Potential Roles of Military-Specific Response to Natural Disasters—Analysis of the Rapid Deployment of a Mobile Surgical Team to the 2007 Peruvian Earthquake

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Abbreviations:
ASF = Aero-Medical Staging Facility
HMMWV = High Mobility, Multipurpose, Wheeled Vehicle
JTF-B = Joint Task Force-Bravo
MST = Mobile Surgical Team
NGO = non-governmental organization
PAHO = Pan-American Health Organization
WHO = World Health Organization

Abstract

The August 2007 earthquake in Peru resulted in the loss of critical health infrastructure and resource capacity. A regionally located United States Military Mobile Surgical Team was deployed and operational within 48 hours. However, a post-mission analysis confirmed a low yield from the military surgical resource. The experience of the team suggests that non-surgical medical, transportation, and logistical resources filled essential gaps in health assessment, evacuation, and essential primary care in an otherwise resource-poor surge response capability. Due to an absence of outcomes data, the true effect of the mission on population health remains unknown. Militaries should focus their disaster response efforts on employment of logistics, primary medical care, and transportation/evacuation. Future response strategies should be evidence-based and incorporate a means of quantifying outcomes.

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Introduction

According to the Pan-American Health Organization (PAHO), the local population alone almost always provides comprehensive, immediate, life-saving functions in the aftermath of a disaster due to natural hazards.[1] The arrival of foreign emergency and surgical capabilities days and weeks after the onset of a disaster is of little benefit. This assertion has resulted in controversy concerning the utility of the rapid deployment of foreign military medical capabilities to disaster zones. In an analysis of lessons learned from tsunami relief in Asia, de Ville de Goyet argued against the attempts of foreign governments to participate in early trauma care.[2] The World Health Organization (WHO) *Technical Hazard Sheet on Earthquakes* lists field hospitals and modular medical units under "Inappropriate Response" with the emphatic tagline, "Do not send them".[3] However, both military and civilian authors argue that early intervention in acute care can reduce suffering.[4,5] Sharp *et al* suggest that the Uniformed Services are uniquely adapted to "provide a rapid response to remote locations, an immediate functioning infrastructure in a devastated area, acute management of injuries, and armed intervention in unstable situations".[4] Despite this, no deployment has reached the epicenter of a disaster in an appropriate timeframe to participate in trauma resuscitation. The time span available to intervene to reduce trauma-related mortality is unknown, but may extend to the first 24–48 hours after the precipitating event.[6] In spite of WHO entreaties to the contrary, foreign governments and

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non-governmental organizations (NGOs) continue to send medical teams in the immediate aftermath of floods, hurricanes, earthquakes, and tsunamis. As response times improve, a threshold of time may reveal which foreign aid contributes to immediate lifesaving. The rapid deployment of a military surgical team in the immediate aftermath of a large-scale earthquake is described.

Event

In the early evening of 15 August 2007, an earthquake measuring 8.0 on the Richter scale and lasting 110 seconds struck the west coast of Peru. The cities of Canete, Chincha, and Ica were affected, and the port city of Pisco and its population of 53,000 was the worst hit.[7]

Damage

On 16 August, international news services began to paint a grim picture of widespread destruction. The adobe dwellings typical of the region were particularly susceptible to seismological collapse. News syndicates described horrific scenes of dead bodies accumulating in Pisco's streets, trapped people, and entire neighborhoods reduced to rubble.[8,9] Debris from collapsed structures obstructed city streets and made early assessments difficult. The death toll began at 450 with a consensus opinion that it would surely rise. One journalist described the scene as "one of the worst natural disasters to hit Peru in the last Century".[9]

Health Damage

The social security hospital EsSalud, one of Pisco's only two hospitals, was destroyed and the state hospital of San Juan de Rios, although still functioning, could only perform at 50% of its pre-earthquake capacity.[10] Medical equipment was salvaged from EsSalud and moved into adjacent buildings to allow minimal continued medical capability in the city center. One hundred ninety-two hospitalized patients required transport out of the city. Unfortunately, ground-based transit of medical aid into and evacuation out of the city was hampered by closure of the Pan American Highway from Pisco to Lima due to landslides.[11]

