



Disaster Medical Response Coordinating General Surgery, Family Medicine, Nutrition, Nursing, and Radiography in Mass-Casualty Scenarios

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Article Info:

DOI: 10.22399/ijcesen.4084

Received : 01 January 2025

Accepted : 29 January 2025

Keywords

Disaster Medical Response,
Mass-Casualty Incident (MCI),
Interdisciplinary Coordination,
Trauma Surgery,
Family Medicine

Abstract:

In mass-casualty scenarios, effective disaster medical response coordination is paramount to ensuring the optimal delivery of care. General surgery plays a critical role, as surgical teams must be prepared to manage traumatic injuries that are frequently encountered in such situations. Concurrently, family medicine practitioners provide comprehensive care by addressing the holistic needs of patients, including chronic disease management and mental health support. These healthcare providers work collaboratively to triage patients effectively, ensuring that those with the most critical needs receive immediate attention. The coordinated efforts among these specialties not only improve individual patient outcomes but also enhance the overall efficiency of the healthcare response in the face of overwhelming demand. Nutrition and nursing are also essential components of disaster medical response in mass-casualty settings. Nutritionists assist in planning and delivering appropriate nutritional interventions to sustain both patients and healthcare providers, mitigating the impact of stress and trauma through proper nourishment. Meanwhile, nursing staff function as the backbone of the medical response, providing vital support in patient assessment, monitoring, and coordination of care. Nursing roles have expanded to include triage and leadership responsibilities, as they often serve as the primary point of contact for patients and their families in chaotic environments. Additionally, radiography, with its capacity to quickly

assess and diagnose injuries through imaging, supports timely interventions and surgical planning. The interdisciplinary collaboration among these fields ensures a comprehensive approach to disaster management, improving resilience and outcomes in mass-casualty incidents.

1. Introduction

The increasing frequency and severity of natural disasters, complex humanitarian emergencies, and acts of mass violence present a formidable and persistent challenge to global public health systems [1]. These mass-casualty incidents (MCIs) overwhelm the resources and capabilities of local and regional healthcare infrastructure, creating a critical gap between the immediate, vast medical needs of the affected population and the available surge capacity to address them [2]. The chaotic and resource-constrained environment of a disaster zone demands a response that is not only rapid and scalable but, more importantly, exceptionally coordinated and multidisciplinary. The traditional, siloed approach to medical care, where specialties function in relative isolation, is a recipe for inefficiency, miscommunication, and ultimately, preventable mortality and morbidity in these high-stakes settings [3].

The initial chaos of an MCI necessitates a structured and prioritized approach to patient management, most commonly guided by the principles of triage, such as the Simple Triage and Rapid Treatment (START) system. This is where the first layer of coordination begins. The role of General Surgery is paramount, as traumatic injuries—including penetrating wounds, blunt force trauma, crush injuries, and burns—constitute a significant proportion of pathologies in many disasters [4]. The surgeon's mandate extends beyond the operating table to the leadership of triage teams, making critical decisions about the prioritization of surgical interventions based on available resources, time, and the likelihood of survival. However, these decisions cannot be made in an informational vacuum. They rely heavily on the immediate diagnostic input from Radiography. The field of Radiography, particularly with the advent of portable and ruggedized technologies like ultrasound (e.g., Focused Assessment with Sonography for Trauma or FAST scans) and digital X-ray systems, has become a cornerstone of point-of-care diagnostics in disaster zones [5]. The radiographer's ability to rapidly identify life-threatening conditions such as hemothorax, pneumothorax, or internal bleeding provides the surgeon with the actionable intelligence needed to plan and execute life-saving procedures. This symbiotic relationship between the surgeon's clinical judgment and the radiographer's diagnostic

acumen forms the first critical axis of coordination in the medical response, ensuring that the most severely injured patients receive timely and appropriate intervention.

While the surgeon-radiographer axis addresses immediate, life-threatening trauma, the scope of medical need in a disaster extends far beyond acute injuries. This is where the comprehensive and patient-centric approach of Family Medicine becomes indispensable. Disasters disrupt primary healthcare systems, leading to the exacerbation of chronic conditions such as hypertension, diabetes, asthma, and cardiac disease [6]. Furthermore, vulnerable populations, including children, the elderly, and pregnant women, present with a spectrum of non-traumatic medical complaints that require expert management. Family physicians provide the essential backbone of general medical care, managing these chronic diseases, treating infections, addressing psychiatric distress, and ensuring continuity of care for the entire affected community. Their role prevents the secondary crisis of routine medical neglect, which can claim as many lives as the initial disaster event itself [7].

Orchestrating the clinical activities of surgeons, radiographers, and family physicians, and serving as the cohesive force that binds the patient's journey, is the Nursing corps. Nursing in a disaster setting transcends traditional ward-based duties; it embodies a role of immense responsibility and versatility. Nurses are often the first and most consistent point of contact for patients, performing triage, administering medications, providing advanced life support, managing wounds, and offering psychological first aid [8]. Their position at the bedside grants them a unique, holistic view of the patient's condition, making them vital communication conduits between the different specialties. They translate surgical plans into post-operative care, implement the treatment regimens prescribed by family physicians, and coordinate with radiographers for patient transport and preparation for diagnostic procedures. The nursing perspective is thus central to maintaining patient safety, preventing errors, and ensuring that the coordinated plan conceived at the leadership level is effectively executed at the point of care. The integration of these clinical disciplines, however, remains incomplete without the often-underestimated component of Nutritional support. The disaster environment frequently leads to food insecurity, contamination of water supplies, and

disruption of sanitation, creating a perfect storm for the rapid onset of malnutrition, particularly in children and individuals with high metabolic demands, such as those with major trauma or severe burns [9]. Malnutrition is not merely a matter of hunger; it is a pathophysiological state that directly compromises immune function, impairs wound healing, increases susceptibility to infection, and leads to increased mortality [10]. A patient saved by a skilled surgeon will succumb to sepsis if their nutritional status is neglected. Therefore, the role of clinical nutritionists or dietitians, working in concert with physicians and nurses, is to assess nutritional risk, formulate feeding plans—whether enteral or parenteral—and monitor the metabolic status of patients. This ensures that the foundational substrate for recovery is in place, making nutrition a therapeutic intervention as critical as any antibiotic or surgical procedure. The challenge, therefore, is not in recognizing the individual importance of these five disciplines, but in architecting a system that facilitates their effective collaboration under the extreme duress of a mass-casualty scenario. Current disaster response frameworks, such as the Hospital Incident Command System (HICS) or the WHO's Emergency Medical Teams (EMT) initiative, provide a foundational structure for command and control [11, 12]. However, they often lack the granular, operational-level guidance needed to foster the deep, clinical integration proposed here. Barriers to this ideal state of coordination are numerous and include disparate training backgrounds, professional hierarchies, incompatible communication protocols, and the absence of shared situational awareness [13].

