

Original Research

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Beirut Blast: The Experiences of Acute Care Hospitals

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Abstract

Mass Casualty Incidents recently increased in intensity and frequency at an unprecedented rate globally. On August 4, 2020, a massive blast hit the Port of Beirut severely damaging its healthcare sector. This study aims to provide a comprehensive understanding of the impact of the Beirut blast on acute care hospitals in the Beirut area, with a focus on understanding healthcare professionals' (HCPs) responses and encountered challenges. A qualitative research design method was adopted to evaluate the experiences of HCPs at acute hospitals located within 5 kilometers of the blast epicenter. 9 hospitals participated in the study. 11 semi-structured interviews were conducted with key informant HCPs using a designed interview guide. HCPs reported severe infrastructural damages in their corresponding hospitals, and 2 were completely non-functional post-blast. Other than physical injuries sustained by HCPs, the blast imposed substantial strains on their mental health, exacerbated by the ongoing socio-economic crises in Lebanon. Moreover, the findings revealed critical challenges which hindered hospitals' emergency responses at the level of communication, coordination, and human resources, as well as supplies. Participants urged for the need to conduct proper triage, arrange emergency operating centers, and deploy outdoor treatment tents among others, to effectively respond to future disasters. The Beirut blast overwhelmed the Lebanese healthcare system and challenged its level of emergency preparedness. This generated evidence to address the deficiencies and strengthen the existing hospitals' emergency response plans. Future efforts should include prioritizing hospitals' emergency preparedness to ensure the provision of care at increased capacity following the impact of a large-scale disaster.

Introduction

Mass Casualty Incidents (MCIs) have recently increased in intensity and frequency at an unprecedented rate, up to 60% globally.¹ MCIs typically occur as a result of natural or man-made disasters,² and consequently exert an enormous strain on local healthcare systems with the generated surge of patients that often overwhelm and disrupt healthcare system performance.³ MCIs cause a wide range of injuries spanning from minor and emotional trauma, to life-threatening injuries associated with long-term disabilities, and further to a host of secondary adversities, or in some cases deaths.⁴

With the recent surge in MCIs globally, governments and healthcare sectors have paid particular attention to emergency preparedness and planning.⁵ Efficient healthcare systems' response is crucial to mitigating the impact of MCIs and preventing life-impacting injuries and fatalities. Past events highlight the complexity and intensity of the demands which are imposed on hospitals following MCIs including mass hospital evacuation, disruption of routine healthcare services, failure in proper case documentation, and the collapse of communication systems etc.² Emergency responses typically overwhelm existing healthcare systems, particularly with the abrupt increase and surge in demand for human resources, medical supplies, and physical space at the onset of the disaster.⁶ Hence, healthcare system preparedness represents a key element in building resilience and responding efficiently to disasters.

The Eastern Mediterranean Region (EMR) is prone to frequent episodes of disasters and ongoing conflicts.¹ Lebanon, a developing country located in the EMR, has experienced several MCIs over the past 40 years.⁷ Conflicts aggravated the country's humanitarian conditions, particularly with the recent influx of refugees from neighboring countries.⁸ Further to ongoing challenges, Lebanon was devastated by 1 of the largest blasts in modern history on August 4, 2020. Approximately 2750 tons of ammonium nitrate exploded at the port of Beirut, claiming the lives of more than 200 people, injuring over 7000, and displacing 300000 individuals across the city.^{9,10} The blast demolished most of the port's neighboring geographies and destroyed houses, schools, museums, and restaurants falling within the path of its traveling supersonic wave. The

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Beirut blast caused serious damages to urban healthcare facilities, interrupting the provision of their medical services, and disrupting the medical supply chain and the overall healthcare infrastructure. 3 major hospitals were severely destroyed, and 3 other hospitals were functioning below capacity post-the Beirut blast, with a loss of an equivalent 500 beds capacity.¹⁰ Prior to the blast, Lebanon was reeling from multiple crises, including the third worst economic crisis in the world, the rapid spread of the COVID-19 pandemic, as well as a protracted social and political unrest.⁹ The combined crises exacerbated the impact of each compounded factor to worsen the country's overall healthcare system, more specifically its level of disaster and emergency preparedness. Nonetheless, little evidence has examined the impact of the Beirut blast on the local healthcare system and its provision of health and medical services.⁴

