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Anesthesiologists' Preparedness and Training Needs in Disaster Management: A Mixed-Methods Study from a Conflict-Affected Region

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Abstract

Objectives: To evaluate anesthesiologists' preparedness and training needs during a mass casualty event in a resource-limited setting, focusing on hospital disaster planning and response effectiveness.

Methods: This study utilized an exploratory mixed-methods design, combining qualitative and quantitative approaches to assess the experiences of anesthesiologists during a catastrophic disaster. Data were collected through interviews and a survey of anesthesiologists who were directly involved in emergency response.

Results: The findings highlight significant gaps in disaster preparedness among hospitals, influenced by factors such as physical infrastructure damage, resource shortages, and limited personnel involvement in disaster planning. Anesthesiologists demonstrated adaptability and commitment despite inadequate training and limited disaster management frameworks. The study underscores the urgent need for standardized disaster preparedness plans, multidisciplinary training, and enhanced psychological support for health care professionals.

Conclusions: This study reveals critical deficiencies in hospital disaster preparedness and anesthesiologists' training in emergency response. Addressing these gaps through robust disaster planning, simulation-based education, and institutional support is essential to enhance health care systems' resilience in resource-limited and conflict-affected regions.

The World Health Organization (WHO) defines a disaster as “A sudden event causing severe destruction of infrastructure, people and the economy and which overwhelms the resources of that country, region or community.” These disasters may be caused by natural events such as earthquakes, tsunamis, and disease epidemics or man-made disasters such as war and industrial accidents.¹

Given that disasters often occur without warning, effectively managing their health care implications requires proactive, comprehensive planning to utilize health care personnel, facilities, and equipment efficiently.² Disasters can range from isolated events, like floods, to prolonged crises, such as the COVID-19 pandemic; therefore, response plans must be flexible to adapt to rapidly changing circumstances.³

A critical pillar of global health security, emergency preparedness forms the foundation of the International Health Regulations (IHR), a legally binding framework enacted in 2005.⁴ While emphasis on disaster medicine and public health preparedness has grown, gaps remain in understanding how prepared physicians feel regarding disaster response. Most existing literature on health care disaster preparedness focuses primarily on emergency departments, despite anesthesiologists' unique qualifications for disaster response. With their expertise in critical care, procedural skills, and proficiency in patient triage and risk assessment, anesthesiologists are well suited to lead institutional and regional medical efforts during crises.⁵ However, research on their perspectives in disaster preparedness is limited. In a 2017 survey, Hayanga and colleagues found that few anesthesiologists felt their hospitals provided sufficient emergency training, with over 70% expressing a desire for more institutional support in this area.⁶

In Lebanon, compounded crises—including sociopolitical instability, economic hardship, and the COVID-19 pandemic—have heavily strained the health care system, especially in terms of disaster and emergency preparedness. Lebanon, a small Eastern Mediterranean country, ratified the IHR in 2007 following a 2006 conflict that disrupted its fragile health system, still recovering from a 15-year civil war ending in 1990. Since 2011, Lebanon has faced a continuous

refugee crisis, and since 2019, a severe financial crisis leading to social unrest, compounded by the COVID-19 pandemic and the catastrophic Beirut port explosion on August 4, 2020.⁷ This explosion, triggered by 2700 tons of ammonium nitrate, resulted in over 6000 casualties, 218 deaths at least, and \$15 billion in economic losses, displacing 300 000 residents and severely reducing hospital capacity.⁸ The blast affected 6 hospitals, rendering 3 completely non-functional and 3 partially operational. Despite this, with support from the Lebanese Red Cross and local communities, casualties were quickly transferred to functional hospitals within and beyond the Beirut area.⁹

The scarcity of data on anesthesiologists' preparedness, experiences, and knowledge in disaster situations highlights a significant gap. This study aims to survey Lebanese anesthesiologists regarding their experiences during the Beirut explosion and assess the disaster preparedness of their departments and hospitals. Additionally, the study explores anesthesiologists' understanding of their roles in disaster response and their preferred training methods. Findings from this research are intended to inform policy changes and training programs to enhance anesthesiologists' preparedness for future disasters in Lebanon and similar contexts.