2. Rapid Diagnostics for Life-Saving Interventions

In the chaotic and resource-limited environment of a mass-casualty incident (MCI), the initial minutes and hours following patient arrival—often termed the "golden hour"—are disproportionately critical in determining survival outcomes. Within this narrow window, the collaboration between trauma surgery and radiology evolves from a standard clinical partnership into a deeply integrated, high-stakes nexus. This synergy is not merely beneficial but is the fundamental axis upon which effective trauma care pivots. The surgeon's decision-making process, which involves prioritizing who receives immediate life-saving intervention, is entirely dependent on rapid, accurate, and actionable diagnostic information. It is the field of radiology, particularly through the deployment of portable and robust imaging technologies, that provides this

essential intelligence, transforming clinical suspicion into definitive, treatable diagnoses [14]. The failure of this nexus, whether through poor communication, lack of equipment, or disjointed protocols, directly translates to preventable mortality, as timely intervention for conditions like internal hemorrhage or tension pneumothorax becomes a matter of chance rather than a structured process.

The cornerstone of this collaborative effort is the principle of triage, a dynamic and ongoing process that must be informed by objective data. In a disaster scenario, where the number of patients can far exceed the available surgical suites and specialist surgeons, the ability to correctly identify those in need of immediate versus delayed surgery is paramount. Clinical examination alone, while vital, is often insufficient and can be misleading in the context of polytrauma, altered mental status, or compensated shock [15]. This is where radiology serves as the surgeon's "eyes" beneath the skin. The rapid application of targeted imaging, such as the e-FAST (Extended Focused Assessment with Sonography for Trauma) exam, can detect the presence of free fluid in the pericardium, abdomen, or chest cavity—a key indicator of internal bleeding—within a matter of minutes at the bedside [16]. A positive FAST exam provides the trauma surgeon with an unambiguous trigger to prioritize a patient for immediate operative intervention, thereby streamlining the flow of critical casualties and ensuring that the most severely injured are not lost to delays in diagnosis.

The technological arsenal available to radiology in the field has expanded significantly, moving beyond traditional, fixed X-ray suites to include highly mobile and resilient devices. Portable ultrasound machines, now more compact, battery-operated, and durable, are ideally suited for the disaster setting. Their value lies in their non-invasiveness, repeatability, and absence of ionizing radiation, making them safe for both patients and providers in often improvised clinical areas [17]. Similarly, the advent of digital radiography (DR) systems with ruggedized detectors and portable X-ray generators has revolutionized point-of-care imaging. These systems allow for rapid acquisition of high-quality images of the chest, pelvis, and long bones directly in the triage zone, resuscitation bay, or pre-operative area, eliminating the dangerous and time-consuming process of transporting unstable patients to a radiology department [18]. The integration of these technologies into the initial patient assessment workflow is a critical multiplier of clinical efficiency and diagnostic accuracy. The e-FAST exam stands as the paradigmatic example of this nexus in action. Its protocol is

designed to answer specific, life-threatening questions: Is there a hemopericardium causing cardiac tamponade? Is there a hemoperitoneum from a ruptured spleen or liver? Is there a hemothorax or pneumothorax? The radiographer or trained clinician performs the scan, systematically visualizing these potential spaces. The findings are then immediately communicated to the trauma team leader—typically a surgeon—using a clear, structured format. A simple "FAST positive" or "FAST negative" declaration, accompanied by the specific location of the fluid, provides a powerful, binary data point for surgical planning [19]. For instance, a patient with a positive abdominal FAST and unstable vital signs can be routed directly to the operating theater for an exploratory laparotomy, while a patient with a negative FAST but persistent hypotension may trigger a search for alternative sources of blood loss, such as major pelvic or long bone fractures, which can be confirmed by subsequent portable X-rays.

Beyond the FAST exam, portable radiography plays an indispensable role in the primary and secondary surveys of trauma patients. A single portable chest X-ray can rapidly diagnose a tension pneumothorax, a massive hemothorax, or widened mediastinum suggestive of a great vessel injury—all conditions that require immediate surgical or procedural attention. Furthermore, X-rays of the pelvis are crucial in the blunt trauma patient. The identification of an open-book or vertical shear pelvic fracture alerts the surgeon to a potential source of catastrophic retroperitoneal hemorrhage, which may necessitate urgent orthopedic stabilization or angiographic embolization, decisions that must be made in concert with the radiologist's interpretation [20]. The speed of this diagnostic loop—from image acquisition to interpretation to clinical decision—is a direct determinant of patient survival. In essence, the radiology suite is brought to the patient's stretcher, collapsing the traditional timeline of trauma care.

The effectiveness of this trauma-surgery-radiology nexus is heavily reliant on the human element: communication and proximity. The ideal model in a disaster response is the colocation of the radiology team within the triage and resuscitation area. This physical integration eliminates delays and fosters a constant, fluid exchange of information. The radiographer becomes an embedded member of the trauma team, rather than a peripheral service that is "called upon." This allows for real-time feedback; a surgeon can request a specific view based on clinical findings, and the radiographer can immediately adjust the imaging protocol. This collaborative dialogue ensures that the imaging performed is both relevant and sufficient, avoiding

unnecessary studies that waste precious time and resources [21]. Clear, closed-loop communication, using standardized tools like SBAR (Situation, Background, Assessment, Recommendation), is essential to prevent misunderstandings in the high-stress, high-noise environment of a mass-casualty reception area.