Local and International Response

Peru's National Institute of Civil Defense established an Emergency Operations Center at the Pisco Airport.[12] With the support of WHO/PAHO, the Peruvian government also established a Humanitarian Supply Management System (SUMA) at that location. Several United Nations teams descended upon the affected areas to participate in assessment and delivery of care. Because Pisco's two hospitals had sustained significant damage, surgical patients were evacuated by ambulance from point of injury to a makeshift, airport-based, Aero-Medical Staging Facility (ASF). This capability was led by the Peruvian Air Force and staffed with military flight surgeons, military and civilian general surgeons, and emergency medicine personnel. While adequately staffed, the unit lacked administrative and logistical capacity. The ASF operated out of the air force base theater, owned minimal medical supplies, and had limited electrical power for limited hours. Once stabilized and packaged for flight, patients were loaded on aircraft and transferred the 160 miles to hospitals in the capital city of Lima.

US Military Response

On 16 August, before the availability of organized damage assessments, the US Ambassador to Peru issued a Declaration of Disaster announcing consent of the Peruvian government to accept unspecified, American, humanitarian aid. At the same time, deployed US soldiers and airmen of Joint Task Force-Bravo (JTF-B) at Soto Cano Airbase, Honduras readied a mobile surgical team (MST) for deployment. The MST, an *ad hoc* design not duplicated elsewhere in the American military, most closely resembles one-half of an Army Forward Surgical Team in its split operations configuration. Designed as the US military's first response to disasters and mass-casualty incidents in Central and South America, the team is equipped for rapid deployment, but not sustained care. It has several mission-specific configurations. The 27-person team included a general surgeon and operating room staff, a flight surgeon trained in internal medicine and cardiology, an emergency medicine physician assistant, a pediatric nurse-practitioner, a preventive medicine officer, security forces, and a command-and-control node. Notably, the non-surgical medical personnel required specific justification because the mission was perceived largely as a surgical one by higher JTF-B commanders. The deployable facility consisted of two Deployable Rapid Assembly Shelter tents each capable of housing three resuscitation beds, an operating room, and two recovery beds or a recovery area for eight patients. Environmental control and electrical power were supplied by a diesel-fueled 40 kilowatt generator-trailer. Additional equipment included two back-up, gasoline-fueled, 750-watt generators, operating room equipment, trauma resuscitation equipment, >600 pounds (272 kg) of pharmaceutical, and two cargo-type, all-terrain High Mobility, Multi-Purpose, Wheeled Vehicles (HMMWV).

American government officials including those from the United States Agency for International Development (USAID)/Office of Foreign Disaster Assistance (OFDA), Department of State, Department of Defense, military Joint Staff, and the Southern Command transitioned the Ambassador's Declaration of Disaster into a direct order for the MST to deploy. The MST was mobilized and in-flight by 12:00 hours (h) on 17 August and arrived in Pisco within 48 hours after the earthquake. Though prepared to begin operations immediately, the team had not sufficiently coordinated with civilian or military authorities on the ground and did not begin relief operations until the morning of 18 August, when in consultation with the Peruvian authorities, team leaders performed area assessments utilizing HMMWVs.

Based on mission analysis, the MST divided its assets into two teams. The unit co-located its surgical capability at the Pisco airport with the Peruvian military team performing aero-medical staging. Non-surgical primary care assets bivouacked at the Pisco airport, but deployed daily to a centralized soccer stadium by HMMWVs to provide aid to the community and identify surgical cases to be evacuated to the surgical team. This plan best fit the goals of: (1) meeting the expectation of the Peruvian authorities; (2) concen-

