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Research Article

Radiology Department Disaster Preparedness: Practice, Strategies and Emergency Response

Gupta Lalit Kumar[1, *], Panda Mamta[1], Kour Varshdeep[1], Jha Ranjit Kumar[2], Singh Dalbir[3]

[1]Department of Medical Radiology and Imaging Technology, Rayat Bahra University, Punjab, India
[2]Department of Medical Radio-Diagnosis and Imaging, B. P. Koirala Institute of Health Sciences, Dharan, Nepal
[3]Department of Forensic Science, Rayat Bahra University, Punjab, India

Abstract

In order to respond effectively to any radiological emergencies, the implementation of disaster management practices is an essential and invaluable aspect. It can be difficult to know in advance exactly what you will be facing when you go to help people in a disaster situation brought about by hurricanes, earthquakes and other events, but the more compact medical technology you can bring in with you, the more you can accurately diagnose and assist those in need. Our disaster plans need to be programmatic, flexible, and should be continuously reviewed and updated. Within a few minutes of a disaster operationalize hospital support for the initial treatment of several injured patients and for ongoing care up to many hours is required. The Radiology Department is at the forefront of patient care in emergency situations, such as mass casualty incidents and natural disasters, providing critical diagnostic services to prioritize and triage patient needs. Radiological imaging is critical for improving patient outcomes and lowering morbidity and mortality, from detecting potentially fatal injuries to guiding surgical procedures. Radiologic technologists, radiologists, nurses, and other paramedic staff must actively participate in patient care. This paper provides an overview of the comprehensive strategy needed to maximize the radiology department's preparedness and response for disasters.

Keywords

Role of Radiology in Disaster, Radiology Management Plan, Natural Disaster, Man Made Disaster, Emergency Radiology, Mass Casualty Events

1. Introduction

A disaster is an unanticipated low probability and high impact event that causes widespread devastation, disrupts routine life and causes large number of people to become ill or injured. A disaster can be natural or man-made (or technological) hazard resulting in significant physical damage or destruction, loss of life & property and destroy the economy. Radiological priorities in the immediate phase of trauma are plain radiography which includes chest, skull, spine, abdomen and pelvis, upper and lower extremities x-rays usually take precedence. The need for active participation for patient

*Corresponding author: lkgupta27@yahoo.com (Lalit Kumar Gupta)

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care by Radiologic Technologist, Radiologists, Nursing and other paramedic staff is essential [1, 2].

Table 1. *Types of Natural Disaster.*

Natural Disaster	Description	Causes	Effects	Precautions
Landslide	The movement of a mass of soil, rock, or debris down a slope is called a landslide.	Severe rainstorms, tremors from earthquakes, eruptive volcanoes, and human endeavours like building and deforestation.	Destruction of property, fatalities, accidents, and pollution of the environment.	Avoid out of constructing in landslide-prone locations, invest in place suitable to drainage systems, and keep vegetation to support the soil.
Floods	When a portion of land gets submerged in water, it is known as flooding. This typically happens due to excessive rainfall, storm surges, or overflowing rivers and lakes.	Heavy rainfall, snowmelt, storm surges, broken dams, and erosion along the coast.	Property damage, fatalities, population displacement, infrastructural and agricultural destruction, and contaminated water supplies.	To prevent development in flood-prone locations, provide early warning systems, build flood defense like dams and flood barriers, and apply land-use planning.
Volcano Eruption	The eruptive process of a volcano involves the emission of gasses, ash, and magma.	Tectonic plate movement, magma chamber pressure rise, and volatile gas presence	Volcanic gasses, ash fall, explosive flows, lahars (mudflows), and lava flows.	Create exclusion zones around active volcanoes, use gas sensors and seismographs to track volcanic activity, and instruct locals on how to evacuate.
Earthquake	An earthquake is a rapid release of energy from the Earth's crust that causes the surface to vibrate.	Volcanic activity, faulting, and plate tectonic movement.	Seismic activity, earth rupturing, landslides, tsunamis (if submerged), and aftereffects including destabilization and flames.	Build earthquake-resistant structures, strap down bulky items, and draft evacuation and reaction plans in case of an emergency.