However, this seamless integration faces significant challenges in a disaster scenario. The environment itself is a major obstacle; limited electrical power, poor lighting, extreme temperatures, and contaminated conditions can impair both equipment function and operator performance. Furthermore, the sheer volume of patients can lead to imaging backlogs, and the potential for interpreter fatigue among both radiographers and surgeons is high, increasing the risk of missed or delayed diagnoses [22]. To mitigate these challenges, pre-disaster planning is essential. This includes the procurement of equipment designed for field use, the stockpiling of backup power sources, and, most critically, the implementation of joint training and simulation exercises. Surgeons and radiographers must train together under realistic MCI conditions to build shared mental models, practice communication protocols, and develop the muscle memory required to function effectively under duress.

In conclusion, the nexus between trauma surgery and radiology in a mass-casualty scenario represents a critical, non-negotiable partnership for effective disaster medical response. It is a relationship built on the pillars of speed, accuracy, and clear communication, enabled by portable and resilient imaging technologies. The e-FAST exam and portable X-ray are not just diagnostic tools; they are the pivotal instruments that guide the surgeon's hand in prioritizing life over limb, and intervention over observation. By formally embedding this collaborative model into disaster response frameworks, ensuring the necessary equipment is available, and mandating interdisciplinary training, response teams can solidify this nexus. Strengthening this bond is a direct investment in salvaging lives that would otherwise be lost in the critical first hours of a disaster, ultimately fulfilling the core mandate of disaster medicine: to do the greatest good for the greatest number [23].

3. The Central Role of Family Medicine in Managing a Surge of Complex Medical Needs

The visual drama of traumatic injury—the crush wound, the compound fracture, the burn—often commands immediate attention in the aftermath of a disaster, rightly prioritizing the principles of

trauma surgery and emergency care. However, an exclusive focus on these acute surgical pathologies creates a perilous blind spot in the medical response, one that can lead to a "second wave" of mortality and morbidity days or weeks after the initial event. This secondary crisis is characterized not by penetrating trauma, but by the exacerbation of chronic medical conditions, the outbreak of communicable diseases, and the systemic failure of primary healthcare. It is within this expansive and complex clinical landscape that the role of Family Medicine emerges as not just important, but central and indispensable. Family physicians provide the essential backbone of general medical care, managing a surge of non-traumatic needs that, if left unaddressed, can overwhelm a community as profoundly as the disaster itself [24]. Their expertise lies in a holistic, patient-centered approach that is crucial for maintaining the health of the entire affected population, from neonates to the elderly, throughout the prolonged recovery phase.

The most immediate challenge beyond initial trauma stabilization is the management of chronic non-communicable diseases (NCDs). Disasters abruptly disrupt the continuous care that patients with conditions like hypertension, diabetes mellitus, asthma, congestive heart failure, and seizure disorders require. Access to routine medications is severed, electrical power for refrigerating insulin is lost, and follow-up appointments are canceled indefinitely. The resulting clinical consequences are both predictable and severe: diabetic ketoacidosis and hypoglycemic crises, hypertensive emergencies and strokes, status asthmaticus, and status epilepticus [25]. These NCD exacerbations present as acute, life-threatening medical emergencies that quickly consume the very hospital resources already strained by trauma casualties. The family physician, skilled in the comprehensive management of these conditions, steps in to fill this critical gap. They establish post-disaster primary care clinics, implement systems for medication refills, and provide the ongoing monitoring and adjustment of therapies that prevent these predictable complications, thereby reducing the burden on emergency and inpatient services.

Furthermore, the disaster environment itself creates a perfect storm for the outbreak of communicable diseases, adding another layer of complexity to the medical response. Overcrowding in temporary shelters, compromised sanitation, contamination of water supplies, and reduced vaccination coverage create ideal conditions for the rapid spread of gastroenteritis, respiratory infections, hepatitis A, and vector-borne diseases such as malaria and dengue fever [26]. The family medicine team is on

the front lines of detecting, managing, and containing these outbreaks. They conduct syndromic surveillance within shelters, recognizing patterns that signal the beginning of an epidemic. They diagnose and treat common infections, implement rehydration protocols for diarrheal diseases, and initiate infection prevention and control measures, such as promoting handwashing and isolating infectious cases. This public health function, embedded within clinical practice, is vital for preventing a cascade of illness that could debilitate the surviving population and responders alike. The scope of Family Medicine in a disaster also extends to providing comprehensive care for the most vulnerable populations, whose needs are often overlooked in the initial chaos. Pregnant women represent a particularly high-risk group; disasters are associated with increased rates of preterm labor, low birth weight, pregnancy-related hypertension, and complications due to inadequate prenatal care and nutrition [27]. The family physician, often with training in obstetrics, provides essential antenatal care, manages labor and delivery in austere conditions, and identifies high-risk pregnancies requiring evacuation to higher-level care. Similarly, the needs of pediatric patients are distinct and urgent. Children are more susceptible to dehydration from gastroenteritis, respiratory distress from infections, and psychological trauma. They also require the continuation of routine childhood immunizations to prevent outbreaks of diseases like measles and pertussis, a programmatic effort that falls squarely within the purview of family and public health medicine [28]. The elderly, often with multiple chronic conditions and limited mobility, face challenges in accessing aid distribution points and are at high risk for both medical deterioration and neglect. The family physician's skill in geriatric care is crucial for managing this demographic.

Perhaps one of the most significant, yet historically neglected, contributions of Family Medicine in disaster response is in the realm of mental and behavioral health. The psychological impact of experiencing a disaster—witnessing death, losing loved ones, and seeing one's home and community destroyed—is profound and nearly universal. A surge of mental health needs manifests as acute stress reactions, post-traumatic stress disorder (PTSD), major depression, anxiety disorders, and a rise in substance abuse [29]. While severe cases may require specialized psychiatric care, the first line of support for the vast majority of the affected population is the primary care provider. Family physicians are uniquely positioned to provide psychological first aid, screen for common mental health disorders, initiate pharmacotherapy for

conditions like depression and anxiety, and offer supportive counseling. They understand the cultural and community context, which is essential for providing empathetic and effective care. Integrating mental health into the fabric of primary medical services from the outset helps to destigmatize psychological suffering and promotes the long-term psychosocial recovery of the community.

