were also a number of climbers who had some medical training. There were at least 10 doctors at EBC from different specialties during the disaster. Most teams brought limited medical equipment and supplies. Under normal circumstances, patients requiring evacuation are flown out by helicopter.

AVALANCHE DAMAGE, DEATHS, AND INJURIES

The earthquake triggered an avalanche of ice from the ridge between the mountains Pumori (7161 m/23,494 ft) and Lingtren (6749 m/22,142 ft) that loom above EBC. The earthquake caused this ice to fall over 1000 m

Figure 3. Timeline of the rescue chain after the avalanche at EBC on April 25, 2015. Small sketches indicate means of transport. The larger sketches show a damaged tent at EBC, the HRA Aid Post at Pheriche, and the PLNN Hospital at Lukla.

(3300 ft) to the slopes above EBC. The ice was pulverized as it fell, but it generated a hurricane-force wind blast. The blast flattened most of the camps in its path through the middle of EBC leaving a swath of destruction. The HRA EBC Clinic medical tent was destroyed, and most of the medical supplies were lost. Deaths and injuries were due to trauma caused by the blast force that toppled people and destroyed tents. Most of the deaths were immediate, due to trauma. There were 15 people who died soon after the avalanche. We estimate that at least 70 people were injured. Injuries ranged from minor to critical. Common injuries included head injuries, pelvic fractures, lower limb injuries including multiple and open fractures, lacerations, and abrasions.

The lower part of EBC was not damaged. It was considered a safe zone and became the designated area for a makeshift field clinic at one of the expedition camps. The senior guide at the camp handled the general organization. One of the expedition doctors took charge of setting up the clinic. Many volunteers, who were eager to help, formed multiple teams. The most immediate tasks were search and rescue followed by patient packaging and transport (Table 1). Some of the casualties were initially carried to the destroyed HRA EBC Clinic and then to the lower part of EBC on improvised stretchers. Each stretcher was carried by at least 8 people. Each team took about 30 min to carry 1 patient to the new field clinic over difficult terrain. Other casualties were carried directly to the new field clinic in the safe zone.

Table 1. Tasks along the improvised rescue chain

<i>EBC</i>	<i>Pheriche</i>	<i>Lukla</i>
Search and rescue	Offload patients from helicopters	Offload patients from helicopters
Patient packaging and transport	Triage patients and prioritize for transport	Triage patients
Set up a field clinic	Provide limited care for patients (further evaluation, additional pain relief, fluids, splinting, packaging)	Carry selected patients to hospital
Triage patients.	Load patients on helicopters	Provide care for patients (further evaluation, additional pain relief, fluids, splinting, packaging, use of x-ray for diagnosis)
Set up an LZ		Bring patients from hospital back to airport
Provide care for patients (pain relief, fluids, splinting, packaging)		Prioritize patients for transport
Support medical teams		Load patients on helicopters and airplanes
Prioritize patients for transport		
Load patients on helicopters		

EBC, Everett Base Camp; LZ, landing zone.

FURTHER CARE

Dining and supply tents were converted to serve as an improvised field clinic. Some expedition teams brought medical supplies, including warm blankets and hot water bottles, to the new field clinic. One of the doctors triaged the patients as they arrived. The walking wounded were sent to another tent. Three tents accommodated the 24 critically injured casualties. There were 3 additional tents for the walking wounded and those with minor injuries. Medically trained rescuers provided care in austere conditions with limited equipment and supplies.

Almost all critically ill patients received analgesic medication immediately after arrival and were given further treatment within 1 h. Notes were written on pieces of paper that were meant to stay with each patient. Most of these notes were subsequently lost.

In addition to providing medical assistance, volunteer teams provided for the other needs of the medical staff and patients, such as food and liquids. Other teams set up a new helicopter landing zone (LZ) close to the new field clinic and wrapped the bodies of the deceased.