Methods

Study Design and Participants

This study employed an exploratory mixed-methods research design, combining both qualitative and quantitative approaches to comprehensively assess anesthesiologists' preparedness and experiences in disaster management during the Beirut blast.

The qualitative research arm

The qualitative research served the purpose of confirming the conceptual understanding of anesthesiologists' performance in disaster response and examining the factors affecting this performance. Incorporation of the findings from the qualitative research contributed to a comprehensive illustration of the anesthesiologist's preparedness and performance during disasters in the Lebanese context.

A focused approach was adopted, engaging anesthesiologists working in Greater Beirut (including the City of Beirut and the surrounding geographical area) hospitals at the time of the Beirut port explosion (August 4, 2020). Interviews and personal testimonies were conducted on November 28, 2020. The interview questions and testimonies covered the following aspects:

- Influx of injured patients and triage
- Hospitals physical facilities availabilities, preparedness, and plans implementation at the time of the explosion
- Personnel availability and efficiency of assembly, considering especially that the personnel may have been affected by the explosion
- COVID-19 precautions and material shortages in times of economic and health crisis
- Debriefing and lessons learned

This contextual framing aimed to elicit authentic responses grounded in real-world experiences. Through rigorous thematic analysis of the collected data, an endeavor was made to describe the experiences witnessed by the anesthesiologists and their expressed claims for disaster preparedness needs, providing valuable insights to inform strategies and policy initiatives aimed at addressing education and support for personnel involved in first line response

to emergencies and to enhance hospital preparedness in times of disasters.

Settings. Qualitative research is important because it provides new insights. The following was considered when designing and making the interviews: resource demands (time and effort recruiting and interviewing participants), potential biases (interviewer bias and social desirability bias), limited generalizability (context-specific and based on small, non-random samples), and challenges in data analysis and participant openness.

A total of 6 anesthesiologists, representing hospitals that received injured patients during the Beirut blast, were interviewed. One worked in a university hospital located within 1 Km of the blast site, which was severely damaged by the explosion, while the other 5 worked in hospitals located within a radius of 1.8-3 km from the blast site, including 3 in university hospitals and 2 in small private hospitals (Figure 1).

Data analysis. Transcripts were analyzed thematically using Microsoft Excel. Participant-generated concepts were inductively categorized into concepts of the initial conceptualization. Saturation (the point at which no new information is arising from the qualitative data) was also assessed by comparing concepts arising from the experience according to the geographical proximity to the blast (closer to the blast vs. further from the blast). If no new information arose in the second set, saturation was said to be achieved.

In phase 1, the members of the investigation team reviewed the transcripts to familiarize themselves with the content. Then, a template of broad themes was generated, derived from the answers to the questions and testimonies. Using a deductive approach, the investigators identified key concepts which were entered in a separate form. Differences in key concepts were resolved through discussion with the full team.

In Phase 2 of the analysis, unifying themes were identified across the key concepts identified in Phase 1. An inductive approach was applied to theorize connections with the aspects covered by the questionnaire (quantitative arm). These unifying themes and connections were discussed with the full team and revised based on discussion, resulting in a comprehensive set of major themes and subthemes (a summary of the data is in the results section).

In summary, thematic synthesis in the study followed a systematic, 3-stage process (color-coding the text line by line, identifying descriptive themes, and then generating analytical themes). This approach promoted transparency, consistency, and minimized bias by aligning the themes with the study's theoretical framework. Any disagreements or differing interpretations among researchers were resolved through collaborative review sessions, where coded data and themes were re-examined to ensure alignment with the study's objectives. To determine data saturation regarding hospitals' proximity to the Beirut blast, the researchers assessed recurring themes, sample diversity, and analytical depth using iterative analysis, stratified sampling, and thematic validation.