Name	City/Village	Age	Sex	Date	Injuries/Illness	Treatment rendered	Evacuated to Lima
Patient 1	Pichunache	21	M	18 Aug 07	8 days out from MVC with infected thigh wounds from femur fracture, fasciotomy, wrist fracture, head injury	I&D of infected hardware under conscious sedation; antibiotics, tetanus	Yes
Patient 2	Lima	30	M	19 Aug 07	Infected toenail	I&D of infected toenail/tetanus	No
Patient 3	Pisco	1	M	19 Aug 07	Diarrhea and dehydration	IV hydration/ observation	No
Patient 4	Pisco	77	M	19 Aug 07	Liver failure and symptomatic ascites	Paracentesis, IV antibiotics	No
Trauma 1	Pisco	16	F	19 Aug 07	Foot fracture from wall cave-in	Splint, IV antibiotics	Yes
Patient 5	Pisco	25	F	19 Aug 07	Fetal distress	OB ultrasound and exam	Yes
Patient 6	Pisco	31	F	20 Aug 07	S/P Bartholin's cyst I&D with post-op hemorrhage	Washout and suture ligation of bleeding vessel, IV antibiotics, conscious sedation	No
Patient 7	Pisco	24	F	20 Aug 07	Acute appendicitis	IV hydration, IV antibiotics	Yes
Patient 8	Pisco	48	F	20 Aug 07	Hand laceration	Washout and closure of wound under local	No
Patient 9	Chincha	37	M	20 Aug 07	Foreign body in eye	Eye washout with saline	No
Patient 10	Pisco	29	M	20 Aug 07	Foreign body in eye	Eye washout with saline	No
Trauma 2	Pisco	40	M	21 Aug 07	Gunshot wound to neck	Tracheostomy, L chest tube, HemCon chitoflex dressing for hemorrhage control, posterior packing of nasopharynx, foley placement in bullet track, blood transfusion	Yes
Trauma 3	Pisco	25	M	21 Aug 07	Gunshot wound to chest and abdomen	FAST u/s exam, stabilization	Yes

Table 1—Patients treated by Joint Task Force-Bravo mobile surgical team in Pisco 18–20 August 2007. The Mobile Surgical Team triaged (but did not treat) 42 additional patients at the co-located Peruvian Mobile Aeromedical Staging Facility (FAST = Focused Assessment by Sonography in Trauma; I&D = incision and drainage; IV = intravenous, MVC = motor vehicle crash; OB = obstetric)

trating areas of expertise in the locations where they were most needed; (3) maximizing MST security; and (4) optimizing interaction at the tactical level with Peruvian forces and humanitarian agencies operating out of the airfield.

Operational Measures

The surgical team doubled the Peruvian ASF capability. It assisted with patient assessments, minor surgical procedures, and flight-line treatment (Table 1). The team offered trauma resuscitation services to non-earthquake-related trauma victims evacuated to the site in the absence of functioning hospitals. Furthermore, its recovery room and nursing staff provided patient-holding resources until medical evacuation (MEDEVAC) aircraft became available. Finally, the MST shared critical medical supplies, medicine, and generator-derived electrical power with the under-resourced ASF in its massive air evacuation operation. The combined Peruvian and MST ASF assets achieved the ability to conduct 24-hour operations for the first time since the crisis began.

The non-surgical team provided general medical care in three daily iterations. The plan of operation included stations for administrative in-processing, provider interaction, and pharmacy. During a three-day period, the team evaluated, examined, and treated 1,382 patients. The spectrum of illness treated was dominated by upper respiratory infections due to the low-lying clouds of post-earthquake dust that continued to smother the city (Table 2).

Several small, less resource intense organizations (including medical teams from nearby hospitals and medical schools, volunteer nurses, and a foreign fire and rescue department) were incorporated into the MST operations.

Date	Number Treated	Upper Respiratory Complaints* (%)	Musculo-skeletal Complaints† (%)	Minor Trauma§ (%)	Gastrointestinal and Genitourinary Complaints‖ (%)	Dermatological Complaints (%)	Psychiatric Complaints¶
18 Aug 07	209	51	16	8	13	9	2
19 Aug 07	626	53	18	14	9	9	2
20 Aug 07	547	56	18	3	11	9	3
Total	1,382	53	17	8	11	9	2

Table 2—Patients treated by the Mobile Surgical Team non-surgical asset in Pisco 18–20 August 2007
*Includes cold and flu symptoms, seasonal allergies, otitis media and externa, pharyngitis, bronchitis, and conjunctivitis
†Includes acute muscle strains, joint sprains, arthritic conditions, and chronic neck, back, and extremity disorders
§Includes abrasions, lacerations, and contusions
‖Includes gastroesophageal reflux, acid indigestion, constipation, diarrhea, abdominal discomfort, vaginal yeast infections, sexually transmitted diseases, and urinary tract infections
¶Includes anxiety, acute stress reactions, grief, and depression