Table 2. *Types of Man Made Disaster.*

Man-Made Disaster	Description	Causes	Effects	Precautions
Transport Accident	Transport accidents include collisions, derailing, and other mishaps involving automobiles, buses, trains, ships, or aircraft.	Errors made by people, malfunctions of machinery, bad weather, and insufficient infrastructure or safety rules.	Environmental pollution, interruption of transportation networks, property damage, injuries, and deaths	Adopt strict safety guidelines and standards, carry out routine maintenance, educate pilots and drivers, and make infrastructural improvements.
Terrorist Attack	A terrorist attack is a planned, violent act committed by an individual or organization with the intention of causing injury, spreading fear, or advancing a political or ideological cause.	Radical ideologies, political or religious reasons, and grievances against certain people or countries.	Death, severe injuries, psychological distress, destruction of infrastructure and property, and disturbance of the social and economic order.	Boost emergency response capabilities, strengthen security protocols, expand monitoring and information collecting, and foster community unity and resilience.
Aeroplane Crash	When an aircraft does not fly in a safe manner and crashes, it can cause property damage and mortality.	Mechanical issues, pilot error, unfavourable weather, mistakes in air traffic control, and acts of terrorism or espionage.	Death, severe injuries, damage to the aircraft and nearby structures, and contamination of the environment.	Respect strict aviation safety laws, carry out routine maintenance inspections, offer thorough pilot training, and improve communication and air traffic control systems.
Bomb Blast	An explosive device detonat-	Terrorist attacks, crimi-	Fatalities, injuries,	Intensify security protocols,

Man-Made Disaster	Description	Causes	Effects	Precautions
	ing, resulting in damage, casualties, and fatal accidents, is called a bomb explosion.	nal activity, acts of war or rebellion, and political violence.	infrastructure and structural damage, psychological suffering, and social and economic disruption.	improve information monitoring, carry thorough screenings and inspections, and educate the public about bomb threats and emergency response protocols.

2. Hospital Disaster Planning

Disaster preparedness for hospitals is crucial in the field of healthcare. The essential components of preparing medical facilities for crises, such as pandemics and natural catastrophes, are covered in detail in this chapter. Risk assessments, emergency response procedures, communication tactics, resource management, and the significance of education and training are all covered. It makes clear how important it is for hospitals to not only predict possible risks but also to put in place effective systems that guarantee the continuous delivery of critical medical treatment in times of emergency [3].

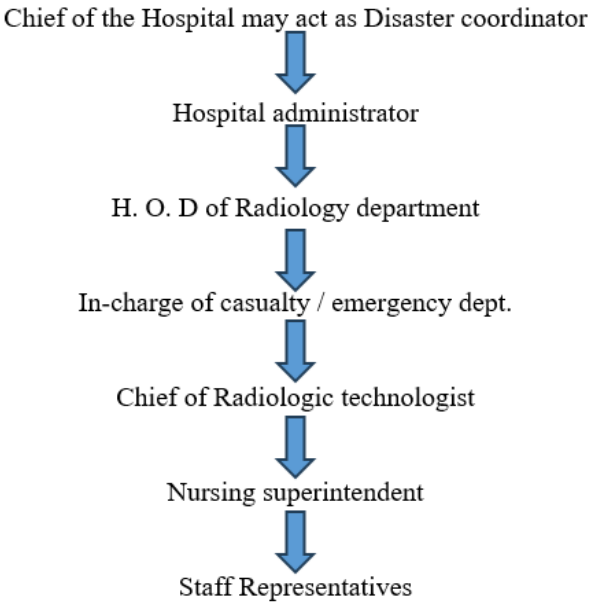

Figure 1. *Schematic diagram of the sequence of disaster committee.*

3. Role of Radiology Department in Disaster Response

Although radiology offers vital diagnostic imaging services for evaluating and treating diseases and injuries, it is essential to disaster response efforts. Radiological imaging helps healthcare practitioners to quickly assess the seriousness of injuries, identify internal injuries, and prioritize care, among other things. It also helps with patient diagnosing and treatment decisions. Furthermore, radiography aids in the efficient and effective management of disasters and eventually improves patient outcomes by recognizing equipment needs and directing patient flow. Thus Diagnostic radiology plays an important role in the evaluation of disaster casualties those are referred to department. Goal to achieve the best services needs to establish policies, procedures, and drills to improve radiology department's preparedness for treating large number of patients injured from disaster [4].