This qualitative research study aims to provide a comprehensive understanding of the impact of the Beirut blast on acute care hospitals in the greater Beirut area and shed light on the experiences that healthcare professionals lived through the disaster. The study's specific objectives are 3 fold: (1) to identify the impact of the blast on hospitals infrastructure and human resources, (2) to understand the response adopted by health professionals post-blast including what measures were taken and challenges faced, and (3) to set forth recommendations and suggestions for future emergency responses. Findings from this study will offer the opportunity to address areas of improvement in hospitals' disaster preparedness plans and improve emergency response in times of crisis.

Methodology

Research design

This study adopted a qualitative research design method to evaluate the experience of acute care hospitals dealing with the Beirut blast disaster. Semi-structured interviews were conducted between January and May 2021 with key informant healthcare workers to gain a rich and deep understanding of disaster and emergency response. The study was approved by the Institutional Review Board (IRB) at the American University of Beirut.

Recruitment Strategy & Participants

A list of hospitals was compiled from the official website of the Ministry of Public Health (MoPH). A selected number of hospitals were included in the study if (1) they are acute care hospitals, (2) located within 5 kilometers from the blast epicenter (Beirut Port), and (3) were affected by the blast. [Figure 1](#) depicts the site of the explosion along with the neighboring hospitals in the greater Beirut area.

11 hospitals were eligible to participate in this study. At each participating hospital, physicians and healthcare professionals were included in the study if they were present at the hospital on the day of the blast and were primarily involved in the post-blast emergency care.

An invitation email was sent to the hospital administration. Those who were interested responded and confirmed their willingness to participate. More than 1 healthcare provider was allowed to participate from each hospital to accommodate for different perspectives into emergency response and the hospital's diverse experiences dealing with the disaster.

To protect hospital privacy, no names or identifiable information was collected about any of the hospitals' healthcare

professionals, patients, or injured victims. For anonymity, hospital names were de-identified in this paper.

Interview guide

A semi-structured interview guide was developed based on inputs from multiple subject matter experts (public health professionals and ED physicians). The interview guide entails 4 sections: (1) Hospital information (e.g., type of hospital, size of ED, etc.), (2) Impact of the Beirut blast (e.g., physical and human resources damage), (3) Challenges and solutions for emergency response, and (4) Psychosocial impact of the blast on healthcare professionals (noticeable changes in job indicators among the staff). The interview addressed 4 primary areas of hospital emergency preparedness including Communication and Coordination, Surge Capacity, Human Resources, and Supplies and Equipment^{11,12}.

Data generation and analysis

Due to the spreading COVID-19 pandemic, all interviews were conducted remotely to protect researchers and participants. The research team obtained verbal informed consent from each participating healthcare professional before conducting the interview. Each interview lasted for 30 - 35 minutes and was audio recorded. The research assistant transcribed the recordings verbatim, de-identified the data, and prepared them for analysis. 2 independent research assistants trained in qualitative research analyzed the transcripts using the 6-phase thematic inductive analytical approach (Braun & Clarke, 2013). The thematic analysis process involved examining and comparing participants' responses to classify themes that recur across key informants interviewed. Concurrent data generation and data analysis ensured that notable topics emerging during interviews were incorporated and clarified in future interviews. Dedoose software (Socio-cultural Research Consultants, Manhattan Beach, CA, USA) was utilized to assist in coding participants' transcripts.

Results

Hospitals and participants' characteristics

Out of the 11 eligible hospitals, 9 participated in this study. Most hospitals were private (89%) and academic tertiary care centers (67%) with functioning Emergency Departments (EDs). Hospitals' capacities ranged from 2 ED hospital beds up to 42. 11 interviews were conducted with healthcare professionals: 7 ED physicians, 2 ED directors, and 2 nurses. All interviewed participants were present during or following the Beirut blast event, held various positions, and played significant roles in the emergency response.

