Haiti earthquake 2010: a field hospital pediatric perspective

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Abstract On January 12, 2010, a 7.0-magnitude earthquake struck Haiti. The region had suffered an estimated 316,000 fatalities with approximately 300,000 injured and more than 1 million people who lost their houses. Following the quake, the Israeli Defense Force Medical Corps dispatched a field hospital unit to the capital city, Port au Prince. The hospital had a pediatric division which included pediatric emergency department, pediatric ward and neonatal unit. We elaborate on the various aspects of pediatric treatment that was provided by our hospital. A total of 363 pediatric patients (younger than 18 years) were admitted to our facility during its 10 days of operation. Out of this total, 272 pediatric patients were treated by the pediatric division, 79 (29%) were hospitalized and 57 (21%) required surgery. The pediatric team included seven pediatricians, one pediatric surgeon and six registered nurses. An electronic record and a hard copy file were created for each patient. Fifty-seven percent of the children presented with direct earthquake related injuries. Twelve patients required resuscitation and stabilization and three patients had died. The majority of injuries were orthopedic while infectious diseases accounted for most of the general pediatric diagnoses. In conclusion, operating a field hospital for a population affected by natural disaster is a complex mission. However, pediatric care has its own unique, challenging characteristics.

Keywords Earthquake · Field hospital · Pediatric emergency department · Disaster medicine

Introduction

On January 12, 2010, Haiti was struck by a magnitude 7.0 earthquake (Richter scale), which caused devastating damage to its capital, Port Au Prince. The International Red Cross estimated that about 3 million people were affected by the quake. The Haitian government reported that an estimated 316,000 people had died, 300,000 had been injured and more than 1 million residents were left homeless [3], as yet there is still no consensual official data available. As a direct consequence of the disaster, the governmental healthcare and welfare infrastructure ceased to function, leaving the capital region with essentially no functional healthcare facilities.

In response to the event and following the Israeli government decision to launch a medical humanitarian mission, a field hospital was dispatched to the region by the Israeli Defense Forces (IDF).

To ensure maximum logistic independence, the hospital was supplied by a fully stocked pharmacy, including sufficient oral antibiotics to be distributed on discharge, imaging system, autoclaves for sterilization and a laboratory that could perform blood and urinary chemistry analysis, blood count, blood gases and microbiology.

The hospital was fully operational by the fourth day post-disaster and was the first major multi-disciplinary medical center to operate in the city following the disaster.
providing various essential resources including a pediatric emergency department (PED), pediatric ward, neonatal care, intensive care unit and a team of surgeons and orthopedic specialists with diverse surgical capabilities.

Pediatric patients arrived to the hospital primarily by private transportation or by foot even though most of them had suffered from serious injuries. The minority were transferred by ambulances as available medical transport services were scarce. Patients were presented initially for primary triage. Pediatric patients were further referred, depending on age and medical condition, either to the PED, ambulatory clinic or to the intensive care unit.

The field hospital was operational for a period of 10 days and served as a referral center for small international medical teams which provided emergency medical treatment within the city.

In this paper, we describe the pediatric team experience and lessons learned during the early post-earthquake period.

Materials and methods

Structure

The hospital was erected in the center of a soccer field within a suburb of Port Au Prince and consisted of tents, divided into seven divisions: internal, surgical, orthopedic, pediatric, gynecologic, ambulatory clinic and auxiliary unit (Fig. 1). The pediatric division consisted of a 16-bed hospitalization ward with a maximum capacity of 20 beds, an eight-bed emergency department with resuscitation capabilities, and a neonatal unit with two incubators and a respirator.

Personnel and resources

The pediatric medical team comprised seven pediatricians, a pediatric surgeon, six registered nurses and two medics. The pediatric triage was fully coordinated with the orthopedic team, intensive care unit and the operating room capacities. The entire team had worked both in PED and on the pediatric ward in order to maximize the limited human resources. The team provided care 24 h a day.