4. Disaster Committee

During catastrophes, the Chief of the Hospital takes ultimate responsibility for organizing disaster response operations as the principal Disaster Coordinator. In order to guarantee a successful and well-coordinated reaction, they supervise the execution of the hospital's emergency management plan, communicate with other organizations and interested parties, and assign resources as needed. The hospital's chief offers strategic leadership and guidance to lessen the effects of catastrophes and protect the health of patients, employees, and the community [5].

The hospital administrator is essential to maintaining the hospital's operational preparedness and care continuity in the event of a calamity. They work along with department leaders to assign resources, carry out emergency response plans, and stay in touch with outside organizations. In addition to managing staff deployment, the Hospital Administrator is in charge of patient evacuation and relocation, handles logistical issues, and makes sure the hospital can efficiently respond to the crisis while putting the safety and well-being of its patients first [6].

The Head of the Radiology Department (HOD) organizes imaging services to assist with patient care and administration, playing a crucial part in disaster response. They work with other departments to prioritize imaging investigations, deploy imaging resources to address urgent patient requirements, and guarantee the availability and performance of radiological equipment. In addition, the HOD is in charge of radiology personnel safety and puts procedures in place to reduce the possibility of radiation exposure in emergency situations [7].

The in-charge of Casualty plays a crucial role in disaster response. They arrange for patient evaluation, guarantee

prompt evaluation and care of wounded individuals, and distribute resources to satisfy patient requirements. In order to maximize the hospital's ability to respond to the crisis, the in-charge of Casualty also coordinates with other hospital departments and outside organizations to ensure a seamless flow of patients and resources [8].

During a catastrophe, radiologic Technologists are deployed and used under the direction of the Chief of Radiologic Technologists. In order to prioritize imaging tests depending on the patient's condition and operational capability, they collaborate with radiology professionals. In order to assist the hospital's entire response efforts, they also enforce radiation protection procedures, maintain the safety and wellbeing of radiologic technicians, and promote contact with other departments. In difficult situations, the Chief of Radiologic Technologists is essential to the continued provision of imaging services [9].

The Nursing Superintendent is in charge of nursing operations in times of crisis, making sure that patients are cared effectively. In order to meet patient requirements, they set up staffing assignments, distribute resources, and carry out nursing protocols. They also communicate with outside organizations and other healthcare departments to support coordinated response activities. In difficult situations, the Nursing Superintendent is essential to preserving high standards of nursing care and ensuring patient safety [10].

During a crisis, the staff representative acts as a point of contact for front-line medical professionals and hospital administration. They advocate for resources and assistance when needed by communicating staff needs, concerns, and feedback to hospital leadership. They also spread knowledge, offer direction, and encourage fellowship among employees, which nurtures a cooperative and strong reaction to the problem. The staff representative is essential to maintaining the health and well-being of employees as well as efficient communication in times of crisis [11].

5. Radiology Management Plan

To maintain essential services and maximize resource use, radiology management during emergencies need a planned strategy. The essential elements of a radiology management plan are covered in this chapter, including staffing plans, equipment servicing, screening procedures, and communication protocols. It highlights how crucial it is to keep imaging capabilities up to date in order to enhance patient care while adjusting to operational difficulties and resource limitations. Radiology departments can play a critical role in disaster response by prioritizing patient needs, cooperating with other departments, and utilizing technology for remote consultations and image sharing. This allows radiologists to make timely diagnoses and treatment decisions even in the most difficult situations [12].

5.1. Mock Drills

Conducting mock drills for radiology department is essential for disaster preparedness for several reasons:

Practice and Familiarization: Staff members can rehearse their duties and responsibilities in a simulated emergency scenario by participating in mock drills. When a true tragedy hits, staff personnel will be more prepared and able to react appropriately thanks to their knowledge with the situation [13].

Finding flaws: Mock exercises highlight any loops or vulnerabilities in the radiology department's disaster preparedness strategy, such as poor communication, broken equipment, or mishandled procedures. By recognizing these shortcomings, specific enhancements and modifications may be made to increase overall preparedness [14].