Emergency preparedness

All participating hospitals confirmed the presence of a disaster plan as part of their emergency preparedness management. These existing plans were divided into various components, including activation, response, recovery phases, and leveled response depending on the scale of the MCI. Moreover, hospitals confirmed conducting disaster drills and training for hospital staff once or twice yearly to strengthen hospital emergency preparedness. Although all hospitals reported full activation of their disaster plans during the blast, none were able to entirely implement it given the extraordinary conditions of the event, its

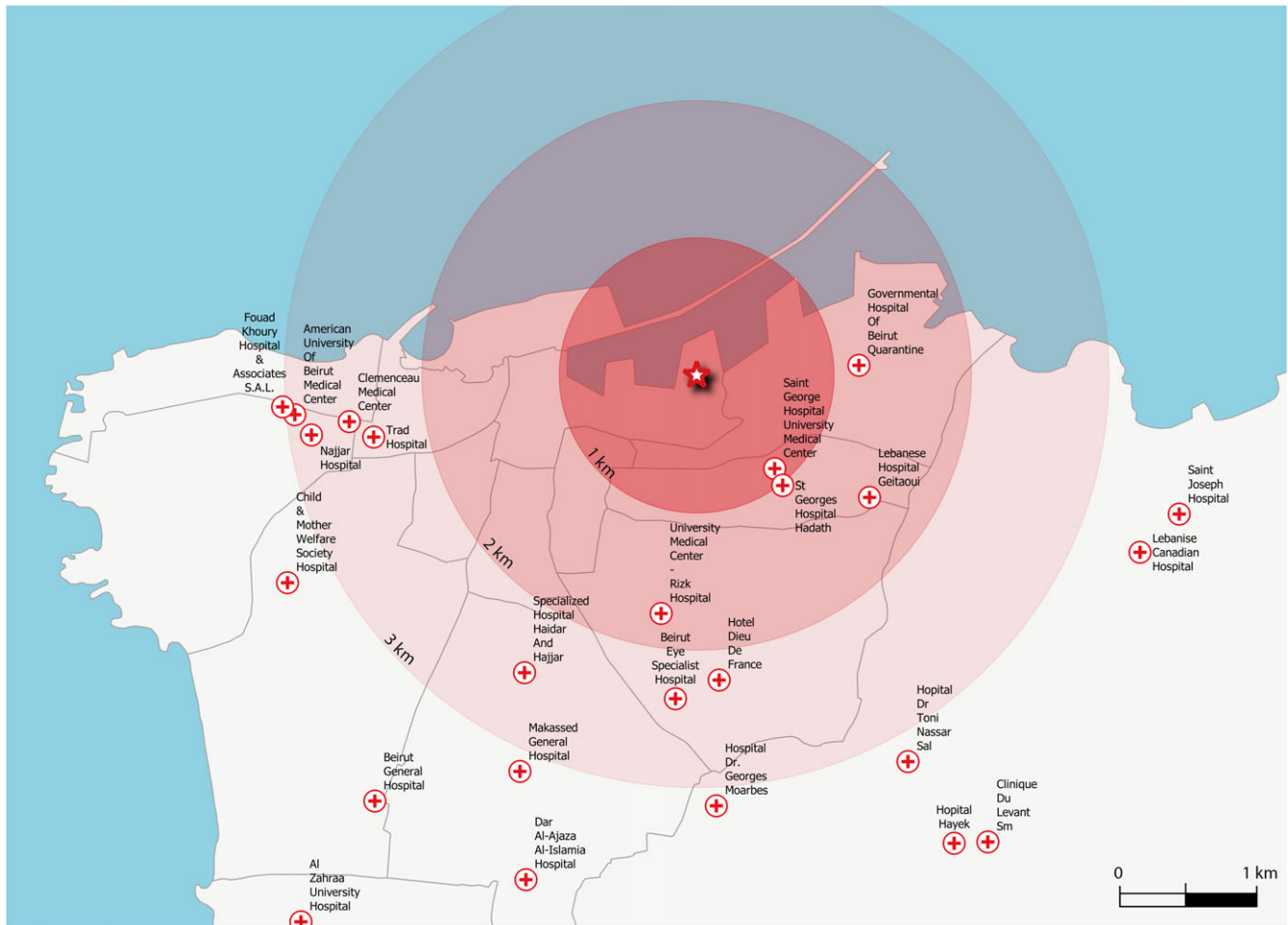


Figure 1. Proximity of hospitals from ground 0, Beirut, Lebanon. © Fabien Lezeau (WITH COLORS).

severe infrastructure damage, and unexpected surge of casualties within the first few hours following the explosion.

