Chapter

Healthcare Military Logistics at Disaster Regions around the World: Insights from Ten Field Hospital Missions over Three Decades

Michael Naor

Abstract

The Israeli Defense Force Medical Corps deployed airborne medical relief operations to disaster regions, inflicted by natural (earthquake, typhoon, and tsunami) and man-made catastrophes. Missions operated around the globe, in Africa, Asia, Caribbean, Europe, and the Middle East. In this study, based on literature review and interviewing of commanders and participants of ten of such missions operating in nine countries (Armenia, Rwanda, Kosovo, Turkey, India, Haiti, Japan, Philippines, and Nepal), we analyze and outline the principals in assembling and operating these missions. Deployment of the relief operations was swift, to address the needs as soon as possible, even at the cost of partial pre-assessment and a wide margin of uncertainty. This was compensated by the design of multi-disciplinarian and self-sufficient and independent units with flexible operative modes, enabling improvisations to cope with unexpected medical and operative needs. The experience gained in these missions led to a well-defined methodology of assembly and deployment of foreign field hospital in a short time. The review shows an evolutionary pattern with improvements implemented from one mission to the other, with special adaptations to address specific requirements and accommodate language, national culture barriers, and ethical dilemmas.

Keywords: disaster relief, field hospital, military logistics, creativity, collaboration

1. Introduction

Global-scale disasters such as the recent earthquake in Haiti, striking without warning, cause massive loss of life, and produce widespread damage to local infrastructure, including medical facilities [1]. Disasters can lead to great loss of life especially if they hit densely populated regions with limited resources and poorly constructed habitation. Furthermore, damage to roads and transportation systems and difficulties in the rescue and evacuation process can impede accessibility to care [2].

Many countries and organizations around the world developed logistic and medical systems designed to cope with disasters. Dispatched foreign field hospital

(FFH) is one type of medical relief system. The World Health Organization/Pan-American Health Organization defines a field hospital as "a mobile, self-contained, self-sufficient healthcare facility capable of rapid deployment and expansion or contraction to meet emergency requirement for a specified period of time [3]."

The Israeli Defense Force (IDF) Medical Corps developed a model of airborne FFH [4]. This model was structured to deal with disaster settings, requiring self-sufficiency, innovation and flexible operative mode in the setup of large margins of uncertainty regarding the disaster environment. The current study is aimed to critically analyze the experience, gathered in ten such missions deployed in nine countries (Armenia, Rwanda, Kosovo, Turkey, India, Haiti, Japan, Philippines, and Nepal).

The rest of the study is organized as follows. We provide a literature review of healthcare humanitarian aid to disaster areas and a formal definition of a foreign field hospital. The methodology being used is case study. Data was collected by interviews conducted in Israel with senior military staff who actively commanded the humanitarian missions in the disaster areas. Supplemental information was gathered from secondary sources cited in paper. We analyze a series of ten case studies over time period of three decades that provide insights in regards to FFHs deployed by the Israel Defense Forces (IDF) to assist in different types of disasters around the world such as Haiti, Turkey, India, Rwanda, Armenia, and the Philippines. We conclude by sketching future research opportunities that can further develop this field of study.

2. Background

A field hospital is an independent health care facility, which is deployed rapidly for emergency purposes, following the request of the affected country. It is important that delegation and recipient countries clarify in advance the details on responsibilities, chain of command, working protocol with authorities and law enforcement agencies, facilities, installation, and operational process of the FFH in order to avoid any misunderstanding. Both parties need to know the details on the date when the FFH will be operational on site, the FFH equipment and services to be provided, the number of medical staff and their qualifications and experiences, the location of the FFH, and its duration of stay. Next, the components of field hospital deployment are described.

2.1 Mission definition and timing of deployment

Disasters around the world with the potential for the need of international medical assistance are assessed by Israeli governmental bureaus (Ministries of Foreign Affairs, Health, National Security and others), as well as by military offices and local non-governmental organizations. Sending a preliminary assessment team is important. This was the case, for instance, in the pre-FFH era, during the ongoing Cambodian disaster in 1979, were prior assessment of needs, combined with fund raising, led to an incorporation of a drafted team into a Red Cross field hospital in Sakeo, Thailand. More recently, for example, a special assessment team was en route to Haiti 11 h after news of the earthquake reached Israel [5]. An assessing advancing team to Japan evaluated the need for a full scale functional FFH, given the damage to local healthcare system and the medical needs at the disaster zone, coordinated the efforts with the local authorities and regional healthcare providers, defined the required location of the operation, and assessed specific irradiation risks [6].

Acute disaster settings often require immediate assistance, precluding time consuming prior assessment. Furthermore, by the time relief operation arrives, conditions and needs might change substantially, especially if the time required for deployment is extended. Therefore, the Israeli FFH was often one of the first international humanitarian missions active on ground, adopting the principal of "just on time and just in place", at the price of incomplete assessment and a large margin of uncertainty. To compensate for that, the FFH was designed in a way to meet unexpected situations, first by being composed of a multidisciplinary team, and second, by being self-sufficient and independent. Lastly, initiative with numerous improvisations with the help of local agencies and manpower helped coping with unexpected situations. For example, the Armenian mission, operated within a roofed stadium, transformed into a city hospital with the use of plastic sheets stretched on cables, which divided the space into functioning departments. This obviously required a substantial aid provided by local authorities and medical staff [7].