The quantitative research arm

The quantitative aspect focused on describing anesthesiologists' experiences during the Beirut explosion, the preparedness of their departments and hospitals for disaster management in addition to their level of awareness about their roles in disaster management. It consisted of a cross-sectional study. It targeted 175 anesthesiologists, members of the Lebanese Society of Anesthesiology working in Beirut and the surrounding geographical area, between November 2020 and December 2020. The questionnaire was administered in English.



Figure 1. Geographical locations of different hospitals and their distance from Beirut port blast.

Questionnaire and variables. The questionnaire used in this study was developed based on current literature⁶ and comprised the following sections:

- The sociodemographic section including age, gender, location of practice, and hospital related information.
- The preparedness of anesthesiology departments and hospitals for disaster management: This section included questions about the availability of disaster management plans at the practice hospitals and personnel training sessions.
- Anesthesiologists' experiences during the Beirut explosion: the questions covered the number of patients admitted that night, the type of works performed, COVID-19 precautions, shortages, and support.
- Anesthesiologists' level of awareness regarding their roles in disaster management: this section assessed the anesthesiologists' level of knowledge about disaster management, their awareness about their important role in emergency response, and their methods of learning.

Statistical analysis

Data from completed forms were imported into a Microsoft Excel spreadsheet. Data analysis was then performed on SPSS software version 25 (Chicago, IL, USA). A descriptive analysis was performed using absolute frequencies and percentages for categorical variables. A Chi-square test was performed to compare between anesthesiologists working in Beirut vs. those outside of Beirut and those working in university-affiliated hospitals vs. those not working in university-affiliated hospitals. A P value <0.05 was considered significant.

Ethical approval

The study was reviewed and approved by the Institutional Review Board (IRB) of the Lebanese American University (LAUMCRH. VA2.9/Nov/2020). All participants were provided with information about the general purpose of the study in the introductory section; their consent was obtained through a clause explicitly stating that completing the questionnaire indicated their agreement to participate in the study, ensuring compliance with ethical guidelines.

Results

This study provides insights into the preparedness and experiences of anesthesiologists during the Beirut blast, combining both qualitative and quantitative data to offer a comprehensive understanding of hospital disaster management and personnel responses.

The Qualitative Research Arm: Assessment of Anesthesiologists' Experiences and Awareness in Disaster Response

The interviews and testimonies covered the story of frontline health care personnel after the Beirut explosion who endeavored to save lives in resource-limited circumstances at times of health crisis (COVID-19) and severe economic constraints. The results revealed inadequate hospital and personnel preparedness for disasters with medical material shortage. According to the interviewed anesthesiologists, not all of them were involved in disaster management planification nor had they received proper training and education about this issue.

The results showed that concept elicitation data suggested 6 key themes directly linked to anesthesiologists' experiences following

the explosion. These themes were multidimensional, intersecting, and overlapping. Key topics included: preparedness and implementation of disaster plans; triage and patient influx; availability of hospital physical facilities; personnel availability and assembly; COVID-19 precautions and material shortages; and aftermath and debriefing. Overall, no significant differences were found in the concepts across varying proximity to the blast, except in the number of patients, severity of injuries, and influx waves, which was higher in hospitals closer to the blast site (see Table 1 for more details on themes, and quotes from participants).

Themes that were mentioned by the participants in the qualitative study illustrated the themes obtained from the questionnaire responses (Table 1). Thus, the disaster scenarios and emergency responses witnessed and experienced by the anesthesiologists (as front-line health care personnel) were validated in the local setting, depending on the geographical location. First, hospitals' proximity to the blast and university affiliation influenced the adequacy of disaster response. Hospitals within 2.2 km were overwhelmed, despite having disaster plans, due to physical damage and staff casualties. University hospitals, further away and undamaged, implemented their plans effectively. These used call systems to rapidly mobilize unaffected staff living nearby. Physicians and residents were redeployed across the emergency department, operating rooms, and post-anesthesia units to meet demands.