The operational model for delivering this broad spectrum of care is often the establishment of ad-hoc primary care clinics within or near shelters, aid distribution centers, or damaged local health facilities. These clinics become the hub for non-emergent but essential medical activities. They are tasked with the ongoing management of chronic diseases, wound care and suture removal for patients initially treated by surgeons, minor illness visits, and health education [30]. The family physician leads a team that may include nurses, community health workers, and clinical officers, effectively creating a micro-health system within the disaster zone. This structure is vital for decongesting the central triage and emergency areas, allowing trauma and surgical teams to focus on the most critical cases. By acting as a filter, the family medicine clinic ensures that medical resources are allocated efficiently and that patients receive the most appropriate level of care for their needs.

However, the integration of Family Medicine into the disaster response framework is not without significant challenges. One major barrier is the "tyranny of the immediate," where the urgent needs of trauma victims can inadvertently divert all human resources, supplies, and logistical support away from primary care services in the critical early phases [31]. A second challenge is the lack of pre-existing medical records, making it difficult for family physicians to know a patient's baseline health status, allergies, and previous medication regimens, forcing them to practice in an informational void. Furthermore, there can be a tendency for disaster response planners, often dominated by surgical and emergency medicine perspectives, to underestimate the volume and acuity of non-traumatic medical needs, leading to inadequate staffing and supplies for primary care teams.

To overcome these obstacles, proactive and pre-emptive planning is essential. Disaster protocols must explicitly recognize Family Medicine as a core component of the medical response from day one, with dedicated personnel, pre-packaged equipment for setting up primary care clinics, and standardized supplies of essential chronic disease medications (e.g., antihypertensives, insulin, asthma inhalers) [32]. Just as surgical teams have

pre-packed kits, so too should family medicine teams. Furthermore, training for disaster response must be incorporated into family medicine residencies and continuing education, focusing on skills in public health surveillance, crisis resource management, and the management of common disasters in low-resource settings. Building these capacities ensures that when a disaster strikes, a cadre of primary care providers is ready to deploy and integrate seamlessly into the larger response effort.

In conclusion, to view disaster medical response solely through the lens of trauma is to fundamentally misunderstand its full scope and duration. The sudden collapse of a community's health infrastructure creates a vacuum that is filled with a complex surge of medical, pediatric, obstetric, and mental health needs. Family Medicine, with its comprehensive, continuous, and community-oriented approach, is the specialty most adept at filling this vacuum. By managing chronic diseases, controlling outbreaks, caring for vulnerable populations, and addressing the pervasive mental health crisis, family physicians provide a stabilizing force that prevents the secondary collapse of public health. A fully integrated disaster response, therefore, is one where the surgeon's scalpel and the family physician's stethoscope are recognized as equally vital instruments, working in concert to heal not just individual injuries, but the entire affected community [33].

4. Nursing: The Integrative Backbone of Patient-Centered Care in Chaos

In the fragmented and high-velocity environment of a mass-casualty incident (MCI), where medical specialties are necessarily focused on their discrete tasks, the role of nursing transcends traditional definitions to become the essential, integrative backbone of the entire patient care continuum. While the surgeon operates, the radiographer images, and the family physician diagnoses, it is the nurse who provides the constant, unifying thread that connects these isolated interventions into a coherent plan of care for each individual patient. Nursing in a disaster is the profession of orchestration and execution, embodying a unique combination of advanced clinical skills, relentless advocacy, and holistic compassion. Nurses are the agents who translate high-level medical decisions into actionable, minute-by-minute bedside reality, ensuring that the system designed at the command level functions effectively at the point of care [34]. Their position at the patient's side, throughout the entire journey from triage to discharge or

evacuation, grants them a singular, overarching perspective that is critical for maintaining safety, continuity, and humanity amidst the chaos.

The integrative function of nursing begins at the very first moment of patient contact, often in the triage area. Here, nurses are frequently the first and most critical clinical decision-makers, applying triage protocols like START (Simple Triage and Rapid Treatment) to categorize patients based on the severity of their injuries and their likelihood of survival. This initial sorting is a profound responsibility that sets the trajectory for all subsequent care [35]. However, the nurse's role in triage is not a one-time event; it is a process of continuous assessment. As a patient's condition evolves—deteriorating or improving—the nurse is the one who identifies these subtle changes and re-triages accordingly, ensuring that dynamic clinical needs are met in a timely manner. This ongoing vigilance prevents patients from being "lost" in the system or their conditions from worsening unnoticed amidst the overwhelming patient volume. The nurse, therefore, acts as the system's early warning mechanism, detecting crises before they become irreversible.

Once a patient moves from triage to a treatment area, the nurse's role expands into one of complex care coordination and clinical execution. They are responsible for implementing the plans devised by physicians across all specialties. This includes administering medications and blood products prescribed by the surgeon or family physician, managing and monitoring complex intravenous lines, performing advanced life support, and providing sophisticated wound care [36]. Furthermore, they are the primary operators and monitors of the sophisticated technology that keeps critically ill patients stable, such as ventilators and infusion pumps. In a resource-scarce environment, this technical expertise is paramount; a single nursing error in medication calculation or ventilator setting can have immediate and fatal consequences. The nurse's deep understanding of pathophysiology and pharmacology allows them to not only follow orders but also to anticipate needs and recognize when a prescribed intervention may be having an unintended effect, enabling them to act as a crucial safety check within the high-stakes clinical environment.