These teams provided needed staff power to maximize the distribution of medicines. Non-medical Peruvian volunteers were brought into the evaluation strategy as additional translators. A Pisco emergency medical technician/ambulance squad was on-call during hours of medical evaluation and responded immediately for ambulance transportation. This asset effectively connected the non-surgical and triage activity of the stadium to the combined American-Peruvian surgical capability and aero-medical staging hub of the airbase. In three days, the entire MST was relieved by a non-surgical, medical US military team. This second US team, robust in pediatricians, obstetricians/gynecologists, and internal medicine resources, continued to treat the population of Pisco for several additional weeks.

Discussion

Rapid deployment of the MST is rare. Most accounts of international emergency relief team deployments document arrival 1–6 weeks after the event (defined as Day 0).[13–18] The US Army 212th Mobile Army Surgical Hospital (MASH) was not operational in Pakistan until day 17 of the 08 October 2005 earthquake that caused 73,000 deaths.[14] Similarly, the US Naval hospital ship, Mercy did not arrive on site in the Indian Ocean until five weeks after the 26 December 2004 earthquake that triggered the Indonesian tsunami that killed 280,000.[19] Though faster ground-based units arrived ahead of the ship, they were not operational until Day 22.[17] Of 13 international teams deployed to assist with the 2004 earthquake in Bam, Iran, not one arrived as early as Day 2 of the disaster.[20] This includes the US government, civilian, Boston-based and International Medical Surgical Response Team.[21,22] Faster international responses have been documented. An Israeli military team was on-site in Turkey within 48 hours of the 1999 Izmit earthquake.[23] The Peruvian experience demonstrates several parallels.

Like that of the Israeli team in Turkey, the MST mission in Peru confirms that the pace of even "rapid" deployments is not fast enough to achieve tangible results in acute resuscitation. The Peruvian Ministry of Health's lead physician stated that the first treatment peak occurred in Pisco on the day after the earthquake, 24 hours before the MST arrived.[11] The Israeli/Turkey and US/Peru missions also confirm the observational utility of expediently delivered resources made possible by the organization and infrastructure of the military.

The experience of the MST mission indicates a potential military role in the early organization and management of air evacuation. Because roads frequently are impassable in the aftermath of disaster-causing events, air transport may be preferred. The establishment of temporary medical facilities on airstrips or landing zones is required to provide comprehensive, ongoing care to victims as they await air evacuation. Furthermore, patients must be staged for flight. Staging consists of medically preparing patients for successful existence at flight altitudes. Critical, yet more routine, tasks include "packaging" patients with litters, blankets, medicines, food, water, sustainable intravenous (IV) lines, and medical documentation to ensure that illnesses and injuries are not confounded by lapses in organization or life support during transport. The evacuation mission exists for several days after the event. A study of the 1995 Hanshin-Awaji Earthquake noted that peak evacuation occurred in the first four days after the earthquake, followed by a pattern of decline in activity that occurred more gradually than that of the rate of successful resuscitation.[24] This makes contributions to evacuation a more realistic goal than surgical resuscitation for most rapid deployment teams. The arrival of the MST on Day 2 enabled it to contribute to the evacuation effort when surge capacity to national resources was most needed. Contributions to the evacuation effort must be considered an essential functional resource for future rapid deployments.

Lessons Learned

The MST experience confirms that the arrival of foreign surgical teams in 48 hours is not quick enough to make a major contribution to the provision of acute surgical care. Though hours and even days faster than previously published "rapid" responses, the MST did not perform any earthquake-related life-saving surgeries. The time window to save trauma victims is small, perhaps on the order of 12–36 hours. This is supported by observations in Peru and by several expert opinions, and justifies the creation of improved local solutions of acute response.[6] Unless mobilization time can be drastically and consistently shortened, initial entry teams should not include surgeons.