'We tried to activate it as much as possible, but our plan did not account for this kind of disaster where our ED is already fully destroyed, and our staff are injured.' [Interviewee 3]

Impact of Beirut Blast on the hospitals and staff

Infrastructure damage

Hospitals located near the blast epicenter reported severe structural damage including blown out elevators, walls, ceilings, and windows, as well as destroyed clinical and critical care wards. Most of these hospitals suffered from electricity power cut-off in addition to severely damaged air ducts, and impaired medical equipment. 2 participating hospitals, which were the closest to the blast epicenter, were completely out of service due to major infrastructure damages. A mass hospital evacuation was performed at these hospitals, particularly of their admitted patients, who were transferred to nearby hospitals. Moreover, incoming wounded victims were denied admission and were redirected to nearby acute care hospitals. Several hospitals experienced partial damages and were forced to provide their health services without any disruption or interruption in the provision of care. The most reported damages among hospitals included shattered glass, broken windows, ruined furniture, and doors, as well as destroyed medical equipment, and collapsed ceilings.

Human resources impact

Further to the infrastructure damage, the blast inflicted injuries on hospital staff. Participating health professionals sustained mild to severe injuries, more frequently reported by health professionals from highly damaged hospitals. The most documented staff injuries were injuries to the extremities, head, and back, as well as lacerations, and fractures. Similar injuries were sustained by hospital-admitted patients. 1 hospital reported the loss of lives of 4 nurses and 17 patients.

Besides physical harm, health professionals experienced the subsequent impact of the blast on their mental health and well-being. Beirut blast greatly affected residents and medical students who had experienced this large-scale disaster for the first time. Many described their stress level and lack of sleep for weeks following the blast. They were continuously talking and thinking about the blast. The live scenes and the constant stream of images on TV and social media platforms showing the aftermath of the blast have been shown to intensify the level of trauma among staff. The near-death experience disturbed many physicians' mental health and well-being.

'The kind of injuries we saw, the chaos . . . Some healthcare workers had their parents injured, were themselves injured, their kids injured; this impacted them big time.' [Interviewee 3]

'This place could've been our end. Maybe if the staff were present during the blast in the hospital, including me, maybe you wouldn't be talking to me right now.' [Interviewee 7]

Some hospitals provided professional psychological support to their staff including free counselling and debriefing sessions to help cope with this major traumatic event.

'This is PTSD. We tried to do workshops on trauma care and sessions for people to talk and write about it. A lot of people are still worried. Every time they hear a door shutting or a window opening, they remember the blast!' [Interviewee 10]

With the subsequent social and economic crises endured by the Lebanese people, the blast served to unveil these multi-layers and exacerbated people's vulnerability to mental and emotional distress. Participants expressed their concerns about the massive exodus of nurses and physicians, not necessarily solely due to the devastating blast, but rather the ongoing economic crisis and lack of proper financial compensation for their efforts.

'My consultation fee is \$100; do I ask for 1.5 million Lebanese Lira? No. I ask for 200000 Lebanese Lira which is equivalent to \$15 due to the currency devaluation. This is why our healthcare workforce is leaving!' [Interviewee 9]

Hospitals response

Participating hospitals received massive casualties after the blast ranging from 100 to 500 injured individuals. The time span between the blast wave and the sudden influx of casualties was short, nearly 10 - 12 minutes following the blast detonation at 6:08 PM. Health professionals reflected on their emergency response while addressing the following primary areas:

Communication and coordination

All participating health professionals recalled enormous chaos on the ground post-blast which hindered optimal communication and coordination among hospitals' staff. Communication channels within the healthcare system in Lebanon were fragmented at the baseline. During the blast, all communication channels were disrupted. This was mainly due to the heavy immediate influx of casualties to local hospitals and the staff's inability to establish immediate control of entry points to hospitals. This was exacerbated by the initial confusion related to the nature and scale of the blast and the previous staff exodus (e.g., newly designated roles and responsibilities). A major internal communication challenge was the inability to utilize Electronic Medical Records (EMR) at certain hospitals to register many patients. This resulted in a significant number of undocumented casualties. Some hospitals had to rely on paper and manual requests, while others used non-permanent markers to write off CT results on the patient's chest.