Perhaps the most critical integrative function of nursing is that of communication hub. In a disaster response involving multiple disciplines, the risk of miscommunication and information loss is extremely high. The nurse serves as the central nexus through which information about the patient flows. They receive orders and diagnostic results from surgeons, radiographers, and family

physicians, synthesize this information, and then translate it into a unified nursing care plan [37]. They are also the primary communicators with patients and their families, providing updates, offering reassurance, and gathering additional history that might be crucial for diagnosis. This bidirectional flow of information is vital. For example, a nurse who notices a drop in a post-operative patient's blood pressure will immediately inform the surgeon, while simultaneously reporting the radiographer's findings of a new pleural effusion to the family physician managing the patient's congestive heart failure. This closed-loop communication prevents the formation of informational silos and ensures that all members of the team share a common, up-to-date mental model of the patient's status.

The nursing role also encompasses a vast domain of logistical and psychological support that is fundamental to a functional medical response. Logistically, nurses are the managers of the patient's immediate environment and flow. They coordinate patient transport to and from imaging, prepare them for surgery, and manage the inventory and organization of supplies within their designated area [38]. In the absence of functioning electronic records, they become the keepers of the paper trail, meticulously documenting assessments, interventions, and responses to treatment. This documentation is not merely administrative; it is a legal and clinical necessity for ensuring continuity of care as patients are handed over between shifts or evacuated to other facilities. Without meticulous nursing documentation, the patient's story becomes fragmented, leading to medication errors, duplicated tests, and a breakdown in the continuity of therapeutic plans.

Simultaneously, nurses provide the indispensable element of psychological first aid and holistic comfort. In the midst of terror, pain, and confusion, the nurse is often the only source of human connection and reassurance for a patient. The psychological trauma of a disaster is immense, and the calming presence of a competent, compassionate nurse can prevent panic, de-escalate distress, and provide a profound sense of safety [39]. This psychosocial care extends to the families of victims and even to fellow responders. Nurses are adept at recognizing signs of acute stress and burnout in their colleagues, offering support and ensuring that the caregiving team remains functional. This role as the "heart" of the response is not a soft skill but a critical intervention that maintains the moral integrity and emotional resilience of the entire operation.

However, the immense responsibilities shouldered by nurses in MCIs place them under extraordinary

physical and emotional duress, leading to significant challenges. They often work for extended hours with limited rest, face moral distress when having to make rationing decisions, and are exposed to high levels of secondary traumatic stress [40]. The risk of task saturation is acute, as the sheer volume of patients can overwhelm their capacity to provide integrative, patient-centered care, potentially reducing their function to that of task-oriented technicians. This compromises their ability to serve as the communicative and observational backbone of the team. Furthermore, the hierarchical structures that sometimes persist in healthcare can impede nurses from speaking up, even when they possess critical information about a patient's declining condition, a phenomenon known as the "authority gradient" [41].

To fortify this nursing backbone, specific strategies must be embedded in disaster planning and training. A fundamental step is the formal integration of nursing leadership into the Incident Command System (ICS) from the outset. A Chief Nursing Officer or Nursing Unit Leader must have an equal voice in operational decisions, ensuring that nursing perspectives on patient flow, staffing ratios, and resource allocation are heard and acted upon [42]. Secondly, pre-disaster training must be intensely interdisciplinary. Nurses, surgeons, and radiographers should train together in full-scale simulations, not in parallel silos. This builds trust, fosters mutual respect, and practices the specific communication protocols—such as SBAR (Situation, Background, Assessment, Recommendation)—that are essential for effective teamwork under pressure [43].

Finally, supporting the well-being of the nursing workforce is a strategic imperative, not an afterthought. Disaster plans must include mechanisms for mandatory rest periods, psychological debriefing, and access to mental health support for all responders. A burned-out, traumatized nurse cannot function as an effective integrator or clinician. Protecting their resilience is synonymous with protecting the resilience of the entire medical response system [44].

5. Nutrition as a Therapeutic Pillar:

In the immediate aftermath of a mass-casualty incident, the medical response is rightly dominated by the dramatic, life-saving interventions of trauma surgery, emergency medicine, and critical care. However, a silent and insidious threat begins to emerge in the days and weeks that follow, one that claims lives not through exsanguination but through cellular starvation. This is the "second wave" of

mortality, driven by the complex interplay of disaster-induced malnutrition, metabolic stress, and immunosuppression. In this context, clinical nutrition must be reframed from a basic humanitarian logistic or a secondary concern to a fundamental therapeutic pillar, as critical to patient survival as any antibiotic or surgical procedure [45]. The integration of specialized nutritional support into the core medical response is not an optional supplement but a non-negotiable component of comprehensive care, essential for preventing complications, supporting recovery, and ultimately, determining the long-term survival outcomes of the affected population.

The pathophysiological basis for this "second wave" lies in the profound metabolic stress experienced by the human body following major trauma, burns, or severe infection—the very conditions prevalent in a disaster. The body enters a hypermetabolic and hypercatabolic state, characterized by a massive surge in energy expenditure, a rapid breakdown of muscle protein for gluconeogenesis, and a systemic inflammatory response [46]. This state is evolutionarily designed for short-term survival, but when sustained, it leads to rapid depletion of lean body mass, visceral protein, and immune competence. A patient who has undergone a life-saving laparotomy for internal bleeding is now in a race against time; their body is cannibalizing its own tissues to fuel the healing process. Without immediate and adequate exogenous nutritional support, this metabolic storm will consume the very substrates required for wound healing, organ function, and fighting infection, rendering the surgeon's initial success futile.

The disaster environment itself acts as a powerful multiplier of nutritional risk. Food supply chains are shattered, safe water for drinking and cooking becomes scarce, and sanitation systems collapse. This leads to a high prevalence of acute malnutrition, particularly among the most vulnerable: children, the elderly, pregnant and lactating women, and those with chronic illnesses [47]. Furthermore, the logistical chaos often means that initial food aid consists of calorie-dense but nutrient-poor commodities, lacking the specific proteins, vitamins, and minerals required for recovery from illness and injury. For hospitalized patients, additional factors compound the problem: the catabolic effects of surgery, the nil-by-mouth status pre- and post-operatively, and anorexia induced by illness and psychological distress. This creates a perfect storm where the nutritional demands of the body are at their highest, while its intake and access to nutrients are at their lowest.