Private hospitals lacked disaster plans and/or training. Availability of free beds during COVID-19 also affected capacity to admit critically injured patients. Also, proximity to the blast influenced patient influx. The closest hospitals (not fully damaged) received the first wave of mostly stable but emotionally distressed patients. Later waves included more severely injured patients, brought by ambulance or car. Triage efforts were inadequate due to overwhelming patient numbers, facility damage, and staff shortages. Many patients were treated without proper identification or documentation.

Furthermore, hospitals near the blast suffered severe structural damage, including destroyed operating rooms. Care was improvised in corridors, parking lots, and even streets. "Operating rooms were overcrowded, with multiple simultaneous surgeries sometimes performed on floors or wheelchairs," illustrates the extreme surge capacity measures employed by anesthesiology teams.

In addition, COVID-19 protocols were largely abandoned due to the crisis urgency. "All patients were taken to the OR without PCR or rapid testing for COVID-19. No masks were used by the patients, no PPE was used by the medical staff, and no one practiced social distancing, "which speaks to the emergency and severe shortages in COVID-19 protective equipment and protocols being sidelined due to the crisis." This contributed to increased rates of infections post-blast. "Debriefing occurred mainly at upper administrative levels ... while [it was] absent in others," captured the variability and overall lack of structured psychological support or reflective processes after the disaster. Medical staff emphasized the need for updated, well-organized disaster plans with regular simulations to improve future preparedness, regardless of the country's context (Table 1).

The Quantitative Research Arm: Demographic Characteristics of the Responding Anesthesiologists

Of the 175 surveys distributed, 60 were completed, representing a response rate of 34.3%. Details of the demographic data are presented in Appendix III, Table 1a. Most respondents were female (66.7%) and aged 35-44 years. Approximately 40% worked in

hospitals with over 200 beds, while 38.3% worked in hospitals with 100-200 beds. Participants were evenly distributed between Beirut and Mount Lebanon. Most anesthesiologists from Beirut were affiliated with university hospitals, which generally have greater capacity in terms of numbers of beds and operating rooms (Appendix III Table 1b).

The preparedness of anesthesiology departments and hospitals for disaster management

Regarding disaster preparedness, 48.3% of respondents reported having a hospital disaster plan that was shared with the anesthesiology team. Another 11.7% indicated that a plan existed but was not shared with the anesthesiology team. Notably, 11.7% of participants reported no disaster plan, while 28.3% were unsure of its existence. Furthermore, when asked about disaster training, 30% of the respondents reported having received adequate training at their hospitals. (Appendix III Table 2).

Anesthesiologists' experiences during the Beirut explosion

The experiences of anesthesiologists during the Beirut explosion highlighted significant challenges. Within 24 hours of the blast, 38.3% of respondents admitted over 50 patients to their operating rooms, with a significantly higher proportion in Beirut hospitals. A substantial majority (85%) of anesthesiologists reported to their hospitals on the night of the explosion. Of these, 53.3% worked directly in the operating room, while 26.7% were deployed to the emergency department. A smaller number contributed to radiology, ICU (intensive care unit), and PACU (Post Anesthesia Care Unit). Anesthesiologists primarily assumed responsibility for running the operating rooms (60%), while surgeons or nurses managed the remaining cases. The complex circumstances following the explosion hindered the implementation of COVID-19 precautions, with only 43.3% of anesthesiologists able to adhere to safety protocols while treating patients. Post-explosion debriefing and psychological support were limited. Only 15% of anesthesiologists reported participating in debriefing sessions, and the majority (66.7%) received no psychological support (Appendix III Table 3a).

While there were no significant differences in the availability of disaster management plans between Beirut and other regions, Beirut hospitals experienced a significantly higher influx of patients. Human resource shortages were more prevalent outside of Beirut (20%) compared to within Beirut (10%). Conversely, equipment shortages were more common within Beirut (16.7%) than outside of Beirut (6.7%) following the explosion.

Both Beirut and other regions faced challenges in implementing COVID-19 precautions. Anesthesiologists outside of Beirut were more likely to lack access to post-explosion psychological support, with 80% reporting no such services (Appendix III Table 3b).