Communications were limited within EBC and virtually nonexistent to the outside, including to the capital and largest city, Kathmandu. There was little information about the condition of infrastructure elsewhere in Nepal after the earthquake. Poor visibility with falling snow precluded helicopter flights. There is no official rescue service or emergency medical service in Nepal. The only aid that could be expected once helicopters were able to fly was evacuation by helicopters that were not medically equipped. Doctors and other volunteers were busy the rest of the day and night taking care of casualties in tents with limited resources. The volunteer doctors organized themselves to work 12-h shifts. An evacuation priority list was made based on patient condition. The most seriously injured, especially patients in shock, had top priorities. Unofficial weather forecasts suggested that conditions would preclude helicopter landings over the next few days.

EVACUATION

Soon after the avalanche, 2 casualties, 1 with major injuries, began descending on muleback to the nearest “hospital,” the HRA Clinic in Pheriche.

Fortunately, the weather cleared overnight. Without warning, the first helicopter arrived at EBC, at 0555, just after dawn. This helicopter began flying patients to Pheriche. A break in the weather at Lukla allowed 4 more helicopters to join the first one in evacuating patients. Once the helicopters arrived, teams were needed to carry injured people to the LZ. Each helicopter could take 2 critical and 1 walking wounded patient per

15-min trip. By about 1030, most casualties had been flown to Pheriche. Records at EBC accounted for about 50 patients who were flown from EBC. Three patients were flown from above the Khumbu icefall.

Pheriche

The closest permanent medical facility to EBC is the 3-bed HRA Clinic in the small village of Pheriche (4300 m/14,100 ft). This clinic is open only during the spring and fall trekking seasons. At the time of the earthquake, the HRA Pheriche Clinic had a staff of 3 doctors, a nonmedical volunteer, and 2 health assistants.

At Pheriche, the earthquake destroyed 1 building and damaged most of the others, but caused only 1 minor injury. About 4 h after the earthquake, the staff at the HRA Pheriche Clinic made brief contact with the HRA staff in Kathmandu and learned of the avalanche and damage to the HRA EBC clinic tent. However, they did not know that there were casualties until the first 2 patients from EBC reached the clinic in Pheriche at about 2100, 9 h after the avalanche. One patient was seriously injured and stayed overnight at the clinic. The other had only minor injuries and was sent to a lodge.

The HRA Pheriche Clinic staff became aware of the evacuation from EBC the next morning when an AS350 helicopter landed unexpectedly early, at about 0630, at the main helicopter LZ about 500 m from the clinic, with 2 of the most severely injured casualties.¹ This is when the HRA Pheriche Clinic staff first learned that there were many casualties at EBC. The pilot indicated that EBC was destroyed and that all casualties would be transported to Pheriche by helicopter. The patients were carried to the clinic while the staff recruited support and the helicopter went back to EBC. About 50 locals and foreigners were recruited or volunteered to help. There were a few doctors, paramedics, and other healthcare providers, but most of the volunteers had no medical training.

The weather was stormy. It was not clear whether helicopters would be able to transport the patients onward from Pheriche to the nearest hospital, at Lukla. The weather between Lukla and Kathmandu was rumored to be unflyable. If this were true, patients would be unable to reach hospitals capable of providing definitive care.

Approximately 30 min after the first landing, the helicopter returned with 2 more casualties. It continued evacuating EBC and was later joined by 4 more AS350 helicopters.² After the first landing, all subsequent landings were on the riverbed near the clinic, much closer than the helipad. The next 16 seriously injured patients were carried about 100 m to the clinic, where

they quickly filled the clinic building and the adjacent "sun room." The walking wounded were triaged and treated in the common room of a lodge next door to the clinic. Each patient was examined and tagged with a large piece of white tape attached to the front of the outermost garment. On each piece of tape the caregivers wrote the patient's name, age, and a list of suspected injuries. There were few further medical interventions. One hypotensive patient with multiple extremity injuries was treated with intravenous fluids and intramuscular analgesic medications. It was beyond the capacity of the clinic to maintain the level of treatment required by the first 2 seriously injured patients, 18 h postinjury.