2.2 Location of the FFH

Since swift air deployment is essential to operate expeditiously, missions were airborne, deployed usually in military Hercules airplanes (that enable transportation of vehicles) and occasionally in commercial aircrafts for long-distance missions such as in Haiti/Japan/Nepal. Location of the medical relief operation was usually decided before arrival, and coordinated by pre-assessment team based on dialogs with local health care system and logistic headquarters. Issues taken into account were accessibility to patients, safety (regarding aftershocks in earthquake scenarios, or appropriate safe surroundings in a war zone), and proximity to air fields (for supplies and evacuation in case of emergency). For instance, an intact, roofed municipal sports center provided an adequate shelter and convenient location for the FFH in the snowy Kirovakan. The gymnastic stadium was divided into four functional areas by stretched cables from which black polyethylene sheets were hung, while supplies and surgical rooms were placed on the podium. In Zaire, sleeping quarters were located within an unfinished, fenced, and easily protected private house adjacent to the field hospital. In the missions to Bhuj, India and to Port-Au-Prince, Haiti, soccer fields were chosen as the operation site, because it's a well confined area, usually with one/two entrances, has walls (protection), and its size is adequate [8, 9].

2.3 Communication systems

In a chaotic post-disaster environment, there is a need to utilize both long-range systems to communicate with the delegation's country of origin, and short-range systems to enable communication between site of field hospital home base and local authorities, ambulances, helicopters, as well as delegations from other countries deployed in disaster area. It includes standard walkie-talkie (130–170 MHz), loudspeakers, telephony, fax, internet, email and video conference. Range, spectrum of radio frequencies, bandwidth, weight, size, ease of usage, reliability, batteries life, and cost are important factors in determining which systems the delegation should bring to disaster area. Caution should be taken when patrolling in disaster area with long antenna near collapsed wiring in an earthquake setting. Standard military VHF radio (30–75 MHz) that are non-dependent on local network, proved to be useful in IDF missions for communication with neighboring military units from various countries.

In IDF mission to Rwanda, military VHF systems were utilized for communication with vehicles moving at the range of up to 30 km from the headquarters at the field hospital, which also covered mobile short-distance communication

between the hospital and the sleeping quarters. In 1999, at Adapazri, Turkey, short wave communication (telephone and Internet) relied on a high frequency (HF) radio transceiver in the range of 3–30 MHz; in 2010 at Port-Au-Prince, Haiti, a direct satellite channel was established with an 8 GB bandwidth; and in 2011, at Minanisanriku, Japan, broadband global area satellite internet network (BGAN inmarsat) enabled Wi-Fi communication [6].

2.4 Electronic medical data storage and handling

A computerized hospital administration information system has capability to gather rapidly information, analyze it, and present it to medical team. It can also give pharmacist in charge data control over release of medical supplies and provide alerts regarding need to replenish developing shortages of critical items. The IDF designed and used in Haiti such an information system which included: identification and demographic information, photo album, admission notes and status, survey of injuries by body system, laboratory and imaging studies, surgical reports, diagnoses, and discharge summary [10]. The usage of such an electronic medical record in mega-disaster scenario ensures medical accuracy, and lowers risk of losing information in chaotic environment when patients are transferred between FFHs from different countries, or when delegation returns back to home country and give control over FFH facility to local healthcare authorities as occurred in most missions. For instance, in Haiti, bar-code readers were used to facilitate patient's registration upon entry to a specific department within FFH and to minimize manual data entry errors. The database of passport-like photographs was useful for family members to locate their relatives and it was suggested for future designing customized radio frequency identification (RFID) technology in order to track patients in disaster area [11]. Such technologies are developed in Israel as part of a national system for disseminating information on victims during mass casualty events [12].

3. Methods

This article synthesizes ten medical relief operations in disaster settings, carried out during the last three decades in the form of deployed FFH, in a particular pattern designed and executed by the IDF Medical Corps. We interviewed over period of four years (2011–2015) physicians who actively participated in the IDF disaster relief missions from 1988 until 2015, as chief medical officers and other personnel who have vast experience in the logistics, policy, and health ministry aspects involved in this humanitarian domain from their service in the Israel Home Front Command. Several of them were also highly ranked in United Nations Disaster Assessment and Coordination [UNDAC] and the Department of Peacekeeping Operations at the United Nations Headquarters in New York. Therefore, they have expert-knowledge about the administrative aspects of collaboration between countries during relief missions. Each interview lasted about 2 h and was recorded and transcribed with permission from key informant. Interview questionnaire guide can be provided as appendix. After conduction exhaustive literature review of principal medical and auxiliary publications, we integrated information detailing the assembly of the missions, (manpower selection and training), their operative modes (supplies and equipment, medical data storage and handling, communication systems), capacity (number of beds, collaboration with other delegations), and termination protocol in order to ensure continuity of care by local medical staff their operative modes and outcome.

A body of knowledge was accumulated over the years by the IDF Medical Corps from deploying numerous relief missions to both natural (earthquake, typhoon, and tsunami), and man-made disasters, occurring at nine countries in different regions of the globe (Africa, Asia, Caribbean, Europe, and Middle East). Longitudinal studies of this sort which juxtapose different humanitarian missions can be helpful in learning and making better decisions in the case of future disasters. Indeed, our study shows an evolutionary pattern with improvements implemented from one mission to the other, with special adaptations to address specific requirements and to accommodate to language and national culture barriers [13].

An important trait of the Israeli FFH pertains to the medical staff selection and training: the staff of the FFH (physicians, nurses, pharmacists, etc.) is recruited in a very selective process [14]. It is composed from mixture of reservists and actual duty soldiers drafted for the voluntary mission. Knowledge of local languages at the disaster area (Russian, French, etc.) is an important criterion for staff selection. Missions to war regions such as Goma, Zaire, were complemented by armed soldiers that also served as stretcher carriers. Additional personnel included laboratory, logistic and communication technicians. For risk assessment two members of Israel national committee for nuclear energy joined the mission to Japan, equipped with dosimeters for continuous monitoring of irradiation [15].

Importantly, the chosen personnel are composed roughly 2/3 of people who participated in past missions and 1/3 new recruits, in order to transfer knowledge gathered between missions and to create an organizational body of experience pertaining to humanitarian aid. This experience has often been enriched by previous practice gained in military medical units in combat regions, unfortunately prevalent in Israel and surrounding countries.