Anesthesiologists' level of knowledge and understanding regarding their roles in disaster management

Most anesthesiologists believed they could contribute significantly to disaster response if adequately trained. A substantial majority (60%) strongly supported the involvement of anesthesiologists in all phases of disaster management, from planning to recovery. Furthermore, 68.3% strongly advocated for multidisciplinary training that includes the entire operating room team (Appendix III Table 4a-4b).

Anesthesiologists' preferred methods of training

While most anesthesiologists have some knowledge of disaster management, a significant proportion (18.4%) reported having

Table 1. Themes obtained from the qualitative assessment

<i>Theme 1 Disaster plans preparedness and ability of implementation</i>	
<i>Geographical distance and university affiliation:</i>	<p>The geographical distance of hospitals from the blast site and their university affiliation played a significant role in their ability to more adequately implement disaster management plans. Hospitals located within a 2.2 km radius from the blast site, though they had disaster plans in place, were overwhelmed when the first victims arrived due to the physical damage to critical hospital utilities and injuries or deaths among attending personnel. In contrast, university hospitals farther from the blast, which remained undamaged, were able to follow their disaster management plans more effectively.</p> <p>-Two university hospitals, which were geographically farther from the blast, had disaster training and plans in place and were able to implement their disaster plans during the explosion.</p> <p>However, 2 university hospitals that sustained physical damage were unable to properly execute their plans, reporting, “We missed it that day. We were able to evacuate the hospital,” and, “The first victim was our disaster plan.”</p> <p>Private hospitals, on the other hand, had no disaster plans in place, and their personnel had not received adequate disaster training.</p>
<i>Availability of free hospital beds in times of COVID–19</i>	Availability of free beds during the COVID–19 pandemic was another critical factor, as it determined the ability to accommodate new patients requiring critical care.
<i>Theme 2: Triage of the injured</i>	
<i>Influx waves and Triage of the injured patients</i>	<p>The interviewees reported the influx of 3 waves of injured people after the blast. The closest 3 hospitals received the first wave of victims within the first hour.</p> <p>“Most of them were clinically stable individuals suffering from lacerations caused by broken glass, yet they were in severe emotional distress and panic.”</p> <p>The second and third waves of more seriously injured patients were often brought in by car or the Lebanese Red Cross.</p> <p>Triage of the injured patients was attempted but proved inadequate due to the overwhelming and disorganized influx of patients, compounded by public panic, hospital facility damage, and the unavailability of the full hospital team.</p> <p>“Of course, our hospital, like all other hospitals, was not able to ensure adequate triage given the massive influx of patients which exceeded our human and material resources.”</p> <p>In the operating rooms, anesthesiologists and surgeons conducted triage based on “stable or not stable” criteria.</p> <p>“Many of the injured were scattered across different operating rooms, sometimes without any identification, as there wasn’t enough time in the emergency room to record patients’ names.”</p> <p>“We received patients with a piece of paper taped to their body containing bits of information: ‘Allergy to penicillin,’ ‘Blood group A+,’ or even information written directly on their bodies, such as ‘normal CT scan...’</p>
<i>Theme 3: Hospitals’ Physical Damage and Improvised Care Amid Overwhelmed Facilities”</i>	
<i>Hospitals physical damage</i>	<p>The hospitals’ damaged facilities were described as follows:</p> <p>“The OR door had been blown out of its frame and parts of the ceiling were hanging. The OR was transformed into open space!”</p>
<i>Improvised care and overwhelmed facilities</i>	<p>In the wake of the blast, care was provided in unusual and improvised ways.</p> <p>“Now we treat our wounded in the corridors, in the parking lot, even in the street.”</p> <p>“As the influx of patients quickly overwhelmed hospital resources, the induction rooms and post-anesthesia care units (PACU) became saturated, and the anesthesiologists’ office was repurposed as a suture room.”</p> <p>“That night we operated on 65 patients in 5 rooms.” “Sometimes we performed 2 to 3 operations at the same time in the same operating room.”</p> <p>“Operations were carried out not only on operating tables but also in wheelchairs and, in some cases, even on the floor.”</p>
<i>Theme 4: Personnel availability and assembly</i>	
<i>Rapid Personnel Mobilization</i>	<p>University hospitals had in place a call system for personnel assembly enabling physicians and staff who lived nearby and were not directly affected by the blast to report to their hospitals that night.</p> <p>“Anesthesiologists were needed everywhere that night: emergency department, radiology, operating rooms.”</p> <p>Residents and attending physicians were deployed to the ER and PACU, while other residents were pulled from different rotations to assist in the OR.</p>
<i>Theme 5: COVID–19 precautions and material shortages</i>	
	<p>The urgency of the crisis has sidelined COVID–19 prevention protocols, especially that the blast occurred during a severe economic, political and health crisis.</p> <p>Many hospitals were already struggling with shortages of personal protective equipment (PPE). This led to a surge in COVID–19 cases in the days following the blast.</p> <p>The anesthesiologist working in a private hospital reported:</p> <p>“All patients were taken to the OR without PCR or rapid testing for COVID–19. No masks were used by the patients, no PPE used by the medical staff and no social distancing.”</p> <p>“We had a shortage in medications and other essential supplies.”</p>