The small AS350 helicopters were later joined by a large MI-17 helicopter that could carry up to 17 casualties at a time from Pheriche to Lukla. As the remaining patients were arriving and were being triaged again, a weather window opened that allowed the 4 most severely injured casualties to be reloaded onto the larger helicopter for the first flight to Lukla. The remaining patients were then flown to Lukla. Some of the AS350 helicopters made several trips. The MI-17 made a total of 3 trips to Lukla. There were 73 patients who were seen at Pheriche, triaged, reloaded, and flown to Lukla. All patients had been flown to Lukla by noon.

Lukla

Lukla (2860 m/9400 ft) is the main gateway to the Everest region. The Lukla airport offers frequent commercial flights to and from Kathmandu. Most mountaineers and trekkers start trekking after flying to Lukla in small fixed wing airplanes. The Pasang Lhamu Nicole-Niquille (PLNN) Hospital is located about a 15-min walk, mostly uphill, from the airport and the main part of the village. The PLNN Hospital is a rural facility without advanced capabilities. The hospital has limited facilities for resuscitation and does not have a blood bank. Severely injured patients who require surgical management must be transported to Kathmandu. The hospital has a heliport that was not used after the earthquake. The medical staff of PLNN Hospital at the time of the earthquake consisted of 2 physicians, 5 nurses, 1 laboratory technician, and 1 x-ray technician. The village of Lukla sustained little damage in the earthquake. The airstrip was intact, but the hospital was heavily damaged.

On the morning after the avalanche, an emergency physician, who regularly works at the PLNN Hospital, was able to fly from Kathmandu to Lukla in the same MI-17 helicopter that flew to Pheriche to help evacuate casualties. Patient care was impossible inside the hospital. Only the x-ray room was intact and functional.

Hospital staff worked outside in improvised shelters. The staff set up a primary triage site at the airport, with plans to carry selected patients to the hospital for treatment or x-ray studies.

At the airport, there were many foreign volunteers from several countries, including nurses, doctors, and paramedics. As the casualties arrived, they were triaged by 2 paramedics. The walking wounded went to the first floor of the airport building. The ground floor was used for patients who had to be carried. There were enough doctors and nurses to provide 1:1 care for the seriously injured. Army soldiers, police, and local volunteers carried more than 30 casualties to the hospital where they received treatment in the improvised shelters, primarily pain relief and cleaning of soft tissue injuries. Several patients had extremity fractures that were diagnosed by x-ray. One patient had rib fractures and a small pneumothorax that did not require specific treatment. A pelvic fracture was also ruled out by x-ray.

An estimated 65 patients were triaged in Lukla. The tags that had been placed at Pheriche were used to help identify injuries. Two severely injured patients who were assessed as requiring urgent surgery or blood transfusions were the first to be transported to Kathmandu. The weather was unsettled. Flights to Kathmandu might have been cancelled at any time. Although many casualties had minor injuries that could have been treated in Lukla, none of them wanted to stay, even after hearing about the difficult situation in hospitals in Kathmandu. All patients were flown to Kathmandu by helicopter or by small fixed wing aircraft that normally fly trekkers and local people.

Kathmandu

After arriving at the airport in Kathmandu, the patients from EBC were transported by ground to various hospitals. Treatment was hard to obtain due to overwhelming numbers of patients in Kathmandu who were already seeking care. Unfortunately, the 2 severely injured patients who were the first to be transported to Kathmandu died without access to medical treatment. We were unable to find information about the treatment of the other patients in Kathmandu.