Demographic data

During its 10 days of operation, 1,111 patients were treated in our field hospital. Children younger than 16 years of age were referred to the PED, whereas older children were treated within the general emergency department. Total Pediatric capacity (younger than 18 years old) accounted for 32% (363 patients) of hospital consultations. The authors retrieved all of the medical records for the 272 pediatric patients 16 years and younger who were treated by the pediatric teams. The rest were either treated in the internal division (16–18 years old) or by the ambulatory clinic. Sixteen neonates were born in our hospital. Healthy newborns were examined by a pediatrician and if healthy remained hospitalized in the gynecology department. Five neonates, including four preterm newborns, required further care by the neonatal intensive care unit thus included in the study.

![Fig. 1 An aerial photograph of the field hospital taken from an helicopter](image-url)
Hospitalization was defined as staying in hospital overnight.

Each patient had an electronic medical record as well as a hard copy paper file. Each record included demographic details, a photograph of the patient, diagnosis and management details.

The authors retrospectively analyzed data retrieved from both registries.

Results

Out of 272 pediatric patients treated by the pediatric teams, 92 (33.8%) were younger than 2 years old. Out of this total, 134 (49.3%) patients were males, 115 (42.3%) were females and data was missing for 23 patients (8.5%).

On average, approximately 27 patients were seen within the PED each day. Of the pediatric patients, 79 children (29%) were hospitalized and 57 (21%) required surgery.

Of the children admitted into the pediatric division, 57% presented with direct earthquake related injuries. During the first 3 days, approximately 80% of patients had traumatic injuries. After the first few days, medical needs shifted from patients who required care for injuries caused directly by the earthquake to diseases and injuries related to the hazardous environment left by the disaster (Fig. 2).

There were significantly more orthopedic injuries than other types of traumatic injuries. These included 48 (15%) fractures, 52 (16.4%) open wounds and 29 (9.2%) crush injuries (Table 1).

Infectious diseases accounted for most of the general pediatric diagnoses of which gastrointestinal infections were the most prevalent (Table 1).

Fracture reduction and fixation combined with fasciotomies and tissue debridement accounted for the substantial proportion of procedures performed (Fig. 3).

The mean duration of hospitalization was 1.4 days. Twenty-two children (8.2%) were hospitalized for 4 days or more.

Three patients died from complicated overwhelming infections. Twelve patients required resuscitation and stabilization, of them, ten patients required fluid resuscitation due to severe dehydration and two patients had to be resuscitated due to cardiopulmonary compromise resulting from untreated infections.

Discussion

We reviewed the management of the 272 pediatric patients treated by the pediatric division of the Israeli field hospital following the devastating earthquake that occurred in Haiti in January 2010. Although children represented a large proportion of the population, they constituted only 32.6% of the hospital admissions. Similar proportion of pediatric and adult patients was reported by Bar-Dayan et al. [1] following the 1999 earthquake in Turkey. This can be explained as: children might have a higher mortality rate, may have survived with fewer injuries or were incapable of reaching our hospital due to incapacitating familial conditions.

The predominance of orthopedic trauma is similar to the pattern of earthquake injuries reported in the literature [2, 6, 13, 17]. Bulut et al. [2] reported that 66% of the patients admitted to their hospital following the 1999 earthquake in Turkey had extremity injuries. Xiang et al. [17] reported that orthopedic injuries accounted for 81% of all pediatric injuries following the 2008 earthquake in China. The University of Miami field hospital in Haiti (UMHH)
reported an approximately 60% rate of procedures with similar predominant wound debridement, orthopedic trauma and amputations ([18] Post-Earthquake injuries treated at a field hospital—Haiti 2010). This pattern is attributed to collapsing buildings and falling debris. Severe head trauma, open skull wounds and burns were relatively rare. It is assumed that children with these types of injury did not survive the initial trauma. Although the UMHH reported a 9% prevalence of head injuries, there was no subdivision of these injuries into categories such as facial, skull or brain parenchymal injuries, hence, this finding could have been explained primarily by superficial head injuries ([18] Post-Earthquake injuries treated at a field hospital—Haiti 2010). Bulut et al. [2] reported a 7% prevalence of head injuries during the post-disaster response following the 1999 earthquake in Turkey, but most of these injuries were minor and could be explained, again, by superficial facial or skull injuries.