(Continued)

Table 1. (Continued)

Theme 6: Aftermath and Debriefing	
Debriefing at the administration level	Debriefing after the blast was conducted at some university hospitals but was limited to the upper levels of hospital administration and departmental leadership. In contrast, no debriefing took place in other hospitals.
Anesthesiologists' opinions	<p>"Many lessons had to be learned. This disaster contributed to improving the response to massive influxes of injured people."</p> <p>"Updating the strategies used, better organization of disaster plans, based on the needs, and having predefined plans with simulations that prepare for disaster situations are essential."</p> <p>"Regardless of the initial conditions of the country or the context, we must always stay one step ahead and prepare for the worst-case scenarios."</p>

little or no knowledge. Additionally, 50% reported having somewhat of an understanding, while 21.6% reported having a great deal of understanding or understanding almost everything. While a majority of anesthesiologists plan to prepare for future disasters, a proportion of 21.7% have either not taken any steps or feel unable to do so. The majority of respondents favored conferences (45%) and simulation workshops (30%) as preferred training modalities. A smaller proportion (16.7%) preferred in-situ simulations. Most respondents (70%) advocated for hospital-organized disaster management training (Appendix III Table 5a-5b).

Discussion

To the best of our knowledge, this is the first study to document Lebanese anesthesiologists' responses, knowledge, and preparedness during a severe dual multi-hazard event in Lebanon, a large-scale explosion compounded by chemical contamination, burn injuries, destructive consequences (especially on hospital facilities), and the ongoing COVID-19 pandemic. Using a mixed-methods approach, we identified key themes that highlight both strengths and gaps in disaster preparedness within anesthesiology departments across Lebanon. Both qualitative and quantitative methods were used. This mixed methods approach was chosen to further promote a more comprehensive understanding of related concepts. It painted a more complete picture of these experiences, providing a valuable perspective on the role of anesthesiologists during mass casualty events. These findings converge with results from international studies that emphasize the critical role of well-prepared health care systems in mitigating the impact of disasters.

The qualitative analysis of the interviewees' responses from anesthesiologists in Beirut and outside Beirut identified 6 key themes of their experiences following the Beirut blast (Table 1). These themes showed no significant differences across proximity ranges to the blast, except for the number of patients, severity of injuries, and influx waves, which were higher in hospitals closer to the blast site that remained operational.¹⁰ Interestingly, the quantitative data aligned with the anesthesiologists' subjective impressions, as the topics identified through quantitative analysis resonated with their expressed thoughts and observed events.