Discussion

PLANNING

In April 2014, at the start of the climbing season, there was an ice avalanche in the Khumbu Icefall between EBC and Camp 1.³ The 2014 avalanche caused 16 fatalities and injured 9 climbers. Although the 2014 avalanche was a multiple casualty incident it was not a disaster. The medical resources at EBC were not overwhelmed. There were

sufficient medical personnel and medical supplies available at EBC. Air transportation direct to definitive care facilities in Kathmandu was accomplished on the day of the avalanche. The medical facilities in Kathmandu were not overwhelmed by a countrywide disaster as they were in 2015.

The 2015 avalanche was completely unexpected. There was no formal disaster plan for EBC, Pheriche, or Lukla. Based on the experience of the 2014 avalanche, the helicopter pilots had developed an informal plan for evacuation of casualties from EBC using staging areas in Pheriche and Lukla.

MEDICAL CHALLENGES AT EBC

Dozens of trauma patients, many with serious injuries quickly overwhelmed the available medical resources. Care had to be given in an austere environment at high altitude in cold, windy conditions. Equipment and supplies were limited and were initially disorganized after the destruction of the HRA EBC Clinic medical tent. Patients had to be moved a considerable distance within EBC before they could receive care beyond first aid.

OTHER CHALLENGES AT EBC

There were major psychological stresses for the survivors. Many of them had to deal with loss of personal gear and separation from their campsites. Some people lost everything except the clothes they were wearing. All the survivors had to deal with the frightening experience of being in a disaster in an austere environment in harsh weather conditions. Many people witnessed the deaths of their friends. Some of the survivors were so psychologically traumatized that they were unable to participate in rescue activities.

Those who were not incapacitated by injuries or psychological trauma became the rescuers. In order to care for the victims, rescuers had to function as a team, with many challenges of language and culture. There were medical and nonmedical personnel. Doctors, nurses, guides, expedition staff and climbers had to work together to help and treat patients with a wide array of injuries.

USE OF STAGING AREAS

At Pheriche, some patients were transferred to a large MI-17 helicopter that was not capable of transporting a large number of casualties from EBC due to the higher altitude, but that could take 17 casualties at a time from Pheriche to Lukla. At Lukla, many patients were transferred to airplanes for evacuation to Kathmandu. At each step there was a higher level of care. Triage at each location was necessary to reassess the patients who were

waiting for further transport to identify patients whose conditions might have worsened and to prioritize patients for transfer to the next destination.

WHAT WENT WELL AND WHY?

Overall, the operation successfully transported many casualties from the disaster site in a remote location to the site of definitive care. This occurred in less than 30 h in a country that was in shambles after a disaster.

At EBC, Pheriche, and Lukla, effective teams formed with no notice at EBC and at Pheriche and with some advance notice at Lukla. Although there was no formal incident command structure, these teams were able to solve multiple problems with the assistance of many willing volunteers.

At EBC, casualties were quickly redirected from the HRA EBC Clinic tent to the lower part of EBC. The core of the team at EBC consisted of a few doctors and expedition guides. The doctors were trained in emergency medicine and anesthesia. All members of the group had specific training in wilderness medicine. They were able to function well despite personal losses and injuries. The conversion of a camp into a headquarters, carrying the injured, setting up a field hospital, wrapping the deceased, supporting the needs of the patients and healthcare providers, and the construction of a helicopter LZ were all accomplished by effective ad hoc task forces.

At EBC, the casualties were numbered and transported according to the severity of their injuries, with the most severely injured transported first. The list of patients facilitated rapid evacuation. At Pheriche, the movement of patients was generally smooth, coordinated by the healthcare team from the HRA Pheriche Clinic with the assistance of many bystander volunteers and the staff of an undamaged lodge near the clinic. Patients arriving from EBC were triaged again and tagged at Pheriche. The information provided on the tags was then used effectively at Lukla, even though there were no other direct communications from Pheriche to Lukla regarding individual patients. In Lukla, patients were triaged one more time and received analgesics. Almost half of the patients arriving in Lukla were transported to the PLNN Hospital, where x-rays were used to rule out major injuries that would have required specific interventions and where patients with soft tissue injuries had the injuries cleaned and dressed.