The hospitals’ triage algorithm had taken into account three parameters: urgency due to patient condition, hospital resources and the likelihood of saving patients’ life. Since we had neither a neurological service nor computed tomography, our approach was to provide appropriate care based on limited resources, thus, patients with severe head injuries were referred to other facilities [10]. This approach is in accordance with the medical disaster response model for triage following an earthquake which suggests treating only patients with more than 50% probability for survival [13].

Inappropriate sanitary conditions, crowded tent camps and contaminated water and food resulted in infectious diseases, particularly gastrointestinal, skin and respiratory infections with increasing prevalence during the course of post-disaster state. This pattern was also observed after the 2004 earthquake and tsunami in Indonesia [4].

The increase in prevalence of chronic illnesses among our patients who were treated in our division during the second week (as presented in Fig. 2) can be partly attributed to the natural decline in trauma cases but also to the absence of local health services in Port au Prince following the disaster, causing an interruption of care for many patients who sought care wherever feasible. A similar trend has been observed in previous earthquakes such as those that occurred in Armenia (1988) [11] and in Kobe, Japan (1995) [14], and is further reflected from the UMHH report ([18] Post-Earthquake injuries treated at a field hospital—Haiti 2010), which observed an equal distribution of earthquake and non-earthquake related injuries during the second week post disaster that shifted towards predominance of non-earthquake related injuries on the fifth week and forth. Furthermore, urgent activities such as searching for family members or finding a place to stay often took precedence over seeking personal care. This may have resulted in delayed presentation of severe acute conditions. This course may also reflect an expected rise of common childhood diseases that are typical for developing countries as had been observed in previous disasters. Guha-Sapir at al. [4] documented a predominance of infectious diseases (53%) on the third week and forth among pediatric patients admitted to the Banda-Acheh field hospital following the 2004 Indian Ocean tsunami [5, 12], most of which were respiratory and gastrointestinal infections. These observations emphasize the necessity to consider non-“disaster related” illnesses when elaborating the structure and resources of a field hospital following similar events.

The most likely explanation for the rate of infected wounds is the lack of clean water and antibacterial medications as well as the delay in receiving appropriate care. Septic patients were admitted for intravenous antibiotic treatment but ultimately all patients received systemic anti-bacterial medications, primarily Amoxicillin-Clavulanate.

In Haiti, tetanus is still a major public health concern [16]. In 2008, only 53% of Haitian population was vaccinated against tetanus. Thus, given the concern for the likelihood of tetanus, pediatric trauma patients were vaccinated regardless of their immunization status. A similar approach was practiced in previous post disaster situations [4] as well as by the UMHH during the current disaster response [9] although eventually it was decided by the UMHH to administer vaccines to all their (and not only trauma) patients. Tetanus toxoid vaccines were readily available (though not abundant) in our facility and weight- ing up the minimal probability of side effects against the high risk for tetanus in non-immunized patients it became clear that patients who had suffered any type of deep wound should be vaccinated. A limited supply of vaccines prevented the implementation of a more permissive approach as was practiced by the UMHH.

Due to the limitation of operation room capacity, many procedures were performed under deep sedation within the PED tent, including soft tissue debridement and skin lacerations repair. This observation emphasizes the importance of sedation skills amongst pediatricians. Deep sedation was obtained with a combination of intravenous Midazolam and Ketamine as the drugs of choice. The presence of pediatric surgeon as part of the team, though not described in previous disasters, enabled implementation

**Fig. 3 Types of operations performed on pediatric patients**

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*Ex. Fix. - External Fixation  
*ENT - Ear Nose & Throat*
of minor surgical procedures within the PED and proved to be highly efficient. The assistance of anesthesiologists was readily available, although ultimately not required.

For pediatric patients who were rescued from the rubble, rehydration and hemodynamic stabilization with intravenous crystalloids, prior to orthopedic evaluation, was the rule.

Although most victims coped amazingly well, some children experienced overwhelming psychological stress and some suffered psychiatric decompensation. This was manifested most commonly as behavioral disturbances, irritability or inappropriate indifference. Weiner et al. [15] reported a much higher prevalence (65%) of psychological symptoms during the post disaster response following the 2008 earthquake in China. This discrepancy may be explained by cultural differences and by the fact that linguistic gaps between caregivers and patients in Haiti (unlike in China) might have inadvertently led the staff to overlook some of the psychological symptoms amongst our patients.