'Communication was challenging because no 1 was able to hear the other. Suddenly, you received 300 patients and you needed to respond, yet all the chaos around you did not allow you to.' [Interviewee 6]

'Our ER had several access doors, yet all of them blew out, so we practically had an ER where it was very difficult to control the flow of people and families.' [Interviewee 4]

Regarding external communication, almost all health professionals reported that connecting with Emergency Medical Services (EMS) was scarce and often non-existent. This problem was previously experienced by participating hospitals during routine operations within the EMS system in Lebanon and was worsened during the blast since EMS agencies were heavily affected by the blast. The lack of communication with any EMS team, the inability to inform hospitals about the expected number of casualties, and the sudden nature of the MCI left ED physicians and nurses

struggling on how to efficiently deal with the surge of casualties and the types and severity of the expected injuries. Overall, all participating hospitals shared the struggle of external communication during the response and felt disconnected in coordination with other hospitals and health respondents.

'We didn't even know that some nearby hospitals were severely damaged. We should've been informed because we later knew that they were trying to transfer patients somewhere else. We did not know what was happening outside.' [Interviewee 2]

Human resources

Amidst the blast emergency, all health professionals reflected on the high level of internal support they received in response to the rising need for urgent patient care. Hospitals that continued to function indicated the prompt reporting of their hospital staff, interns, health, and allied health students, as well as volunteers to contribute to the emergency response. Staff were helping beyond their field of expertise and in any situation they were facing. For instance, some physicians transported patients, while some interns set up extra units.

'From medical students, residents, to volunteers, everyone was helping with a full family-like spirit.' [Interviewee 11]

On the other hand, some interviewees indicated that having large numbers of medical students on board felt overwhelming and burdensome at some point amidst the chaos, although they initially offered tremendous support.

'I think having a lot of people was an issue. I know they have a lot of help to offer, but I think also they can sometimes be sort of a burden.' [Interviewee 10]

'The medical students helped us a lot . . . But at some point, when the rush was over (after 4 hours), I felt like they were a burden on us, so we started asking them to leave.' [Interviewee 9]

Some hospitals received external support in the blast aftermath. The Lebanese Army helped in transporting previous patients from highly damaged hospitals to other nearby hospitals. Civilian agencies, inter-governmental organizations, and other NGOs also supported in mapping, repairing, and renovating site damages.

The timing of the blast (6:08 PM, after regular working hours) also contributed to the lack of specialty physicians present at the hospital post- blast, those who would have been qualified to perform specialized procedures and operations on critically injured victims. Moreover, road blockage hindered access and delayed the arrival of many hospital staff following emergency plan activation.

'We had very little number of staff working. It was at 6 pm at night. I was on duty as an ER physician, and I had with me only 2 ER residents. All physicians were late to arrive . . . ER physicians, ophthalmologists, pediatrics specialists etc.' [Interviewee 2]

Injured hospital staff presented an additional burden that challenged hospital effectiveness in responding to the blast disaster. Hospitals were faced with the reality of dealing with their injured staff, caused by shattered glass, flying objects, and their inability to serve as respondents during this MCI. This aggravated the situation as several healthcare professionals were in dire need of treatment and couldn't provide care to arriving casualties.

'We had staff in the ER. Instead of them taking care of the patients, they were the patients themselves!' [Interviewee 6]

Supplies and equipment

During the response, some health professionals reported a lack of access to hospitals' supplies. Employees at central dispensing units were not present at the time of the blast to facilitate access to supplies, thus delaying deployment and timely use. Supplies were often placed in locked rooms where the responsible person in charge of the keys was either not on duty or lost in the blast chaos. Even those who were able to access the storage room lacked familiarity with the available stockpiles.

'It's quite challenging for someone who doesn't know anything in the Storage room to go inside and get what she or he wants. Also, it was dark and late at night.' [Interviewee 4]

Several hospitals also suffered from the inability to secure sufficient supplies for a long period to respond to the large scale of presented casualties. Supplies such as staplers, gauzes, suture bags, and gloves, as well as antiseptics were massively used during the response.