Based on IDF experience at Adapazari, Turkey, it is recommended, a (nurse):(physician) ratio of (1–1.5):(1), as opposed to a (2.5–3):1 ratio in regular civilian hospitals because paramedics and medics are available for active assistance [16]. These nurses have to be specialized, work longer and more intensive shifts than in a regular hospital. Consequently, physicians need to assist in classic nursing issues.

Adjustments in hospital structure were made during missions. Thus, IDF FFHs functions ranged from primary care and first aid clinics as in the Kosovo and Japan missions, to regional first echelon for patients released from ruins in Turkey, to municipal hospitals, as happened in India or Armenia, and to a medical referral center, as happened in Haiti, Nepal and the Rwandan disasters. In this last example, the operative mode and structure changed over time, in parallel with needs. This mission served initially as a regional cholera camp, but with the recognition of its capabilities, it became a referral center for trauma and other surgical cases, for patients with meningitis and other complicated medical conditions, as well as for critically ill babies requiring intensive care settings.

The functional structure of the FFHs changed accordingly. In Rwanda, a triage and rehydration facility changed into adult and pediatric wards, with a latter addition of expanding departments for surgical/orthopedic/obstetric patients and for those with non-diarrheal critical infections, such as meningitis [17, 18]. The FFH in India was setup in a fully self-sufficient tent encampment. It provided variety of surgical and diagnostic procedures such as: orthopedics (soft tissues, amputations, fracture reduction, external fixation), plastic surgery, skin grafts, debridement/reconstruction, appendectomy, caesarian section, pediatric neonatal intensive care unit, and deliveries. The FFH in Adapazari, Turkey (1999) served for few days as a first level facility for injured population rescued from wreckage, principally providing surgical and orthopedic surgical facilities and managing patients with crush syndrome and associated renal failure [19]. At later stage, beyond the salvageable

rescue period, the hospital principally provided first aid and primary care for the nearby population, as the number of patients with acute and chronic medical, pediatric and neonatal conditions exceeded that of traumatic cases [20]. The heterogeneous mixture of medical staff enabled the transformations that took place in the operative mode of the FFH.

In the same way, the Haiti mission coped in the first days with injuries caused directly by the earthquake, with very busy orthopedic and surgical units, doubling the surgical capacity by cross-over mixed teams concomitantly addressing needs for various surgical disciplines. A few days later, when patients with less urgent medical needs arrived, staff assignments, organization of unites, and hospitalization policy were readjusted.

4. Results

Our case studies cover a variety of field hospitals deployed by the IDF. Descriptive information of the missions is described in **Table 1** and statistics is presented in **Table 2**. The studied disasters vary in their type, size, and number of casualties, addressing different types of required medical services.

All earthquakes in our case studies had a magnitude of higher than 7 on the Richter scale, associated with mass casualties and damage to local health facilities, requiring foreign assistance. FFH can confront various levels of acuity. If the number of casualties is extremely high (Haiti), one may expect confronting severely wounded patients. If the damage is mainly to the infrastructure (Nepal), one will confront more chronic conditions. It depends on the number of injured people seeking medical care, number of other FFH, how fast the team arrives, the baseline standard of care, damage to local facilities, etc.

For example, in the missions to Armenia or India, most treated casualties in the FFH were principally survivors with minor or intermediate injuries and patients with a variety of acute and chronic medical conditions seeking substitute for the non-functioning local health systems. In some cases, as in Haiti, the FFH served as a tertiary medical center, in the absence of domestic alternatives until the establishment of an appropriate substitute, in this case the floating hospital USNS Comfort [21, 22]. In the two missions to Turkey, the FFH served as a buffer and regional second echelon, relieving pressure from nearby functional local health systems [23, 24]. In Japan, due to the rather late arrival and efficient local medical and evacuation systems, the team work took the form of a primary care service.

Our study also reviews missions addressing medical needs of displaced and crowded refugees in two other countries: Kosovo, and Rwanda [25]. While the Kosovo mission addressed anticipated ongoing medical needs of such a population, the relief operation to Goma, one of many heterogeneous medical relief missions orchestrated by the UNHCR, faced overwhelming outbreak of lethal diarrheal epidemics that exceeded any reasonable capacity [26]. In addition to treating such patients this mission became a referral center for complicated patients transferred from other health facilities.

The evolution of IDF humanitarian operations started by deploying mobile clinics to disaster areas, the first time in Kefalonia (1953), and subsequently in Skopje (1963), or by joining international relief operations such as a Red Cross hospital for Cambodian refugees in Thailand in 1979 [27]. Later, it developed into the adaptable structure of FFHs where the scale was tailored to the disaster arena. The first full scale FFH was in Armenia and later in Turkey, and subsequent missions.