Linguistic gaps, indeed, presented a practical challenge regarding treatment of patients who were not able to provide important details about their medical conditions, medications or immunization status. The assistance of local translators proved to be crucial but could not fill the gap of missing medical information.

Another challenge we faced was how to deal with the need for surge capacity in our field hospital. As soon as the hospital was deployed, patients began to arrive, as news of the existence of our facility began to spread, largely by word of mouth. In less than 2 days, the hospital had operated at full capacity, sooner than we had anticipated, partly because it began to serve as a referral center for other primary care teams that were deployed in the surrounding area and due to the scarcity of advanced medical facilities in Haiti. Indeed, we struggled continuously to settle the natural conflict between limited capacity and optimal, desirable standard of care. For example, most children were discharged 1–2 days following fracture reduction/fixation or amputation without any physical rehabilitation and with only short duration follow-up. In order to address the needs for efficient turnover of patients who outweighed our limited capacity, an efficient, centralized triage system was set up in which patients were distributed according to their medical problem. Pediatric ambulatory patients were referred either to the ambulatory clinic, orthopedic department or PED taking into account their age, general condition, type and severity of medical presentation and the receiving department’s capacity. For example, pediatric patients with minor injuries were generally treated in the ambulatory clinic unless they were very young (under 2 years old) or when their capacity was overwhelmed. In either case patients were referred to the PED for evaluation and treatment. Older children with straightforward simple, orthopedic diagnoses were referred directly to the orthopedic department for short procedures (such as casts) again, according to capacity. The difficulties of efficient triage after an earthquake were addressed in a study from China [17]. Similar to our system, in order to shorten the triage waiting time, the triage was carried out by senior physician (surgeon or emergency physician). In addition, since the bottleneck in such a scenario is the operation room’s capacity, the post-operative care was carried out by pediatricians.

The pediatric teams had worked around the clock and often used an approach of permissive discharge combined with short-term follow-up. In selected cases, patients were invited to return for follow-up visits in order to reassess their condition and to secure treatment continuity. We tended to use systemic therapy with oral anti-microbials and oral rehydration solutions in order to enable prompt discharge whenever feasible. Our failure rate appeared to be negligible so that no deterioration was observed during follow-up reassessments of these patients. We feel that such an approach was appropriate under these unique circumstances, especially given the fact that our field hospital was the only functional facility with advanced medical capabilities during the first few days.

In order to further improve capacity control while being well aware of the risks of not providing adequate postoperative care, we notified each health facility that for every patient referred to us for a higher level of care, we would expect the referring facility to be willing to accept one of our patients for immediate postoperative management in exchange. This policy enabled us to maximize the throughput of our operating room by increasing the number of operations and procedures that we were in a unique position to perform, while ensuring that our patients were not abandoned [7].

Aside from the necessity for a high turnover of patients, the relatively short mean hospitalization time (1.4 days) was attributed to the lack of available rehabilitation measures and by the scarcity of intensive care beds. In contrast, the UMHH had reported a median length of stay of 13 days for earthquake related injuries and 6 days for non-earthquake related injuries. This discrepancy can be explained by the ability of the UMHH to provide rehabilitation services and by its evolvement into a tertiary referral center for severe injured patients requiring long term management ([18] Post-Earthquake injuries treated at a field hospital—Haiti 2010).

In the setting of a shattered infrastructure, sustainable electrical power was lacking; therefore, discharge with medications requiring refrigeration, such as suspensions, was not an option. Children who required such medications were given adult tablets pre-cut to the appropriate dosage or capsules with instructions on how to open and sprinkle the capsule contents into food. For young children we provided formula and diapers in addition to medications.
Pediatric patients were usually accompanied by family members. Unlike in other facilities [9], only one relative per patient was allowed inside the facility. Both visitors and patients were required to wear identification stickers at all time. Family members were responsible for feeding and bathing the patient as well disposing of waste. Few children were admitted without the attendance of relatives, therefore, had to be discharged in coordination with local and international relief organizations in order to secure treatment continuity elsewhere. Moreover, compliance was further motivated due to the fact that the hospital served as a source of fresh food and clean water for patients and their families. As described, selected patients (as many as 8% of patients) were invited for follow-up return visits with a 100% observed compliance. This is a surprising observation taking into account transportation and environmental difficulties. It is probably attributed to the lack of any treatment continuity elsewhere. Moreover, compliance was further motivated due to the fact that the hospital served as a source of fresh food and clean water for patients and their families.