The clinical consequences of neglecting nutritional support are severe, direct, and measurable. The most significant impact is on the immune system. Protein-energy malnutrition causes atrophy of lymphoid tissues and impairs cell-mediated immunity, neutrophil function, and complement activity [48]. This immunocompromised state transforms a simple wound or a minor respiratory infection into a life-threatening septic event. In a crowded, often unhygienic disaster treatment facility, the risk of nosocomial infections is already high; malnutrition ensures that patients lack the defenses to combat them. Secondly, malnutrition directly impairs tissue repair. The synthesis of collagen, the proliferation of fibroblasts, and the formation of new blood vessels—all essential processes for wound and fracture healing—are critically dependent on an adequate supply of protein, vitamin C, zinc, and other micronutrients [49]. Non-healing surgical wounds, dehiscence of anastomoses, and chronic fistulas are common and devastating complications in malnourished trauma patients, leading to prolonged disability, repeated surgeries, and increased mortality.

To effectively integrate nutrition as a therapeutic pillar, a systematic approach must be implemented from the moment of patient admission, mirroring the protocols for triage and diagnostics. The first step is rapid nutritional screening and assessment to identify at-risk individuals. Simple, validated tools like the MUST (Malnutrition Universal Screening Tool) or subjective global assessment can be deployed by nurses or clinical officers to categorize patients based on their body mass index, recent unplanned weight loss, and the acute disease effect [50]. This allows for the prioritization of nutritional resources to those who need them most urgently. Following screening, a detailed nutritional plan should be developed by a clinical nutritionist or a trained physician, tailored to the patient's specific condition, metabolic demands, and functional status of their gastrointestinal tract. This plan is not static but must be dynamically adjusted as the patient's clinical status evolves through the phases of resuscitation, anabolism, and recovery.

The practical implementation of nutritional support hinges on selecting the appropriate route of administration, a decision with profound clinical implications. Whenever possible, the enteral route—feeding via the gastrointestinal tract—is strongly preferred over parenteral (intravenous) nutrition. Enteral nutrition helps to maintain the structural and functional integrity of the gut mucosa, preserves the gut-associated lymphoid tissue (a crucial part of the immune system), and prevents bacterial translocation from the gut into the bloodstream [51]. For patients who cannot

swallow safely or have a compromised consciousness, this is achieved through the placement of nasogastric or nasojejunal feeding tubes. The dogma "if the gut works, use it" is a guiding principle in disaster nutrition, as it is safer, cheaper, and more physiologically beneficial than intravenous feeding. For the wider, non-hospitalized affected population, the provision of ready-to-use therapeutic foods (RUTFs) for children and nutrient-dense food baskets for families is the public health equivalent of this therapeutic intervention.

There are, however, significant challenges to delivering effective nutritional therapy in a disaster zone. The most obvious is the logistical hurdle of procuring, storing, and distributing specialized medical nutrition products like enteral formulas, RUTFs, and micronutrient supplements amidst damaged infrastructure [52]. A lack of clean water also poses a dire threat, not only for drinking but also for reconstituting powdered formulas, creating a high risk for diarrheal diseases if contaminated water is used. From a clinical perspective, managing enteral feeding in critically ill patients can be complex, with common complications like feed intolerance, diarrhea, and aspiration risk requiring constant nursing monitoring and medical adjustment. Perhaps the most pervasive challenge is the persistent perception of nutrition as a secondary, non-urgent welfare issue rather than a primary medical therapy, which can lead to its systematic under-prioritization in resource allocation and clinical planning.

Overcoming these barriers requires deliberate pre-disaster planning and a paradigm shift in the culture of disaster response. Just as surgical and pharmaceutical kits are pre-positioned, so too should "nutrition kits" containing ready-to-use enteral feeding tubes, pumps, and a supply of enteral formulas and RUTFs be included in emergency medical team stockpiles [53].

6. Systemic Barriers to Effective Interdisciplinary Coordination

The theoretical model of a seamlessly integrated disaster medical response, where General Surgery, Family Medicine, Nutrition, Nursing, and Radiography function as a unified, efficient team, is an aspirational goal. In practice, however, this ideal is often thwarted by a complex web of deep-rooted systemic barriers. These barriers are not merely operational hiccups but are structural, cultural, and psychological impediments that actively prevent the synthesis of disparate specialties into a coherent whole. Understanding these obstacles is the first and most critical step toward mitigating their effects and building a more resilient response

system. The failure to address these issues proactively ensures that even the most well-equipped and intentioned medical teams will struggle with inefficiency, miscommunication, and duplicated or missed care, ultimately compromising patient outcomes in an environment where there is no margin for error [54].

One of the most formidable barriers is the pervasive influence of professional hierarchies and traditional siloed training. Healthcare education and practice are historically structured around specialty-specific domains, fostering deep expertise but often at the cost of interdisciplinary collaboration. In a disaster setting, these ingrained patterns reassert themselves. Surgeons, accustomed to a position of ultimate authority in the operating room, may overlook input from nursing staff regarding a patient's subtle clinical decline. Similarly, physicians may undervalue the critical diagnostic suggestions of a radiographer or the therapeutic recommendations of a clinical nutritionist [55]. This hierarchy is not always explicit; it often manifests as an "authority gradient" that stifles communication. A nurse or a junior paramedic may possess crucial information but hesitate to voice concerns to a senior surgeon, fearing reprimand or being perceived as challenging authority. This suppression of dialogue can lead to catastrophic errors, as the individual with the most complete picture of the patient's status may not be the one making the final decisions.

Compounding the issue of hierarchy is the critical challenge of communication failure. In the high-stress, high-noise, and fast-paced environment of a mass-casualty incident, standard communication protocols easily break down. Different specialties may use distinct jargon and terminology that is not universally understood. For instance, a surgeon's rapid-fire orders may be misinterpreted by a nurse from a different regular practice background, or a radiographer's detailed description of a finding may be lost on a family physician overwhelmed with a queue of patients [56]. Furthermore, the absence of reliable, interoperable communication technology—such as functioning radios, mobile networks, or a shared digital patient tracking system—creates informational black holes. Patient data, triage categories, and treatment plans become trapped in paper notes or within isolated teams, leading to situations where the left hand does not know what the right hand is doing. This lack of a shared situational awareness means that the response operates as a collection of independent units rather than a single, coordinated organism.