Considering that the care and evacuation of injured patients from EBC was not planned in advance and had to be improvised, the operation went extremely smoothly until the patients arrived in Kathmandu. A major factor in this success was the formation of effective teams. At

EBC, the volunteers were all staff and members of expedition teams, used to carrying out assigned tasks. Many of the volunteers at Pheriche and Lukla were staff and members of organized treks. The helicopter crews also were able to function as a coordinated team.

WHAT LESSONS WERE LEARNED?

It is not possible to plan for every disaster, but basic planning might have avoided many problems. The care and evacuation of patients might have been facilitated by coordinated disaster plans at EBC, Pheriche, and Lukla. Other hazards exist in the Khumbu (Everest) region, including earthquakes, landslides, avalanches at EBC and in other locations, rockfall, fire, floods, and severe storms. Plane and helicopter crashes also have the potential to create mass casualty incidents.

Communications were disrupted after the earthquake. Satellite phones were functioning for international calls, but could not be used to call nonsatellite telephones in Kathmandu. Plans to use satellite phones in a disaster might have helped coordination of the rescue effort. It would have been helpful to have a plan specifying whom to contact and to have guidelines for transfer of patient care to ensure that important information was shared. The staff at the HRA Pheriche Clinic could have made better plans to anticipate a mass-casualty evacuation if the communication from Kathmandu and information from EBC had included an estimate of the number of casualties. Better communications and establishment of an evacuation plan might have prevented many problems experienced by patients arriving in Kathmandu from Lukla, including the 2 deaths.

Medical supplies and equipment should not have been concentrated in a single place at EBC. Although many teams brought their own medical kits, the majority of medical materiel was at the HRA EBC Clinic. Storing supplies in various locations would likely have prevented the loss of some medical supplies, if not equipment.

Recordkeeping was a problem as highlighted by the varying numbers of recorded casualties along the rescue chain. There is no evidence that failure to track patients between sites affected outcomes. Every patient at EBC who was triaged with major injuries was given a note with name, vitals, injuries, and treatment given. The notes were meant to stay with the patient, but most of the notes were lost during transport. At Pheriche, another effort was made to record the names and injuries of the casualties. It was difficult to keep track of the volunteer who had the list and to ensure that all casualties were recorded. This task was started well into the evacuation. It would likely have been helpful to have started

immediately when the first casualties arrived. No formal triage system was used at any of the sites.

Safety was also an issue. The helicopters were hot-unloaded and reloaded (engines running and rotors turning), putting patients and volunteers at risk.

Many people, both Nepalis and foreigners, who were in the Khumbu region during the earthquake, became victims or rescuers. Some people were both. Most people struggled with the psychological aftermath of the earthquake for months. Some are still struggling almost 3 years later. There was no organized debriefing. In Kathmandu, limited psychological resources were available. Psychological support for the survivors in Khumbu might have benefited many people who have struggled to return to normal lives.

THE EVACUATION OF EBC DID NOT DELAY RESCUE EFFORTS ELSEWHERE IN NEPAL

Concerns have been expressed about whether there was inequity of disaster relief in the first day after the earthquake. These concerns cite the prompt evacuation of casualties from EBC by helicopter, while speculating that the helicopters that evacuated EBC could have been better used to evacuate local people in other areas. At the time of the evacuation, little was known about conditions in the most severely affected areas of Nepal. Communications were very limited. Weather conditions on the day of the earthquake and the next few days made reconnaissance flights too risky in most of the hard-hit areas. Damaged roads prevented access by ground to assess the needs for medical evacuation. The evacuation of EBC did not delay rescue efforts elsewhere in Nepal. It is also important to remember that Nepali expedition staff as well as foreign climbers were killed and injured at EBC.