Coordination and Collaboration: Mock exercises help radiology personnel coordinate and work together with other departments and other parties that are involved in disaster relief. In times of emergency, effective collaboration and communication are essential, and simulated drills offer a chance to rehearse coordinating efforts [15].

Assessment and Input: Through the use of mock drills, managers may assess how well the radiology department's disaster response strategy and protocols are working. In order to enhance future reactions, the strategy, training initiatives, and resource allocation techniques can be revised in light of observations and comments received during drills [16].

Building Confidence: Taking part in practice exercises gives radiology staff members the self-assurance they need to respond appropriately and promptly in actual circumstances. In times of stress and worry, having faith in one's skills and the department's preparedness can help reduce tension and anxiety [17].

All things considered, simulated drills are a vital resource for improving the emergency preparedness level in radiology department, correct mistakes of various role players, avoid misunderstanding in roles and responsibilities, for better coordination among the teams, make it accustom so as to react instantly/correctly, check the proper functioning of instruments used by disaster response teams, call radiologists to provide immediate readings of plain films and special studies because “Time is Treatment”

5.2. Required Resources

Enough radiology personnel (radiologists, technologists, and supporting staff), equipment, and supplies should be available.

5.3. Action and Steps

The Radiology department has to adopt comprehensive plans and take proactive measures to effectively regulate and

minimize the impact of catastrophes. The department can take the following measures and steps:

Create a Disaster Preparedness Plan: Create a thorough plan that outlines personnel roles, duties, and procedures in case of an emergency. Numerous situations, such as mass casualty occurrences, technology dangers, and natural calamities, should be covered by this strategy [18].

Perform risk assessments to find possible threats and weak points unique to the radiology division, such as building damage, equipment malfunctions, and power outages. Determine how these risks could affect patient care and create mitigation plans appropriately [19].

Establish Communication procedures: To guarantee rapid and effective communication during emergencies, put communication systems and procedures into place. Establishing channels of communication with other departments, hospital management, emergency personnel, and outside organizations is part of this [20].

Staff Education and Training: Regularly educate and train radiology staff members on disaster preparedness and reaction procedures. To replicate emergency situations and assess staff performance, conduct simulated drills and exercises [21].

Implement strategies to safeguard radiological equipment and necessary resources, including radiation shielding, protective clothing, and backup power sources. Make sure you have enough supplies and medicine on hand to assist patient care in an emergency [22].

Coordinate with External Partners: Form alliances and collaborate with other organizations, nearby hospitals, community groups, and emergency management departments in your area. To improve overall preparedness and coordination, work together on disaster planning, resource sharing, and response initiatives [23].

Ensure Continuity of Operations: Create strategies and protocols to keep vital radiology services available in case of emergency. To provide continuity of care, this involves choosing substitute facilities, deploying mobile imaging machines, and putting telecommuting systems into place [24].

Disaster Management Plan in Radiology department needs to take proper action to control the disaster situation and give the better patient care. Conduct mock drill to ensure timely availability of monitoring equipment (radiation dosimeters for measuring). Create radioactive contamination screening protocol in radioactivity disaster e.g. Nuclear Disasters, safety measuring radiation dose etc. The plan should also optimize and streamline radiological study protocols for use during a mass casualty event. The Radiology department may improve its readiness and resilience in the event of a disaster by implementing these preventative measures, protecting the community, employees, and patients.

6. Protocols for Mass Casualty Event

The Radiology department must follow certain procedures in the case of a Mass Casualty case (MCE) in order to effectively manage the patient inflow and prioritize care. Usually, these protocols consist of:

Triage and Prioritization: Putting triage procedures into place to quickly evaluate and rank patients according to the seriousness of their ailments or injuries. Patients with potentially fatal injuries who need urgent imaging investigations are given priority for prompt assessment [25].

Resource Allocation: Allocating radiological resources (equipment, personnel, and supplies) in an efficient manner to increase throughput and reduce delays is known as resource allocation. Prioritizing MCE patients may require temporarily reallocating resources from non-urgent sectors [26].