'We used all our resources. Everything! Our store the next day was empty!' [Interviewee 9]

'We used a stapler in a place where we should've used silk. We responded to the needs in a practical and feasible way, our response was not ideal, given the circumstances and conditions.' [Interviewee 6]

COVID-19 measures

The blast occurred during the peak period of the COVID-19 pandemic. Amidst the post-blast emergency response, practicing COVID safety measures was extremely challenging, if not impossible for health professionals. In general, healthcare workers expressed their concerns that the blast incident might be a super-spreader event for COVID-19 infection, particularly with the limited availability of Personal Protective Equipment (PPEs), the overcrowded emergency rooms where spaces lacked proper ventilation, and where maintaining physical distance was impossible. COVID-19 protection measures varied across hospitals during the response, particularly with the scarcity of PPE available supplies. In some cases, health professionals were unable to change their PPE and kept it on for extended hours. For most hospitals, the surge capacity and its associated high demand for immediate care were beyond health workers' and hospitals' capacity, thus depleting PPEs and challenging their activated emergency plans.

'I did not have time to wear my PPEs. I was wearing my scrubs and white coat and I was fully covered with blood at the end.' [Interviewee 2]

'I worked till 2 am and I did not wear PPE; it wasn't on our mind, to be honest. We just had the gloves and that's it. Not a second would you think of COVID-19 during that time.' [Interviewee 7]

Only 1 healthcare professional confirmed that staff abided by the hospital's strict COVID-19 protective protocol during the response, however, that hospital was relatively further away from the epicenter with fewer number of casualties received.

'We were all wearing full PPEs. All our staff were wearing N95. We were even giving masks to any patient who came in without 1.' [Interviewee 8]

Recommendations and suggestions

Reflecting on their experience on the ground, participants shared relevant recommendations and suggestions that can serve to enhance hospitals' emergency preparedness and timely crisis response:

Establish a hospital disaster plan

Hospitals should have an established emergency and disaster preparedness plan to respond to disasters and emergencies efficiently and effectively. Training workshops should be adopted to familiarize hospital staff with an existing plan and provide the required capacity building to impart the necessary skills for timely emergency response.

Conduct proper triage

Participants highlighted the importance of triage to maximize service capacity amid a scarcity of time and resources. Many hospitals utilized disaster triage plans to classify patients into either life-threatening injuries, potentially serious injuries, minor injuries, or deceased casualties. In principle, the participating hospitals had a color-coded triaging method to categorize casualties into red (immediate or priority 1), yellow (delayed or priority 2), green (minimal or priority 3), or black (expectant, no priority).

'I think the best thing we have done that saved us was our triage!' [Interviewee 2]

'The more efficiently you triage, the better you serve and manage patients. Triage allows you to decrease lost time and properly facilitate the operations in the hospital.' [Interviewee 8]

Arrange emergency operating centers

Health professionals reiterated the priority for establishing emergency operating centers (EOC), a central command and control facility that will be responsible for coordinating disaster management functions at a strategic level during an emergency. Hospitals reported that EOC needs to be timely activated to promptly assess needs once a disaster occurs and communicate pro-actively with relevant stakeholders. This will help in addressing resource allocation among healthcare centers in an efficient manner.

Maintain safety stock of supplies

ED physicians advised on the importance of maintaining a safe stock of supplies at a proximity to the ED. These supplies should be easily accessible and serve to facilitate timely emergency responses. In the case of Lebanon, it was challenging to secure sufficient healthcare supplies and medications due to the dire economic situation and the high cost of imported medical supplies.

Provide color tags and vests

A suggested tool for enhancing coordination during chaotic MCIs was to use color-coded vests and tags that will help to easily identify people in charge, such as ED team leaders. This, generally, would facilitate the identification of roles, and responsibilities, particularly for the mobilized staff who need support navigating an unfamiliar ED.

Deploy outdoor treatment tents

Setting up treatment tents outside of the hospital premises was recommended as an effective approach to prepare for the inevitable surge of casualties at times of disasters. These tents would be utilized as triage sites to allow patients to be evaluated without entering the ED, or for managing low acuity cases.

Encourage a supportive environment

All participants expressed their appreciation of the efforts provided by the healthcare workforce post-blast. They commended the dedication of the hospital staff who demonstrated extraordinary persistence and a high team spirit. The experienced collectiveness gave the workers a sense of solidarity and support amid this major disaster. In some hospitals, even though some personnel were injured, they were still providing care to their patients and helped in the evacuation process.