Country	Description of FFH
Armenia	In December 1988, a 7.1 magnitude earthquake occurred in Kirovakan, Soviet Armenia. The IDF medical corps deployed a field hospital to Kirovakan. The FFH team included general and orthopedic surgeons, anesthesiologists, experts in rehabilitation, internal and emergency medicine, nephrology, and pediatrics. The medical relief operation was originally designed to serve as a pediatric rehabilitation center combined with dialysis facilities, as requested by the Soviet authorities but eventually provided primary care. The majority of patients received ambulatory treatment, but there were additional trauma cases, gynecology-obstetrics, and a few acute general surgical cases. Sources: [7, 18, 17].
Rwanda	In July 1994, IDF deployed 3 teams sequentially for 6 weeks to Goma, Zaire, following a tribal strife in Rwanda with consequently displaced population subjected to large scale epidemics (principally cholera and dysentery) and famine. The length of the operation requiring team substitution every 2 weeks, with replacements and supplies arriving by subsequent cargo airplanes, enabling continuous prolonged operation. In each team there were experts in internal medicine and pediatrics with subspecialties, clinical microbiology/tropical medicine, critical care, anesthesiology and neonatology, general and orthopedic surgeons, and gynecologists. The FFH comprehensive multi-disciplinary facilities provided primary and secondary care. The FFH composed of a triage unit, pediatric, medical and surgical wards, and diagnostic facilities. Sources: [7, 18, 25, 36].
Kosovo	The conflict in Kosovo in the 90s escalated in 1999, causing more than one million people from Kosovo to flee from their country to the neighboring countries of Macedonia and Albania. In April 1999, the IDF provided medical services to the refugees. The structure of the hospital was composed of several wards: emergency room, internal medicine, obstetrics and gynecology, pediatric and neonatology, delivery, pharmacy, laboratory x-ray, and security. Twenty hours after arriving in Macedonia, the FFH became functional in the Brazda camp. The IDF field hospital became the referral center for all others primary medical teams. Most of the patients were treated for infections (because of poor sanitary conditions in the refugee camps), exhaustion, and chronic illness (heart disease, diabetes, etc.). Sources: [26].
Adapazari, Turkey	On August 17, 1999, a major earthquake (7.4 Richter) occurred in western Turkey. The city of Adapazari was severely hit. The Israeli field hospital was sent by the Israel Defense Force (IDF) command. The IDF field hospital located in Adapazari provided advanced surgical and medical services; it included trauma care and life saving surgeries and was ready to accept patients in 24 h after arrival on site. The site included 5 beds for intensive care treatment and 80 beds for general hospital admission including internal medicine, obstetrics and gynecology, and surgery. The hospital staff was overall composed of 102 personnel acting as a secondary referral center. Sources: [6, 16, 19, 20, 23, 28]
Duzce, Turkey	In Nov 1999, an earthquake of 7.2 magnitude struck Turkey, this time in the region of Duzce. The IDF medical corps Field hospital was sent 3 days after the disaster. It functioned for 9 days, aiming to substitute for a part of the damaged medical facilities. It acted as a secondary referral center providing specialized and surgical care The hospital structure included seven clinical branches: emergency room (triage), operation room (OR), surgical intensive care unit, internal medicine, orthopedics, pediatrics, obstetrics, and gynecology. The Israeli Field hospital managed to fill the gap in the local medical system, and during its peak operation, its capacity was 300 patients per day. The field hospital focus was on secondary medical care rather than primary and urgent care. Sources: [24].
Bhuj, India	On January 26, 2001, a 7.7 Richter earthquake occurred in India, with the epicenter located in the city of Bhuj. The IDF-led relief activity in India departed within 84 h after recruiting personnel from both regular army and reserve units and initiated hospital activity at site on day six. The field hospital had a fully self-sufficient tent enactment with 30 beds and included auxiliary services units such as radiology, laboratory and medical supplies, and a logistical support unit. The total number of personnel deployed for the India operations was 97. Sources: [8].

Country	Description of FFH
Port au Prince, Haiti	A 7.2 Richter magnitude earthquake struck Haiti on January 2010. The Israel Defense Medical Corps Field Hospital was on site and operational 89 h after the earthquake and provided medical care to many patients during its 10 days of operation. The hospital brought all required supplies in order to stay independent and provide fast deployment, including medical requirements such as antibiotics, imaging machines and lab facilities, and energy sources and accommodations. The Field Hospital consisted on 121 hospital staff members, divided in different units, including medical, surgical, pediatric, orthopedic, gynecologic, ambulatory and auxiliary. The capacity of the Field hospital was 60 inpatient beds, which could be expanded to 72. Sources: [5, 6, 9, 10, 21, 22, 35, 42]
Japan	An earthquake of 9.0 on the Richter scale struck Japan on March 11, 2011. It caused a Tsunami that washed away 250 miles at northeast Honshu. The IDF send a delegation to build a small scale FFH in the format of clinic. Its clinic was located on the east coast in the town of Minami-Sanriku. It served mainly as a referral unit for diagnostic and medical treatment. It was staffed with 55 personnel. The structure of the FFH consisted of several wards: registration-triage and discharge, gynecology, internal medicine, laboratory, surgery, pediatrics, surgery, pharmacy, laboratory and imaging, and a logistics command center. Also, a team of 8 translators helped the FFH crew. In addition, there were an imaging crew equipped with ultrasound and X-ray, a hematology-microbiology-chemistry laboratory, and wireless services. Sources: [6, 15, 42]
Philippines	The typhoon Haiyan struck the Philippines on November 8, 2013. Five days after the event, an IDF team from Israel was assigned by the Philippines government to provide medical assistance to the city of Bogo, where a local hospital that serves more than 250,000 people was operating at partial capacity. The FFH team in the Philippines decided to combine its physical setup with the local structure and support the local medical staff with its experienced medical group, to provide maximum benefit and thereby create one integrated medical infrastructure. Although the IDF team had 25 physicians representing most medical subspecialties and first-class logistics support, they decided to relinquish sole decision-making authority and improvised to establish a model of cooperation with the local health care administrators. Sources: [31, 32, 37, 38]
Nepal	A 7.8 Richter magnitude earthquake struck Nepal on April 25, 2015. The IDF mission that established a field hospital in Kathmandu on April 29 consisted of 126 personnel including 45 physicians. They arrived with 100 tons of equipment and supplies, and capacity to treat 200 patients per day. It was largest IDF mission deployed overseas. Its wards included 2 operating rooms, 8-bed intensive care unit, trauma, obstetrics, gynecology, surgical, orthopedic, and imaging facility. Sources: [29, 30, 43]

Table 1.
Description of IDF disaster relief missions.