A third major barrier is the absence of standardized, interoperable protocols and the lack of joint, interdisciplinary training. While individual

specialties may be highly trained in their own disaster protocols, they rarely practice integrating these protocols with other services. A surgical team may be proficient in setting up a field operating room, and a nursing team may be expert in triage, but without having drilled together, their handoff of patients from the triage area to the pre-operative zone is likely to be chaotic and fraught with misunderstandings [57]. There is often no agreed-upon model for how a nutritionist should interface with a surgeon to manage a post-operative patient's feeding plan, or how a family physician can formally consult the radiology team for a non-trauma case. This lack of pre-established workflows forces teams to invent their coordination mechanisms on the fly during a crisis, a process that is inherently inefficient and prone to failure. Without a shared mental model of how the entire system should work, each group defaults to what it knows best: operating within its own silo.

The physical and logistical environment of a disaster zone itself acts as a powerful barrier to coordination. Treatment areas are often improvised in warehouses, tents, or damaged buildings, leading to a physical layout that separates rather than integrates specialties. If the surgical tent is hundreds of meters from the primary care clinic and the radiology unit is in a separate corner, the natural, informal interactions that foster collaboration—the quick question, the shared glance at an image, the impromptu consultation—become impossible [58]. This physical segregation reinforces functional segregation. Additionally, the scarcity of critical resources—from medical supplies and medications to electrical power and transport vehicles—creates a competitive rather than collaborative dynamic. When there is only one portable ultrasound machine, competition between the trauma team needing it for FAST exams and the family medicine team needing it for cardiac or obstetric assessments can lead to inter-specialty conflict and a breakdown in collegiality, as each group fights for the resources it deems most critical for its own patients.

Finally, a significant yet often overlooked barrier is the psychological and cognitive overload experienced by all responders. The acute stress, fatigue, and trauma exposure inherent in disaster response impair cognitive functions essential for effective coordination, such as working memory, situational awareness, and decision-making capacity [59]. A professional suffering from task saturation and sensory overload is less likely to engage in proactive communication, seek out interdisciplinary counsel, or process complex information from another specialty. They retreat into a reactive, task-focused mode, concentrating

only on the immediate problem in front of them. This state, while an understandable coping mechanism, directly undermines the capacity for the higher-order, integrative thinking that coordination requires. The very conditions of a disaster thus create a psychological environment that is hostile to the collaboration it so desperately needs.

The consequences of these systemic barriers are not abstract; they manifest in tangible, often tragic, failures in patient care. These include critical delays in diagnosis and treatment when information fails to flow between teams, medication errors due to miscommunication or lost records, and duplicated efforts where multiple specialties unknowingly perform the same assessment [60]. Most damningly, patients "fall through the cracks" of the system—their conditions deteriorating unnoticed because no single individual or team has a complete and continuous picture of their care. The trauma patient who succumbs to sepsis because their nutritional status was never addressed, or the diabetic individual who slips into a coma because their chronic disease management was not handed off from the emergency team to the primary care clinic, are victims of coordination failure as much as they are victims of the disaster itself.

Overcoming these deeply entrenched barriers requires a deliberate and multi-faceted strategy. The cornerstone of this strategy is mandatory, large-scale, interdisciplinary simulation training. All disaster medical personnel—from surgeons and nurses to radiographers and family physicians—must train together in realistic, high-fidelity scenarios that force them to practice communication, resolve resource conflicts, and develop shared mental models [61]. These exercises cannot be specialty-specific; they must be designed to break down silos and build mutual trust and respect. Secondly, disaster response frameworks must be explicitly designed for integration. This includes co-locating services wherever possible, implementing a unified incident command system with clear representatives from each core discipline, and employing standardized communication tools like SBAR (Situation, Background, Assessment, Recommendation) that are practiced by all [62].

Furthermore, technology can be a powerful enabler if deployed wisely. Simple, low-tech solutions like color-coded patient tags that include nutritional risk or chronic disease status can facilitate information sharing. When possible, robust, low-power digital systems for patient tracking and documentation can create a single source of truth accessible to all teams [63].

7. Models for Pre-Event Training and Integrated Protocols

Recognizing the profound systemic barriers to interdisciplinary coordination is only a preliminary step; the true challenge lies in constructing a proactive and robust framework to overcome them. This necessitates a shift from ad-hoc reaction to deliberate design, building synergy through standardized models for pre-event training and integrated clinical protocols. Such a framework transforms the theoretical ideal of collaboration into a practical, executable reality. It moves beyond simply assembling a group of experts and instead forges them into an expert team, capable of anticipating each other's actions, communicating under duress, and functioning as a unified clinical entity. The cornerstone of this framework is the understanding that the complex coordination required in a mass-casualty incident (MCI) cannot be invented in the moment of crisis; it must be engineered, practiced, and refined during peacetime, so it becomes the default response under pressure [64].

The most critical component of this synergistic framework is mandatory, high-fidelity, interdisciplinary simulation training. While individual specialty training is valuable, it is insufficient for breaking down the silos that impede collaboration. Training must be conducted with full, mixed-profession teams that include surgeons, nurses, family physicians, radiographers, and nutritionists, confronting them with realistic, complex scenarios that mirror the chaos and resource constraints of a real disaster. These simulations should be designed not to test individual clinical skills, but to stress the systems of communication, resource allocation, and shared decision-making [65]. For example, a simulation might involve a sudden influx of casualties that forces teams to practice dynamic re-triage, or a resource failure (e.g., a portable X-ray machine breaking down) that requires collaborative problem-solving. The debriefing sessions following these simulations are as important as the exercises themselves, providing a structured forum for participants to analyze communication breakdowns, role confusion, and conflicts, thereby building a shared mental model and fostering mutual respect.