'I was surprised by how they managed, by how focused and determined they were. No 1 left his/ her patient, and they took the responsibility to evacuate even when they themselves were showered with blood.' [Interviewee 9]

Discussion

To the best of our knowledge, this is the first study that examines the impact of the Beirut blast on acute care hospitals, with a focus on understanding healthcare professionals' and ED physicians' responses and encountered challenges post-blast. This study contributes to the broader body of knowledge within the field of emergency preparedness and further provides insights into lessons learned to avoid future tragic disasters and enhance emergency responses.

Similar to the findings conveyed in the literature, this study underscores the outcomes of mass casualty events including sustained physical injuries¹³ and psychosocial distress on affected individuals (e.g., stress reactions, PTSD, depression, insomnia, and disturbance in social relations).^{14–16} The study highlighted the invisible psychosocial impact of the blast that was further amplified by the multiple socio-economic contributing factors (e.g., overlapping economic, social, and political crises in the country amid the fast-growing pandemic). These accumulated crises exacerbated the mental health status of the healthcare professionals,^{17–19} which was strongly reflected in health workers' increased absenteeism post-disaster and decreased job satisfaction and productivity.²⁰ During MCI, health professionals are exposed to ample stressors and occupational risks such as exposure to traumatic stimuli, adverse work environment, and time pressure, among others.²¹ These stressors make health professionals prone to a heightened risk of suffering from psychological distress. In the event of an MCI, health professionals with limited disaster preparedness training and limited prior exposure to MCI are often called in to support in an emergency. The provision of care outside physicians' unique specialty may cause additional discomfort and intensify perceived stress.²¹

While disasters might be unpredictable, effective preparedness is crucial in curtailing their devastating effect on individuals and healthcare systems, particularly in settings where resources are limited.²² 1 of the key factors for effective crisis management is having a clear communication system to timely convey data and information which are critical for establishing and maintaining situational awareness in hospitals.²³ Communication and coordination were identified as 1 of the most challenging aspects of emergency preparedness following the Beirut blast disaster. A recent national study underlined the deficiency in hospitals' emergency preparedness at various Lebanese hospitals pre-blast.²⁴ This lack of preparedness was markedly witnessed during the blast response. This current study revealed that communicating with Emergency Medical Services (EMS) was sparse post-blast. In Lebanon, the EMS system is a volunteer-based service, and it was clearly overburdened with the scale of the blast. Most

transported casualties were sent to the same nearby hospitals. As a result, hospitals near the MCI site are often overburdened with a surge in patients' capacity, whereas more distant hospitals receive a limited number of casualties.²⁵ Hence, the lack of coordination between pre-hospital and hospital teams is highly detrimental to any disaster response. A similar scenario was reported during the World Trade Center attacks in 2001, whereby the decision taken by EMS teams to transport all the initial casualties to the 3 nearest hospitals without effective coordination with ED personnel clearly overwhelmed those institutions.²³ Moreover, communication was classified as the most challenging aspects of disaster management during Hurricane Katrina and the 9/11 attack.²⁶ Similar to what has been reported in previous disasters, communication challenges represented additional technical issues (e.g., lack of proper identification and documentation on electronic systems, crashed electronic medical records).⁷ For this reason, switching to backup paper documentation is recommended during MCIs due to ease of use and availability.

Arranging emergency operating centers (EOCs) is essential in the response to emergencies and to manage responses during MCIs.²⁷ For instance, 2 disasters occurred in Taiwan due to train derailment; in both events, the EOCs could not effectively integrate associated agencies to deal with the incident.²⁷ This resulted in a lack of coordination and reduced efficiency in utilization of resources, thus disrupting command structure operation and casualty evacuation.²⁷ Other solutions highlighted in the literature include identifying a clear chain of command, tailoring triage to the context of conflict, placing security personnel at all ED access points, and always keeping patient records with patients.²⁸

Shortage of essential supplies and medications further challenges the emergency preparedness response post-blast. Evidence suggests that maintenance of supplies for a couple of hours after a disaster occurs is often a weak point.²⁹ Before the blast, Lebanon was suffering from a prominent medication and medical supply crisis due to its economic collapse and the spreading of the COVID-19 pandemic which consumed most of the local resources.^{30,31} The delay in deployment of medical supplies to the ED along with the difficulty in accessing essential equipment during the initial response phase was identified as major challenges in earlier blast events (2013 car bombing) in Lebanon.⁷ Therefore, maintaining and promoting the supply chain, as well as improving the performance and familiarity with available stockpiles especially in times of crises, are of utmost importance.