All missions were self-sufficient in terms of means of transportation, fuel, drinking water and food supplies, generators and electrical supply, communication systems, tents, kitchen and laundry accessories, and equipment for mechanical maintenance, as well as with means of physical security and preventive medicine. Medical equipment and supplies were based on standard gear of field hospitals stored in military warehouses, supplemented with specific items, medications and supplies tailored for specific mission characteristics [28]. All missions were equipped with standard units for field operations, with ventilators, monitors, and defibrillators, with oxygen supply, with X-ray and ultrasound machines and with a basic diagnostic laboratory (for blood counts, urinary chemistry analysis, microbiology cultures, blood smear staining, coagulation profile, blood gases analysis, serology, and with complementary facilities as needed, such as kits for HIV detection following accidental needle sticks by personnel. There was a limited supply and storage capacity for blood products and with the means for on-site collection, and

Country	Armenia	Rwanda	Kosovo	Turkey (Adapazari)	Turkey (Duzce)	India	Haiti	Japan	Philippines	Nepal
Date (month, year)	Dec-88	Jul-94	Apr-99	Aug-99	Nov-99	Jan-01	Jan-10	Mar-11	Nov-13	Apr-15
Type of disaster	6.8 Richter earthquake	Rwandan refugees	Albanian refugees	7.6 Richter earthquake	7.2 Richter earthquake	7.7 Richter earthquake	7 Richter earthquake	9.0 Richter earthquake	Typhoon	7.8 Richter earthquake
Time until initiation of FFH	12 days		4 days	24–36 h	63 h	6 days	89 h	2 weeks	5 days	82 h
Duration of deployment	13 days	6 weeks	16 days	1 week	9 days	10 days	10 days	2 weeks	10 days	11 days
Number of casualties	25,000	Hundreds of thousands		2627	705	20,005	230,000	28,000	6300	9000
Number of injured	19,000	Hundreds of thousands		5084	3500	166,812	250,000	2800	28,000	23,000
Number of beds in FFH	25	50	35	80		30	72		80	60
Total number of patients	2400	6000	1560	1205	2230	1223	1111	400	2686	1668
Total personnel	34	110	76	102	100	97	100	55	147	126
Physicians	20	18	15	21	21		45	14	25	45
Nurses	3	21	7	10	13		27	7		29
Paramedics and medics	7	4	2	18	19		21			
Pharmacists	1	2	1	1			2	1	1	1
Radiology technicians	1	1	1	1	1		2	1	1	1
Laboratory technicians	1	1	1	1	1		3	2	1	1

Table 2.
Data on relief missions.

screening of blood products. Powered plasma, used for instance in Nepal, helped compensating for the limited storage capacity for blood products [29], and the use of ultrasound-guided nerve blocks for limb surgery saved turnover time and recovery from anesthesia [30].

An important result highlighted during the analysis was the ingredient of creativity needed in all missions with the variety of injuries and diseases they faced (disaster and non-disaster related). Crush injuries and traumatology in missions deployed to earthquake scenarios, epidemics in Rwanda, and later in Haiti, malnutrition and endemic diseases in both missions and in Kosovo, etc. In the mission to Philippines surgical interventions were considered in FFH for therapeutic, palliative, and diagnostic purposes of head and neck tumors [31]. Similarly, another example of improvisation during IDF mission to Philippines occurred when a child with a suspected brain abscess was successfully diagnosed and properly treated [32]. This complex heterogeneity required adaptations in equipment and supplies, not always foreseen, especially with altering clinical challenges. Other improvisations were the extended use of local or regional anesthesia over general anesthesia to shorten recovery periods, the primary abdominal closure with plastic infusion bags due to inflamed Shigella-related necrotizing enterocolitis requiring intestinal resection, blood donation by medical personnel to avoid HIV transmission to recipients in hyperendemic population in Rwanda and Haiti, or the use of protracted (days) ventilation with Ambu bag by hired personnel, in the case of continuous use of all available respirators. Another example of creativity is the self-production of orthopedic hardware, for instance the conversion of Steinman pins into Scentz screws with the aid of a local blacksmith and an engraving machine [33]. These screws underwent standard autoclave sterilization and proved effective in open fractures fixation in the Haiti mission.

5. Discussion

Although each and every disaster presents unique challenges for aid teams, numerous lessons can be derived from the ten IDF missions over the last three decades. After each mission, a rigorous post-mission comprehensive review was held in order to derive lessons about decisions regarding how to improve cooperation with local healthcare providers and foreign delegations.

In general, Israel policy has been to send a large delegation and allow both local and foreign medical personal to join its team [34, 35]. For example, in the IDF field hospital in Armenia, local medical staff that could not operate the destroyed local medical facilities was incorporated in the IDF FFH, enhancing efficacy, translating, utilizing available local facilities, such as sonography and laboratory equipment, and particularly by bridging cultural and professional gaps. Local logistic systems provided warmed housing, transportation and technical aid at the site of action. In Kosovo (1999), young Albanian students volunteered to provide translations, while in Haiti (2010) eight Columbian doctors and nurses joined the surgical teams, enabling around the clock surgeries at 3–4 operating tables.

At the IDF hospital in Rwanda [36], hired locals were used as translators, in preparing local food and in feeding patients, in the preparation of oral rehydration solutions, and in additional maintenance and logistic tasks. Locals were hired in Haiti, Nepal, and the Philippines as well. This help was especially important as the numbers of hospitalized patients increased over time. Incorporating a Dutch Medical Corps company that operated a rehabilitation/convalescence department for severely debilitated patients further expanded overall capacity to about 200 beds. In meetings held at the UNHCR headquarters, representatives of the

various medical relief missions were briefed by CDC experts regarding epidemiology and susceptibility of prominent pathogens, exchanged clinical data and developed a working network of collaboration. Few examples are the conversion of the IDF FFH into a referral center for other medical facilities, the creation of an outflow tract for convalescing children without families in orphanages, a major contribution of a French Army Microbiology laboratory in the diagnosis and management of infectious diseases such as meningitis, and a help by various agencies in supplementing medical supplies and equipment at shortage.