The replacement of destroyed primary care infrastructure continues to be a worthy target. In Peru, the MST's primary care mission evaluated and treated >100 times as many patients as the surgical asset. Again, without health outcomes measures, interpretation is limited. However, depending on the rubric used, this service could be considered the more cost-effective of the two. As mentioned, because the evacuation timeline is one that more realistically permits early intervention, evacuation tasks should be investigated further by militaries wishing to contribute to early, foreign, disaster relief. The US Air Force contains modular Mobile Aeromedical Staging Facilities that could contribute to evacuation missions. In spite of the considerable expense, logistics, and personnel used to transport the MST, its relatively low surgical yield should make it clear that the rapidity of response is not as important as appropriateness. As such, communication with the lead agency should drive the decision-making process. There are many merits to a "pull" system as opposed to one in which resources are indiscriminately "pushed" based on perceived needs.

As staff experts in the field, physician-advisors should be cognizant of non-evidence-based decisions in their leadership. In general, this mission provides an example of the consequences of planning and response without knowledge or analysis of previous outcomes data. The MST physicians were able to exert limited influence on the JTF-B command to allow appropriate primary care augmentation to the surgical asset. Physicians should continue to intervene in executive decision making to effect change through education. Military medical providers have been able to completely modify mission profiles in the provision of humanitarian care in combat environments.[25] Even though the communication of medical evidence to action-oriented, non-medical authorities is challenging, the alternative is continued higher-level decisions driven by the "humanitarian impulse",[26] that reduce impact.

While militaries may have advantages in the ability to rapidly deploy resources, they continue to lag in the area of appropriate identification of measures of effectiveness. Arguably, a major limitation of this case report is lack of outcome measures. Although tailored for a short-duration, surgical resuscitation mission, the MST was equipped with intrinsic flexibility. Even though the MST reinvented its mission to one of acute primary care and aero-medical staging, the team did not have the tools needed to collect impact measures of its work. In the end, the MST only can claim to have treated patients and "helped out" with evacuation. The 1,382 patients treated number does not clarify the impact of the mission on community health. A more worthwhile set of data would include measures of the change in citywide morbidity. Outcome indices and the direct and indirect impact on mortality and morbidity essentially are unknown in the majority of military disaster relief and humanitarian missions. The lack of deployed capacity for data analysis among operational military assets such as a MST, remain a major deficiency of current military planning. Outcome evaluations must occur operationally to determine if unique military assets are cost-beneficial and effective in reducing overall mortality and morbidity. Additionally, to effectively partner with civilian humanitarian agencies and organizations, militaries must adopt universal health indices compatible for transition to the host government or NGOs once the military leaves the affected area.

Conclusions

The experience of the MST confirms known difficulties of the rapid deployment of foreign surgical teams to disaster sites. Likewise, it reinforces that primary acute care can reduce suffering and will likely improve outcomes. Heavy surgical response is counterproductive because it arrives too late to contribute. Militaries should concentrate on aspects of transportation, communication, and logistics that disaster-affected foreign countries often lack. By addressing these areas with the benefit of data, analysis, and lessons learned, militaries may begin to mitigate overall mortality and morbidity in a quantifiable way. Outcome measures or measures of effectiveness, a strength of military planners in non-aid situations, would be useful in determining validity of these assets during future disasters.

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Military Medical Assistance Following Natural Disasters: Refining the Rapid Response

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All countries came into Egypt, to Joseph, to buy grain, because the famine was severe in all the earth

Genesis 41:57

Since the beginning of recorded history, governments have provided humanitarian assistance during disasters due to natural hazards. The eruption of Mount Vesuvius on 24 August AD 79 destroyed the cities of Pompeii and Herculaneum. In response, the emperor of Rome established a relief fund to assist the displaced and widowed.[1] Today, disasters due to natural hazards are attended by an outpouring of humanitarian aid from both governmental and non-governmental agencies. The military, in particular, often is tasked with the initial governmental response, owing to its state of readiness.