Availability of human resources was another major challenge encountered in the post-blast. As the event occurred at a late time, a reduced staff capacity was on duty at local healthcare facilities, they were either not present or struggling to reach the hospital due to roads blockage. This is consistent with the international literature where logistic problems (e.g., geographical distances, inaccessible terrain, destroyed roads, or telecommunications infrastructure and traffic jams caused by evacuations or destruction) are considered obstacles that negatively hindered the overall emergency response when managing mass casualty.¹⁴ Consistent with the 2015 Boston Marathon Bombings response,²⁸ the high influx of personnel into the ED represented an additional issue faced during the blast response. The study participants particularly referred to the overflow of medical students in large numbers into the ED, overcrowding an already congested place. A similar scenario was reported during the Downtown Beirut bombing.⁷ Medical students lack appropriate disaster training as they focus on acquiring skills for making the right diagnosis rather than principles of triage and emergency management.³² This calls for the provision of adequate

emergency response training for medical students to impart the necessary skills to effectively respond and support ED teams in emergencies.

Aligning with findings from a national study, surge capacity was identified as 1 of the major deficiencies noted amongst the hospitals in Lebanon.²⁴ Hospitals' surge capacity represents a key component in determining a hospital's level of preparedness and its potential ability to accommodate a large influx of patients. Barbish and Koenig identified the 4 'S' that represent the main elements of surge capacity: Staff, Stuff, Structures, and Systems.³³ Those elements were critical as raised by the participants in this study. Tailored and context-sensitive preparedness measures are needed to ensure hospital resilience facing surge capacity across all spectrums of the healthcare system including infectious diseases pandemics, wars and conflicts, or large-scale disasters.²⁴

According to multiple studies, the establishment and adoption of triage criteria during MCI is fundamental to ensuring a timely emergency response.^{7,32,34} Triage can serve to decongest emergency departments, thus allowing for the provision of care for patients with the highest acuity level.³⁴ Among existing triage methods, the Simple Triage and Rapid Treatment (START) system, which stratifies casualties into color codes: red, yellow, green, or black, has been widely used. This method was mostly adopted by the participating hospitals and was 1, if not the most, significant response element during the response. Moreover, providing ED physicians and nurses with color tags or vests will effectively facilitate the capacity to coordinate activities. As ED providers are more trained on MCI response while being familiar with the ED setting, such designation and visibility for the ED medical providers and nurses will help to expedite the response process and make it effective.³⁵ To maximize preparedness for MCI, the previous challenges, among others, must be taken into consideration. The suggested recommendations by the healthcare professionals align with lessons learned from other disasters in the literature.²⁸

Limitations

This study has some limitations. First, the study interviews were conducted 6 months following the Beirut blast, which might have introduced some biases into participants' actual reflection on the details of the blast. Although this buffer time allowed for mature reflections on recovery and preparedness, it is possible that participants were not able to recall important details of their experience on the ground during the response. Second, participants reflected on important recommendations for improving hospital preparedness and response during disasters; nonetheless, they are based on key informant interviews while lacking group brainstorming opportunities with diverse perspectives pooled from multiple stakeholders. Future research should build on these individual recommendations to capture a group of diverse stakeholders engaged in interactive sessions using design thinking and group prioritization techniques.

Conclusion

This study reveals deep insights into the experiences of health professionals in response to the Beirut blast. With the dearth of evidence-based knowledge in disaster medicine and crisis management, best practices and recommendations rely on lessons learned and shared experiences. This study offers lessons into the challenges identified by health professionals, some of which are relevant to address the deficiencies in the healthcare system and

strengthen its emergency preparedness and response. It is essential to prioritize hospitals' emergency preparedness on the agenda of policymakers and cater to informed procedures that aim at mitigating the substantial impact of emergencies on the healthcare sector. Future efforts should include mitigation measures to allow the provision of care at increased capacity following the impact of a large-scale disaster.

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