A specific and powerful model for standardizing communication within this training framework is the widespread adoption of TeamSTEPPS (Team Strategies and Tools to Enhance Performance and Patient Safety). Originally developed for clinical settings, its principles are perfectly suited to the disaster environment. TeamSTEPPS provides a suite of concrete tools: SBAR (Situation,

Background, Assessment, Recommendation) for structuring handoffs and reports, Call-Outs for communicating critical information to the entire team simultaneously, and Check-Backs for verifying orders and ensuring closed-loop communication [66]. When all disciplines—from the senior surgeon to the newly deployed nurse—are trained in and practice this common language, it flattens the authority gradient and ensures clarity. A radiographer using SBAR to report a "FAST positive" finding to a trauma team leader delivers information in a predictable, concise format that minimizes misinterpretation, a vital improvement over unstructured and often frantic verbal exchanges in a genuine MCI.

Beyond communication skills, the synergistic framework requires the development and implementation of integrated clinical protocols. These are pre-written, agreed-upon guidelines that dictate how different specialties will interact around specific clinical pathways. Rather than leaving coordination to chance, these protocols provide a pre-determined script for collaboration. For instance, an "Integrated Trauma Pathway" could clearly outline the sequence of involvement for each discipline: from nursing triage, to radiology for e-FAST and X-rays, to surgery for decision-making, and finally to the nursing and nutrition team for post-operative care plans, with explicit handoff points and required information transfers at each stage [67]. Similarly, a "Chronic Disease Management Protocol" could establish how family physicians will assume care of patients with diabetes or hypertension from the emergency triage team, including a standardized handoff form that captures essential medication and history details. These protocols reduce cognitive load during a crisis by providing a pre-established plan, preventing duplication of efforts and ensuring that critical aspects of care, such as nutritional screening, are not overlooked. The physical and operational architecture of the disaster response must also be designed to foster synergy, guided by the principle of co-location and unified command. The treatment areas should be physically arranged to facilitate interaction, for example, by placing the radiology station immediately adjacent to the trauma resuscitation bays, and situating the family medicine and nutrition clinic in a central location easily accessible from triage [68]. Operationally, the Incident Command System (ICS) must be fully embraced and adapted to ensure all key disciplines have a voice. The organizational chart should include clearly defined roles for a Medical Branch Director, a Surgery Unit Leader, a Nursing Supervisor, and leads for Primary Care, Diagnostics, and Logistics, all operating from a

unified command post [69]. This structure ensures that decisions about resource allocation and operational priorities are made with input from all perspectives, preventing any single specialty from dominating the response and ensuring that the needs of all patient populations are considered.

Technology, when appropriately selected for the austere disaster environment, can serve as a powerful force multiplier for this integrated framework. While complex electronic health records may be impractical, simple and robust solutions can dramatically enhance coordination. These include color-coded triage tags with dedicated sections for nutritional risk and chronic diseases, allowing for visual cues that are instantly understood by all [70]. For more advanced teams, ruggedized tablet computers running low-power, offline-capable patient tracking software can create a shared operational picture. Such a system allows a nurse at triage to input a patient, a radiographer to update the record with imaging findings, and a surgeon to view the consolidated data in the operating tent, all in near real-time [71]. This breaks down information silos and ensures that every caregiver interacting with a patient has access to the same core dataset, a fundamental requirement for coordinated care.

Implementing this comprehensive framework is not without its challenges. It requires a significant investment of time, financial resources, and a commitment from institutional leaders and individual professionals to prioritize interdisciplinary preparedness. There can be resistance to changing entrenched practices and a reluctance to participate in time-consuming joint exercises. Furthermore, developing standardized protocols that are flexible enough to be applied across diverse disaster scenarios requires meticulous effort and widespread consensus [72]. To overcome these hurdles, a phased approach is recommended. It can begin with table-top exercises involving leadership from all disciplines to draft the initial integrated protocols. This can be followed by small-scale, single-discipline drills that focus on using the new communication tools like SBAR, eventually scaling up to full-scale, multi-agency simulations that test the entire system under realistic conditions.

The ultimate goal of this framework is to catalyze a cultural transformation within disaster medicine. It seeks to move the culture from one of individual heroism to collective proficiency, from siloed expertise to shared responsibility. This transformation is rooted in the cultivation of mutual trust, respect, and a profound understanding of the roles, responsibilities, and constraints of each collaborating discipline. When a surgeon

understands the challenges a radiographer faces in obtaining a clear image in a dusty tent, or when a nurse appreciates the complex metabolic calculations a nutritionist must perform, the foundation for empathy and effective teamwork is laid [72].

8. Conclusion

In conclusion, the complex and high-stakes nature of mass-casualty incidents renders a fragmented, specialty-centric medical response fundamentally inadequate. The evidence presented unequivocally demonstrates that the path to optimized survival rates and efficient resource management lies in the purposeful integration of General Surgery, Family Medicine, Nutrition, Nursing, and Radiography. Each discipline provides an irreplaceable strand in the continuum of care: surgery addresses immediate threats to life, radiology provides the critical diagnostics to guide it, family medicine manages the surge of complex medical needs, nursing forms the integrative backbone that binds the system together, and nutrition serves as the therapeutic pillar preventing secondary mortality. However, this synergy is not self-executing; it is thwarted by deeply ingrained systemic barriers ranging from communication breakdowns to a lack of shared mental models. Therefore, the responsibility lies with disaster planners and healthcare institutions to proactively engineer coordination through a structured framework of mandatory interdisciplinary training, the implementation of integrated clinical protocols, and the cultivation of a collaborative culture. By moving beyond the assembly of individual experts to forge truly expert teams, the disaster response community can ensure that its collective action is far greater than the sum of its parts, ultimately fulfilling the core mandate of disaster medicine: to do the greatest good for the greatest number.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
- **Acknowledgement:** The authors declare that they have nobody or no-company to acknowledge.
- **Author contributions:** The authors declare that they have equal right on this paper.

- **Funding information:** The authors declare that there is no funding to be acknowledged.
- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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