In this issue of *Prehospital and Disaster Medicine*, Malish *et al* analyze the response of an Army Mobile Surgical Team (MST) following the 2007 Peruvian earthquake.[2] Even though the MST was deployed and operational in less than 48 hours (one of the best-documented response times in the literature), they were unable to provide a single earthquake-related life-saving surgery. They did claim, however, to make a significant contribution to the evacuation effort and provided acute care augmentation to the overwhelmed local health services.

The conclusions made in this article support the findings of other emergency humanitarian relief agencies—that is, responding medical assets seldom respond rapidly enough to substantially contribute life-saving surgical needs. Either these needs will have been met through the intervention of local health services or the opportunity to intervene already will have expired.[3]

Following the 2001 earthquake in Gujarat, India, Bremer reported that most surgical teams arrived too late to provide life-saving care.[4] In his review of 43 foreign field hospitals deployed following four recent disasters, von Schreeb *et al* found that none of the foreign field hospitals arrived early enough to provide emergency trauma care.[5] Even when surgical assets are available, they are utilized infrequently relative to non-surgical assets. In describing the aftermath of the 1999 earthquake in Turkey, Bar-Dayan *et al* noted that of the 2,230 patients treated at the Israeli Defense Forces field hospital over a nine-day period, 90% had non-traumatic illnesses.[6] Another Israeli Defense Force medical unit performed surgery <6% of the 1,200 patients they treated following the same earthquake.[7]

During a sudden-onset disaster, rapid response teams intending to provide medical care should be capable of providing sufficient support to enable local medical facilities to re-establish adequate services. To achieve this goal, rapid response teams should configure away from a surgical capability in favor of a multi-disciplinary medical capability, and as appropriate, facilitate rapid evacuation for those who may benefit. The latter point potentially is significant in that the rapid evacuation of critically ill patients to higher levels of care lessens the burden of local medical facilities and frees up critically needed bed space.[8] For example, following an earthquake, urgent hemodialysis to treat crush syndrome may be important to arrange.[9]

Ideally, the rapid-response team is a flexible, self-sufficient, and rapidly mobile unit capable of meeting the needs of a wide variety of disaster and humanitarian response missions. The current inventory of US military medical units is limited in this regard. The MST described by Malish *et al* is a modified Forward Surgical Team (FST), which is quite mobile, but of course, is designed for resuscitative surgery of battle casualties and little more.[10] Navy Shock-Trauma Platoons (STPs) and Air Force Small Expeditionary Aeromedical Rapid Response (SPEARR) Teams also are highly mobile, and both offer more flexible designs and broader mission capability than the surgically focused FSTs.[11,12]

Army Medical Companies are larger units and come in a variety of forms, and all offer ambulatory care capabilities, initial non-surgical resuscitation, limited ward care, and are equipped for basic laboratory, plain radiography, and ground ambulance evacuation.[10] They are fully mobile but considerably larger and heavier than FSTs, STPs, and SPEARRs. Given the scale of many disasters, the larger footprint may be an advantage (assuming a larger unit can be transported to the scene in the first place). The most capable medical unit, the Combat Support Hospital is simply too large to expect a rapid response. Of note, similar units to those described exist in the other US uniformed services and the militaries of many nations.

Even if a suitably sized and configured medical unit is selected from the current military inventory, there will be inevitable mismatches between the needs of the disaster-stricken population and the battle-focused design of military units. Spinella *et al* showed that deployed military medical facilities could not adequately manage the large number of pediatric patients received.[13] Similar lessons have been learned and shared by other military organizations.[14] Until recently, it was unreasonable to expect the US military to configure medical assets for a primary humanitarian disaster missions first and combat and defense missions second.[15] With a renewed emphasis on homeland security and domestic response, it is conceivable future medical units may be designed with disaster response in mind.[16]

The success of any disaster rapid-response team ultimately depends on its ability to adapt to the acute needs of the local population, assist in re-establishing local medical services, and facilitating medical evacuation, logistics, consultation, and communication. Military units often are the best option for nations willing to help, but a more nuanced approach can be of even greater benefit. Since rushing in to provide emergency surgery does not seem to be helpful, for now, a more capable and flexible response, even if slightly slower, may be better. In the future, as the US and other militaries develop and refine their primary disaster response capabilities, an appropriately rapid and tailored response may be possible.

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