Intact domestic third level medical facilities at the perimeter of the disaster settings enabled transfer of treated patients. This option occasionally offered stabilized critically wounded patients better critical care than in the field conditions. For instance, in Armenia (1988), a patient with ruptured viscera, shock and hypothermia was transported by a Russian Army helicopter, escorted by Israeli and local anesthesiologists to Yerevan, following a lifesaving urgent control of internal bleeding. Air transport of treated and stabilized patients to Macedonian hospitals in the Kosovo mission (1999), and to major hospitals in Ankara and Istanbul in the Turkish earthquake disasters (1999) helped maintaining the operating capacity of the FFH at the disaster settings. Similar cooperative pattern was adopted following the disaster in Nepal (2015), with the IDF FFH in Kathmandu working in collaboration with the Nepalese Birenda Army Hospital. In Bhuj, India (2001), an IDF Hercules airplane remained at hand, providing airlift of treated casualties to remote hospitals in India. In Haiti (2010), such patients were transferred to local primary care facilities to continue with postoperative care, facilitating coping with the never-ending stream of newly admitted patients. The best way to facilitate such cooperation among medical centers is through a centralized system such as the United Nations Disaster Assessment in this event, or the UNHCR headquarters in humanitarian aid to refugees.

A totally different type of collaboration might be the incorporation of the FFH medical staff within an overwhelmed and injured local medical facility. This approach was adopted in the FFH mission to the Philippines (2013) where it was decided to combine efforts with the local facility, creating one integrated medical infrastructure [37]. The IDF delegation was integrated with the Severo Verallo memorial district hospital, an urban healthcare facility with approximately 80 beds, which was understaffed and had limited resources. The IDF 25 physicians representing most medical subspecialties, with the additional medical personnel worked under the medical and administrative direction of the local health care directors, while the logistic staff assisted the repair of the local hospital, restoring electricity, and providing much-needed supplies and equipment such as a mobile X-ray machine and an autoclave. Open discussions, held to establish clear lines of responsibility and co-sharing of tasks, helped in building trust and cooperation [38].

The mission's termination timing depended on the resolution of the disastrous event, for instance the termination of influx of patients removed from ruins in earthquake Turkish disasters, or the control of diarrheal epidemics among Rwandan refugees by the installation of appropriate water and food supplies and sanitation. Another important factor is the restoration of local health systems, as occurred in Armenia or the Philippines, or the establishment of appropriate long-lasting substitute services such as a Norwegian field hospital that settled at Goma, Zair, or the arrival of the USNS Comfort floating hospital, and other medical facilities operated by the Red cross and the University of Miami in the Haitian disaster. In such settings a handing over procedure of hospitalized patients was carried out, with their available medical data. Some convalescing but fully incapacitated patients were handed over to other non-medical local humanitarian facilities such as monasteries and orphanages. The termination of mission was coordinated with and orchestrated

by the local health authorities in order to ensure continuity of operations by local medical staff or newly arrived substitutes. In most cases, supplies and equipment were handed over to local health systems under the direction of local authorities.

While the selection and incorporation of drafted highly qualified medical personnel within the military framework, characteristic for the Israeli FFH model, provides excellent medical performance customized for the specific mission, this restricts the longevity of the mission, as drafted personnel are expected to resume their civil work within a relatively short period of time. Thus, most missions lasted 2–3 weeks, only. Nevertheless, as happened in the Rwandan disaster, and in other missions addressing disasters in Cambodia and in Ethiopia, substituting teams of medical experts and additional personnel were created with changing operative shifts at 2–4 weeks intervals [39]. This enabled protracted mission activity, as required.

6. Conclusions

In conclusion, our study provides comprehensive review of ten missions conducted by the IDF over the last three decades. **Table 3** summarizes insights emerging from our research for future relief missions. The uniqueness of our study is that we investigated the response to different types of disasters, with some of the humanitarian missions sent in response to natural disasters (earthquake, tsunami, or typhoon) while others were delivered to war zones and ethnic clash terrains.

1.	An advanced team is crucial for defining needs, expectations, priorities, and identifying risks, as well as facilitating legal details with local authorities
2.	Swift deployment providing adaptive operative flexibility is maintained by delegation's multi-disciplinary heterogeneity of personnel, and readiness for improvisations
3.	Coordination with both the local health system and other aid organizations operations in disaster area is essential
4.	It is imperative to be aware and respect the national culture differences between an aid mission and the affected country
5.	Field hospital must be entirely self-sufficient (transportation, energy, food, water, equipment and supplies)
6.	Providing security to field hospital may be necessary in conflict areas
7.	The contribution of translators and local health employees is significant
8.	Integration of volunteer teams from other countries into field hospital can fill lack of human resource and improve operations
9.	The optimal operative period is 2–3 weeks. Substitutions and supplementary airborne logistics are required for longer missions
10.	Standardization of procedures is essential in order to optimize medical response
11.	After few days, most of medical activity becomes non-urgent treatment of population
12.	Communication devices, Information systems, and electronic medical data storage and handling records improve efficiency of field hospital
13.	Before departure back to home country, the delegation should coordinate with local authorities the transfer of authority over the FFH facility, equipment, and supplies in order to ensure continuity of operations by local medical staff
14.	Ethical issues pertaining to treatment of patients and their families in disaster area must be taken into consideration before mission deployment

Table 3.
Insights emerging from our study for future relief missions.

More specifically, the cases we describe in Rwanda and Kosovo contribute to the literature because they demonstrate the usefulness of FFHs not only for natural disasters but also in situations of civil war. The ten missions varied also in their geographical distance from the home base in Israel, which impacted arrival time. While some of the disasters where located in developing countries such as Haiti, others occurred in highly developed countries such as Japan. The objective of the missions determined the duration of stay. For example, in the earthquake disasters in Turkey, FFHs were designed to assist in the acute care of casualties for a few days, only, within the period of time of recovering survivors trapped under the ruble of collapsed buildings, while at Rwanda, the goal was to participate in protracted, large scale lethal epidemics among displaced population fleeing a civil war.