RECOMMENDATIONS

The risk of a major earthquake in the Himalaya is not over.⁴ The geological stress that caused the 2015 earthquake was only partially released. It is urgent that Nepal prepare for the next earthquake. A regional hazards analysis and disaster plan should be developed for the Khumbu region, including EBC. Many injuries and deaths might have been avoided if expedition staff and members at EBC had sheltered from the avalanche wind blast behind large fixed features such as boulders and embankments, which are ubiquitous at EBC. Emergency equipment and supplies should be stockpiled in safe places at EBC and possibly elsewhere in the Khumbu region. Local medical providers and laypersons as well as itinerant medical providers and staff at EBC, the HRA clinic at Pheriche, and the PLNN hospital at Lukla should receive training

in disaster response and emergency medical treatment.⁵ This training should also be provided to staff at alternate sites in the area, including the 2 other main medical facilities, the Kunde Hospital and the medical clinic at Namche Bazaar. Nepali mountain and helicopter rescue teams have been trained by foreign specialists.^{6,7} They have been involved in prior mass casualty incidents³ and are a potential resource for further missions. These teams should receive training in the management of mass casualties in remote locations.

The disaster plan should include an evacuation plan to Kathmandu or to alternate locations, such as the city of Biratnagar, in the event that Kathmandu is affected by a disaster to the point of being unable to receive casualties. Organizations operating in the Khumbu region should also consider plans to offer psychological support to the survivors of a future disaster.

Conclusion

An avalanche caused by the Nepal earthquake of April 25, 2015 in Nepal killed 15 people on the day of the earthquake and injured over 70 at EBC. Due to bad weather, the casualties could not be evacuated immediately and had to be cared for at EBC during the afternoon and overnight. On the day after the earthquake all casualties were evacuated by air to Kathmandu, with intermediate stops at Pheriche and Lukla. Although most casualties were successfully treated, 2 patients died after reaching Kathmandu. We recommend development of a regional hazards analysis and disaster plan for the Khumbu region.

Acknowledgments: The authors thank the HRA EBC Clinic team, HRA Pheriche Clinic team and the staff of the PLNN Hospital at Lukla, everyone who helped at EBC, Pheriche, and Lukla, the helicopter companies and pilots, everyone who cared for the patients in Kathmandu, and everyone in Nepal and around the world who provided support after the earthquake.

Author Contributions: Study concept (KZ, KT, AN, MP, BB, MBM) analysis of data; critical revision of the manuscript (KZ, KT, AN, MP, BB, MBM, AB); drafting of the manuscript (KZ, MBM AB).

Financial/Material Support: None.

Disclosures: None.

References

1. Salas RN. Humanity, teamwork, and art in post-earthquake Nepal. *N Engl J Med*. 2015;373(3):205–7.
2. Zafren K. The great earthquake in Nepal—a personal view. *Wilderness Environ Med*. 2016;27(1):171–5.
3. Stokes S, Koirala P, Wallace S, Bhandari S. Tragedy on Everest: the Khumbu Icefall. *Emerg Med J*. 2015;32(5):418–20.
4. Bilham R, Mencia D, Bendick R, Bürgmann R. Implications for elastic energy storage in the Himalaya

- from the Gorkha 2015 earthquake and other incomplete ruptures of the Main Himalayan Thrust. *Quat Int.* 2017;462:3–21.
5. Brants A, Metcalfe T. Practical tips for working as an expedition doctor on high-altitude expeditions. *High Alt Med Biol.* 2017;18(3):193–8.
 6. Thapa GB, Neupane M, Strapazzon G, Basnyat B, Elsenshon F, Brodmann Maeder M, et al. Nepalese mountain rescue development project. *High Alt Med Biol.* 2014;15(1):91–2.
 7. Maeder MM, Basnyat B, Harris NS. From Matterhorn to Mt Everest: empowering rescuers and improving medical care in Nepal. *Wilderness Environ Med.* 2014;25(2):177–81.