During this operation, we practiced a newly introduced electronic registry system [8]. The main application consisted of an administrative database which provided information on admissions, discharges, surgical operations and patient distribution by department. The system also monitored the flow of patients within the hospital and noted dates and times of entry to the various departments. A second module within the application was an electronic patient record which included identification and demographic information, photo album, admission notes and status, survey of injuries by body system, laboratory and imaging studies, surgical reports, patients’ movements within the hospital, diagnoses, and discharge summary.

A computerized hospital administration information system has the ability to gather the required information quickly and accurately, to analyze it, and present it to the decision-making command level promptly, thus enabling an informed decision making process. Moreover, the use of an electronic medical record in a major-disaster scenario helps to ensure the adequacy of care, enabling rapid patient transits within the various hospital departments while lowering the risk of losing valuable medical information. In addition, an electronic medical record system contributes to effective patient discharge by producing a clear, concise, discharge summary which assists in maintaining continuity of care. Further benefits include the establishment of control over potential bottlenecks within the hospital, efficient management of the surgical waiting lists, easy identification and tracking of patient locations within the hospital, ability to transmit radiographic images to stations throughout the hospital, facilitation of the treatment of returning patients, and the production of database for research purposes.

In addition, the system also fulfilled a vital need of the calamity-struck local population. Many children arrived at the hospital without a guardian. The database of passport-like photographs produced by the system indeed enabled family members to locate their relatives in the hospital through our database.

A potential drawback of the system is the possible formation of a dependency on technology in a harsh, unstable and sometimes unpredictable environment. Therefore, it is mandatory to have a fallback plan such as the use of hardcopy paper forms as was practiced in our hospital. Additional drawbacks may be that dedicated personnel are required to deploy and maintain a computer network and that such a system may potentially slow down caregivers during peak hours.

In the face of environmental hardships, our system was able to introduce order, provide means of identifying patients and management of their care, and produce timely valuable information that guided the operation.

Lessons learned

- Pediatric resuscitation capabilities are highly required in a post-disaster environment, thus, at least one resuscitation facility should be planned within the PED.
- Limited capacity burdened by high admission rates should promote an efficient triage system based on reliable flow of information regarding capacity through an electronic registry system. Permissive, though prudent, discharge policy should assist to balance field hospital resources.
- Pre-planned alternatives for medications which require refrigeration should be considered.
- Importance of sufficient supply of tetanus toxoid vaccines in post disaster environment is emphasized, especially in developing countries were vaccination rates within the general population are poor.
- Intensive care and surgical capabilities are an essential component of PED function, thus, pediatric staff in a field hospital should include pediatricians with intensive care and surgical skills. Alternatively, pediatric surgeon should be integrated as a part of the pediatric division.
- In a post-disaster environment, shortage in anesthesiologists as well as in operating room capacity is expected. Therefore, deep sedation for surgical procedures such as debridement or laceration repair may eventually take place in the PED, thereby requiring that pediatric teams be experienced in deep sedation practices and monitoring.
- Electronic medical registry is not only essential for triage and capacity control but also in order to facilitate patients’ information flow during transfer, return visits as well as for research purposes.
Conclusion

Operating a PED in a field hospital for a population affected by natural disaster is a challenging, nevertheless noble mission. This devastating earthquake, unfortunately, will not be the world’s last disaster. We, as the pediatric team of the IDF field hospital in Haiti had the privilege, for a limited period of time, to assist injured and sick children affected by the disaster. At the same time, we have a duty to learn and share our experience with colleagues worldwide. We hope that our experience will help to promote further knowledge regarding disaster medical response for children and enhance the development of efficient algorithms and procedures for better preparedness.

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References

3. Emmanuel Tronc. From one emergency to the next—Haiti earthquake—One month on, Policy & Advocacy Coordinator, Médecins Sans Frontières, Haiti, 13/2/10