Rapid Imaging Protocols: Putting them into practice will speed up diagnostic assessments and simplify patient treatment. This might be reduced imaging routines designed to detect serious injuries or illnesses that need to be treated right away [27].

Communication and Coordination: Maintaining lines of communication open with the hospital's administration, other departments, and outside organizations that are participating in the MCE response. Arranging for the smooth integration of patient flow, resource requirements, and evacuation schedules with the general disaster response operations [28].

Staff exercises and Training: To get radiology personnel ready for MCE scenarios, frequent staff exercises and training are conducted. To maximize response effectiveness and efficiency, this involves executing diagnostic guidelines, quick imaging methods, and communication tactics into practice [29].

Individuality of the patient should be maintained. Each patient should have its unique identification that can be done by providing him/her some specific ID No. Patient should be admitted/ transferred according to their condition to respective wards. Patient prioritization according to the nature of injury for radiological examination should be done properly. By complying to such guidelines, the Radiology division may contribute significantly to the coordinated response to MCEs by enabling prompt and precise diagnostic assessments that enhance patient care and eventually lead to better results [30].

7. Colour Coding of Requisition Forms and Alert and Recall System

In radiology, color-coding requisition forms is a methodical way to organize and prioritize imaging requests according to patient situations' urgency. Healthcare personnel may rapidly identify and prioritize situations that require immediate attention by color-coding requisition forms, therefore guaranteeing prompt diagnosis and treatment.

Colours like red, yellow, green, blue, and black give radiology personnel a visual clue as to how important each imaging request is. For example:

Red forms usually denote high priority situations, including trauma patients or those with problems that require immediate

imaging in order to make treatment decisions quickly [31].

Forms with a yellow colour may indicate medium priority instances, which need quick attention but don't pose a direct threat to life [32].

In ambulatory or mild situations, when scheduling of imaging may be based on availability without compromising patient care, green forms are frequently utilized [33].

Blue forms are reserved for patients who have passed away, making it easier to handle and record imaging data correctly in post-mortem circumstances [34].

Patients who have died away are indicated by black forms, which helps to ensure that appropriate processes are followed for departed people and that imaging resources are not used unnecessarily [35].

Radiology departments may efficiently prioritize imaging investigations, streamline workflow, and distribute resources according to patient requirements by putting in place a color-coded system. This method improves patient care, encourages efficiency, and makes sure that urgent situations get the attention they need quickly, all of which contribute to better results for patients undergoing diagnostic imaging treatments.

One of the most important aspects of planning and reaction for a disaster in the radiology department is the Alert and Recall System. In the case of an emergency, this system is made to quickly mobilize radiology personnel and resources, guaranteeing a prompt and well-coordinated response to patient demands.

Radiology staff are informed when an alarm is triggered by approved means of communication, such smartphone applications or pager systems. Employees are told to report to certain assembly locations or staging sites, where they will be given more instructions and given tasks depending on the kind and intensity of the incident [36].

Additional radiology staff members who might be off duty or working in other parts of the hospital might be called in using the Recall System. By doing this, the department is guaranteed enough personnel to handle an increase in demand for imaging services in the event of a crisis [37].

The radiology department can better deploy people, as a designated person who first receives the disaster alert is responsible to recall the staffs mobilize resources rapidly, and deliver critical diagnostic services as systems like Coded light system, Personal paging, Telephones/mobile, Wireless system as well as Siren system etc.

During emergencies by putting in place an efficient Alert and Recall System [38].

8. Essential Resources, Necessities, and Diagnostic Equipment in a Radiology Department during a Disaster Situation

There are implications for design, planning and organization of X-ray departments to be considered in disaster prone-areas. It should be as near as possible to triage areas, on the same floor, with broad, unobstructed passages like one-way flow throughout the department.

There should be provision for easy passage of equipment and trolleys through doors and corridors and large circulation areas, working rooms and waiting spaces with plugs for electricity. Availability of oxygen and suction devices, hanging infusion sets, proper water storage, not only for drinking purposes but also for service-toilets, air conditions and auto processors, power back up in the form of generators and UPS etc. should be checked [39].