A crucial avenue of research concerns the ethical issues humanitarian operations face, such as which patients to admit, given the limited capacity of hospital beds and other resources [40, 41]. For instance, it was noted based on experience in Japan and Haiti that premature deliveries, low-birth-weight neonates, and other complications with increased risk of infection and blood-loss increase at disaster areas. Because survival rates of low-birth weight neonates delivered in a disaster environment are diminished, the dilemma of whether to impose a minimum weight threshold for preterm neonates to receive treatment is an ethical issue, which obstetrics and gynecology teams should be prepared to deal with [42]. Another example, during Nepal mission it was found that procedural sedation and analgesia (PSA) should be a priority when treating pediatric victims of disaster since they are prone to psychological distress secondary to the traumatic event [43].

In sum, this study has highlighted the importance of studying the fruitful collaboration between military and civilian organizations in the establishment of field hospitals. We hope that the future research avenues we sketched will motivate other scholars to engage in this field to prepare the global community to deal with major disaster relief operations.

Author details

Michael Naor
School of Business Administration, The Hebrew University of Jerusalem, Jerusalem, Israel

*Address all correspondence to: michael.naor@mail.huji.ac.il

References

[1] Peleg K, Reuveni H, Stein M. Earthquake disasters: Lessons to be learned. Israel Medical Association Journal. 2002;**4**:361-365

[2] Rokach A, Nemet D, Dudkiewicz M, Albalansi A, Pinkert M, Schwartz D, et al. Advanced rescue techniques: Lessons learned from the collapse of a building in Nairobi, Kenya. Disasters. 2009;**33**(2):171-179

[3] WHO/PAHO. Guidelines for the Use of Foreign Field Hospitals in the Aftermath of Sudden-Impact Disaster. Department of Emergency and Humanitarian Action, the World Health Organization; Area of Emergency Preparedness and Disaster Relief; 2003

[4] Ran Y, Hadad E, Daher S, Ganor O, Yegorov Y, Katzenell U, et al. Triage and air evacuation strategy for mass casualty events: A model based on combat experience. Military Medicine. 2011;**176**(6):647-651

[5] Kreiss Y, Merin O, Peleg K, Levy G, Sagi R, Abargel A, et al. Early disaster response in Haiti: The Israeli field hospital experience. Annals of Internal Medicine. 2010;**153**(1):45-48

[6] Finestone AS, Levy G, Bar-Dayan Y. Telecommunications in Israeli field hospital deployed to three crisis zones. Disasters. 2014;**38**(4):833-845

[7] Heyman S, Eldad A, Wiener M. Airborne field hospital in disaster area: Lessons from Armenia (1988) and Rwanda (1994). Prehospital and Disaster Medicine. 1998a;**13**(1):14-21

[8] Bar-On E, Abargel A, Peleg K, Kreiss Y. Coping with the challenges of early disaster response: 24 years of field hospital experience after earthquake. Disaster Medicine and Public Health Preparedness. 2013;**7**(5):491-498

[9] Farfel A, Assa A, Amir I, Bader T, Bartal C, Kreiss Y, et al. Haiti earthquake 2010: A field hospital pediatric perspective. European Journal of Pediatrics. 2011;**170**:519-525

[10] Levy G, Blumberg N, Kreiss Y, Ash N, Merin O. Application of information technology within a field hospital deployment following the January 2010 Haiti earthquake disaster. Journal of American Medical Association. 2010;**17**:626-630

[11] Rosen Y, Gurman P, Verna E, Elman N, Laor E. Rapidly-deployed small tent hospitals: Lessons from the earthquake in Haiti. Prehospital & Disaster Medicine. 2012;**27**(3):1-2

[12] Adini B, Peleg K, Cohen R, Laor D. A national system for disseminating information on victims during mass casualty incidents. Disasters. 2010;**34**(2):542-551

[13] Naor M, Linderman K, Schroeder RG. The globalization of operations in eastern and Western countries: Unpacking the relationship between national and organizational culture and its impact on manufacturing performance. Journal of Operations Management. 2010;**28**(3):194-205

[14] Hartal M, Yavnai N, Yaniv G, Gertz D, Fleshler E, Kreiss Y. Old challenges and new perspectives on developing military physicians: The first 4 years of the new Israeli model. Military Medicine. 2016;**181**(2):129-135

[15] Merin O, Blumberg N, Raveh D, Bar A, Nishizawa M, Cohen-Marom O. Global responsibility in mass casualty events: The Israeli experience in Japan. American Journal of Disaster Medicine. 2012;**7**(1):61-64

[16] Margalit G, Rosen Y, Tekes-Manova D, Golan M, Benedek P, Levy Y, et al.

Recommendations for nursing requirements at a field hospital, based on Israel defense forces field hospital at the earthquake disaster in Turkey—August 1999. Accident and Emergency Nursing. 2002;**10**(4):217-220

[17] Maayan S, Marks N, Viterbro A, Zeide Y, Morag A, Neil L, et al. HIV infection and susceptibility to epidemic bacterial infections among Rwandan refugees. International Journal of Infectious Diseases. 1997;**1**(4):199-201

[18] Heyman SN, Ginosar Y, Niel L, Amir J, Marx N, Shapiro M, et al. Meningococcal meningitis among Rwandan refugees: Diagnosis, management, and outcome in a field hospital. International Journal of Infectious Diseases. 1998b;**2**(3):137-142

[19] Halpern P, Rosen B, Carasso S, Sorkine P, Wolf Y, Benedek P, et al. Intensive care in a field hospital in an urban disaster area: Lessons from the august 1999 earthquake in Turkey. Critical Care Medicine. 2003;**31**(5):1410-1414