Key findings revealed a complex interplay of factors affecting disaster response. A critical finding of this study is the varying degree of hospital preparedness. The deficiency in hospitals' emergency preparedness at various Lebanese hospitals was highlighted by a national survey.¹¹ While most hospitals had disaster plans, their implementation and effectiveness varied, particularly in hospitals closer to the blast site. Those hospitals were overwhelmed by a surge of critically injured patients and infrastructure damage,⁷ hindering their ability to effectively implement disaster plans. In contrast, hospitals farther from the blast site, particularly

university-affiliated hospitals, were better positioned to activate their disaster plans and implement emergency protocols. This aligns with global findings that hospitals with less physical damage are better equipped to respond to disasters.¹² However, the lack of comprehensive planning in smaller, private hospitals remains a significant concern. This finding underscores the need for robust preemptive planning, standardized across all hospital types, especially in high-risk areas, to ensure an effective response.¹³

Hospitals severely impacted by the blast faced significant staffing challenges, as many personnel were injured, unable to reach the hospital, or had affected family members. This is consistent with literature on mass casualty events, where obstacles,¹⁴ such as blocked roads and damaged infrastructure, hinder health care professionals from reporting to duty.¹⁵ Despite these challenges, the results showed that most anesthesiologists demonstrated a high level of commitment by reporting to their workplaces. These health care professionals played a crucial role not only in operating rooms, but also in various settings, such as emergency departments and radiology. Their versatility and leadership were evident in their ability to adapt to diverse roles, as they managed the overwhelming patient influx and assumed responsibility for running the operating rooms, particularly in smaller hospitals outside of Beirut. In addition, the blast exposed pre-existing vulnerabilities in the Lebanese health care system as well as resource shortages, including medical supplies, medications, and PPE, which further compounded these challenges.^{16,17} This led to improvised care in unconventional settings, emphasizing the importance of robust supply chain management, and highlighting the need for resilient health care systems capable of managing mass casualty events.¹⁸

Another important gap revealed by our study is the psychological impact of disaster response and the absence of enhanced support. The blast exposed health care workers to a multitude of stressors, including traumatic events, harsh work environments, and physical injuries. This psychological impact was further compounded by Lebanon's ongoing crises and the COVID-19 pandemic. Many anesthesiologists reported significant stress, anxiety, and emotional fatigue.^{19,20} This aligns with global research highlighting the mental health toll of disasters on frontline health care workers.²¹ Unfortunately, psychological support mechanisms were inadequate. While some university hospitals offered debriefing sessions, participation was limited. This lack of support highlights a critical gap in post-disaster management, considering the well-documented long-term consequences of such trauma, including burnout, anxiety, and depression.²² Moving forward, structured debriefing sessions and readily accessible mental health resources must be integrated into disaster preparedness plans.²³

While most anesthesiologists possessed adequate knowledge of disaster management, a considerable proportion (18.4%) reported

limited understanding. Additionally, while a majority expressed intention to prepare for future disasters, 21.7% had not taken concrete steps. Despite the reported presence of disaster plans in many hospitals, anesthesiologists often felt underprepared and uninvolved in hospital-wide planning efforts. This highlights the need for their inclusion in disaster preparedness initiatives from the onset. By leveraging their expertise,²⁴ anesthesiologists can play a pivotal role in optimizing emergency responses.

The study further revealed that anesthesiologists favored conferences and simulation workshops as preferred training modalities. However, the lack of standardized training and the need for a multidisciplinary approach remain significant challenges. Lessons learned from previous disasters align with the recommendations and experiences shared by participants in our study. Preparedness for disasters is vital, especially in resource-limited settings. The lack of coordination and proper training significantly hindered disaster response efforts.²⁵ To address the gap between perceived and actual preparedness, multidisciplinary training and simulation-based programs should be introduced in parallel with knowledge-building sessions. Anesthesia societies, medical schools, and health ministries play a crucial role in promoting standardized disaster training and ensuring that hospitals have the necessary resources and protocols in place. Tailored and context-sensitive preparedness measures should be taken to ensure hospital resilience and effective response to large-scale disasters.

Limitations

While this study provides valuable insights into the experiences of anesthesiologists during the Beirut blast, it is important to acknowledge its limitations. First, the study relied on a self-reported survey, which may have been subject to recall bias, and the survey was not piloted; therefore, it may have missed some important topics. Secondly, the qualitative component of the study was based on a limited number of interviews conducted approximately 2–3 months post-blast, which may not fully capture the long-term psychological and emotional impact of the event in addition to methodological, practical, and interpretive challenges. Also, the sample size was relatively small, potentially limiting the generalizability of the

findings. Future research with larger sample sizes and longitudinal studies can provide more comprehensive insights into the long-term effects of disasters on health care professionals.