[20] Wolf Y, Bar Dayan Y, Mankuta D, Finestone A, Onn E, Morgenstern D, et al. An earthquake disaster in Turkey: Assessment of the need for plastic surgery services in a crisis intervention field hospital. Plastic & Reconstructive Surgery. 2001;**107**(1):163-170

[21] Merin O, Miskin IN, Lin G, Wiser I, Kreiss Y. Triage in mass-casualty events: The Haitian experience. Prehospital & Disaster Medicine. 2011;**26**(5):386-390

[22] Yitzhak A, Sagi R, Bader T, Assa A, Farfel A, Merin O, et al. Pediatric ventilation in a disaster: Clinical and ethical decision making. Critical Care Medicine. 2012;**40**(2):603-607

[23] Bar-Dayan Y, Beard P, Mankuta D, Finestone A, Wolf Y, Gruzman C, et al. An earthquake disaster in Turkey: An overview of the experience of the Israeli defense forces field hospital in Adapazari. Disasters. 2000;**24**(3):262-270

[24] Bar-Dayan Y, Leiba A, Beard P, Mankuta D, Engelhart D, Beer Y, et al. A multidisciplinary field hospital as a substitute for medical hospital care in the aftermath of an earthquake: The experience of the Israeli defense forces field hospital in Duzce, Turkey, 1999. Prehospital and Disaster Medicine. 2005;**20**(2):103-106

[25] Heyman SN, Ginosar Y, Shapiro M, Kluger Y, Marx N, Mayyan S. Diarrheal epidemics among Rwandan refugees in 1994: Management and outcome in a field hospital. Journal of Clinical Gastroenterology. 1997;**25**(4):595-601

[26] Amital H, Alkan JA, Kriess I, Levi Y. Israeli defense forces medical corps humanitarian mission for Kosovo's refugees. Prehospital and Disaster Medicine. 2003;**18**(4):301-305

[27] Adler J, Bodner E, Stein SB, Goldfarb J, Engelhard D, Naparstek J, et al. Medical Mission to a refugee camp in Thailand. Disasters. 1981;**5**(1):23-31

[28] Finestone AS, Bar-Dayan Y, Wolf Y, Stein M, Tearosh J, Zaide Y, et al. Diagnostic medical auxiliary equipment in a field hospital: Experience from the Israeli delegation to the site of the Turkish earthquake at Adapazari. Military Medicine. 2001;**166**(7):637-640

[29] Merin O, Yitzhak A, Bader T. Medicine in disaster area: Lessons from 2015 earthquake in Nepal. JAMA Internal Medicine. 2015:E1-E2

[30] Lehavi A, Meroz Y, Maryanovsky M, Merin O, Blumberg N, Bar-On E, et al. Role of regional anaesthesia in disaster medicine: Field hospital experience after the 2015 Nepal earthquake. European Journal of Anaesthesiology. 2016;**33**(5):312-313

[31] Marom T, Merin O, Segal D, Tsumi E, Lin G, Erlich T. Ethical and clinical dilemmas in patients with head and neck tumors visiting a field hospital in the Philippines. American Journal of Disaster Medicine. 2014;**9**(3):1-8

[32] Weiser G, Mendlovic J, Dagan D, Albukrek D, Shpriz M, Merin O. Case report: A brain abscess in a disaster zone—Beyond the call of duty. Disaster and Military Medicine. 2015;**1**(13):1-3

[33] Lin G, Lavon H, Gelfond R, Abargel A, Merin O. Hard times call for creative solutions: Medical improvisations at the Israel field hospital in Haiti. American Journal of Disaster Medicine. 2010;**5**(3):188-192

[34] Bar-Dayan Y. International collaboration in disaster medicine – It is time for the "big step" in disaster preparedness. Prehospital and Disaster Medicine. 2008;**23**(4):280-281

[35] Peleg K, Kreiss Y, Ash N, Lipsky AM. Optimizing medical response to large-scale disasters: The ad hoc collaborative health care system. Annals of Surgery. 2010;**253**(2):421-423

[36] Heyman SN, Horovitz J, Nehama H, Sofer S, Orbach J, Amir Y, et al. Sudden death during fluid resuscitation: A lesson from Rwanda. Lancet. 1994;**344**:1509-1510

[37] Albukrek D, Mendlovic J, Marom T. Typhoon Haiyan disaster in the Philippines: Pediatric field hospital perspectives. Emergency Medicine Journal. 2014;**31**(12):951-953

[38] Merin O, Kreiss Y, Lin G, Pras E, Dagan D. Collaboration in response to disaster—Typhoon Yolanda and an integrative model. New England Journal of Medicine. 2014;**370**:1183-1184

[39] Kassis I, Lak L, Adler J, Rinat C, Shazberg G, Fekede Tewade D, et al. Medical relief operation to rural northern Ethiopia: Addressing an ongoing disaster. Israel Medical Association Journal. 2001;**3**:772-777

[40] Merin O, Ash N, Levy G, Schwaber MJ, Kreiss Y. The Israeli field hospital in Haiti: Ethical dilemmas in early disaster response. New England Journal of Medicine. 2010;**362**(1):e38

[41] Glassberg E, Bader T, Nadler R, Benov A, Zarka S, Kreiss Y. When humanitarian trumps politics. Israel Medical Association Journal. 2015;**17**:339-340

[42] Pinkert M, Dar S, Goldberg D, Abargel A, Cohen-Marom O, Kreiss Y. Lessons learned from an obstetrics and gynecology field hospital response to natural disasters. Obstetrics and Gynecology. 2013;**122**(3):532-536

[43] Weiser G, Ilan U, Mendlovic J, Bader T, Shavit I. Procedural sedation and analgesia in the emergency room of a field hospital after the Nepal earthquake. Emergency Medicine Journal. 2016;**33**(10):745-747