Despite these limitations, this study provides valuable insights into the challenges faced by anesthesiologists during the Beirut blast. The low response rate likely reflects the challenges they faced at the time, including psychological fatigue, pandemic-related pressures, and infrastructure disruptions. Despite this, the responses provided particularly meaningful insights grounded in first-hand experience. By sharing these experiences and lessons learned, we can inform the development of more effective disaster response strategies for anesthesiologists and health care systems in conflict-affected regions.

Recommendations and Future Perspectives

Three years post-Beirut Blast, follow-up assessments revealed progress in disaster preparedness. Larger hospitals, particularly university-affiliated institutions, implemented revised disaster plans with a key role for anesthesiologists. Regular training and drills, coupled with anesthesiologists' development of their own response plans, significantly enhanced triaging and patient care during emergencies.

To enhance disaster preparedness and response, several key recommendations emerge: standardized disaster training programs that include both didactic learning and practical simulation, with tailored modules for anesthesiologists, should be implemented for all health care professionals, including anesthesiologists. Robust supply chain management systems and stockpiling of essential medical supplies are crucial. Prioritizing mental health support, including debriefing sessions and ongoing counseling, is essential for the well-being of health care workers, particularly anesthesiologists, who often bear a significant psychological burden. Actively involving anesthesiologists in disaster planning and training can leverage their expertise and optimize patient care. By implementing these recommendations and fostering collaboration between anesthesia societies, medical schools, health ministries, and hospitals, Lebanon and other conflict-affected regions can build more resilient health care systems capable of effectively responding to future disasters (Table 2).

Table 2. Lessons learned from the study on anesthesiologists' disaster preparedness

#	Lesson learned	Key message	Implications for practice
1	Disaster Plans Need Implementation, Not Just Existence	Many hospitals had disaster plans but failed to execute them during the crisis due to infrastructure damage and lack of training.	Hospitals must test, update, and practice disaster plans regularly.
2	Anesthesiologists Are Critical Frontline Responders	They played multiple roles beyond the OR — in triage, ICU, ED, and improvised care settings.	Disaster plans should specifically integrate anesthesiologists in all phases of disaster management.
3	Training is Essential and Must Be Multidisciplinary	Most anesthesiologists lacked disaster response training but expressed willingness to learn. Simulation-based and multidisciplinary training was preferred.	Regular simulation workshops and team-based disaster drills are needed for all health care staff.
4	Psychological Support is Often Overlooked	Few anesthesiologists received debriefing or mental health support post-disaster.	Mental health support, stress management, and structured debriefing should be part of disaster response.
5	Resource Management is Critical in Crisis	Hospitals struggled with shortages of medications, equipment, and PPE. Improvised care settings were used.	Strengthen hospital supply chain management and ensure stockpiles of essential materials.
6	Geography and University Affiliation Influenced Response	University hospitals and those farther from the blast were better able to implement disaster plans.	Preparedness plans should account for geographical risks and ensure smaller hospitals are equally supported.

Conclusion

The Beirut blast serves as a stark reminder of the devastating impact of large-scale disasters on health care systems, particularly in fragile contexts. This study provides valuable insights into the challenges faced by anesthesiologists during this crisis. By understanding the specific needs and limitations experienced by these frontline health care providers during the crisis, we can identify key areas for improvement in disaster preparedness and response.

To enhance future preparedness, it is imperative to invest in robust disaster plans, regular training, and adequate resource allocation. Prioritizing the mental health of health care workers, particularly through debriefing sessions and psychological support, is crucial for mitigating the long-term consequences of such traumatic events. By learning from the experiences of Lebanese anesthesiologists, we can inform the development of more effective disaster response strategies for health care systems worldwide, particularly in regions facing similar challenges.

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