Interpretation and reporting should be done quickly. Radiology services are a critical component of the hospital response to a disaster. Many patients requiring radiology over a relatively short time period may lead to bottlenecks. At least one x-ray technologist will be on-site, and additional technologists will need to be mobilized. Most hospitals will be able to provide plain radiographic imaging but will not be fully equipped to address all radiological needs that will arise in an event of this magnitude (ability to do special imaging or ultrasound may be limited). Radiology staff should be familiar with the hospital disaster plan, their individual roles and responsibilities, and the roles and responsibilities of all essential departments [40].

The radiology department's diagnostic tools are essential for evaluating and treating patient injuries and diseases in an emergency. The maintenance of operational capability is crucial for the timely and correct provision of diagnostic imaging services, even in the presence of imminent issues such power outages, equipment damage, or resource limits. Here are some things to think about while managing diagnostic equipment during a disaster:

Portable Imaging Systems: Because they can be swiftly deployed to the point of treatment, portable ultrasound devices, computed tomography (CT) scanners, and X-ray equipment are crucial in disaster response. Critically injured patients may now be imaged at the patient's bedside thanks to these portable equipment, which minimizes the need for patient transfer and speeds up diagnosis and treatment [41].

Mobile Imaging Units: To offer full diagnostic imaging services, mobile imaging units with X-ray, CT, or magnetic resonance imaging (MRI) abilities can be sent to disaster areas or temporary medical facilities. These units may function independently for the hospital infrastructure and are outfitted with generator power, ensuring continuity of treatment in distant or resource-constrained environments [42].

Point-of-Care Ultrasound (POCUS): POCUS equipment is small, light, and flexible, which makes it perfect for quick evaluation of trauma patients and other urgent conditions in emergency situations. POCUS can improve diagnostic skills in harsh conditions by helping with the assessment of internal injuries, the identification of formation of fluid, and the direction of invasive operations [43].

Radiation Protection Measures: To protect patients, em-

ployees, and rescuers in crisis scenarios involving radiological risks, such as nuclear accidents or bomb attacks, radiation protection measures are crucial. Minimizing radiation exposure hazards during diagnostic imaging operations requires obedience to ALARA's principles, lead shielding, and dosimetry monitoring.

The radiology department can continue to offer crucial diagnostic services and support patient care in emergency situations by utilizing portable, mobile, and point-of-care imaging technologies and putting in place the necessary radiation protection measures. In the end, this will improve the outcomes for those who are affected [44].

9. Facility Preparation and Precautions for Radiologically Contaminated Patients before Radiological Examinations

Activate hospital plan: Obtain radiation survey meters, call for additional support: staff from Nuclear Medicine, Radiation Oncology, Radiation Safety Officer (Health Physics), establish triage area, establish area for decontamination of uninjured persons.

Plan to control contamination: Instruct staff to use standard precautions, establish multiple receptacles for contaminated waste, protect floor with covering, designate separate entrance, designate one side of corridor, or transfer to clean gurney before entering [45].

Precautionary procedures must be put in place by the radiology department in case of a radioactive contamination disaster in order to protect patients and personnel during radiological exams. Prior to performing radiological exams on individuals who could be contaminated, the following safety measures need to be followed:

Screening and evaluation: To detect any possible contamination issues, patients undergoing radiological tests should go through a comprehensive screening and evaluation process. This could involve asking patients if they have recently been exposed to radioactive materials, evaluating any visible contamination, and looking over any radiation exposure history that is available [46].

Decontamination Protocols: Before beginning radiological exams on a patient who is suspected or proven to be contaminated with radioactive materials, suitable decontamination protocols should be put in place. To reduce the spread of infection, this might involve throwing away contaminated clothes, cleaning exposed skin areas with soap and water, and offering protective covers [47].

Radiation Monitoring: To determine the patient's and the surrounding environment's radiation exposure levels, radiology staff members should employ radiation monitoring equipment. This makes it possible to guarantee that radiation exposure levels remain within acceptable bounds and that the necessary safety measures are implemented to reduce the danger of radiation during imaging operations [48].

Radiology personnel should use the proper personal protective equipment (PPE), such as gowns, gloves, and protective eyewear, when doing radiological exams on patients who may be contaminated. This reduces the possibility of personnel being exposed to radiation and helps prevent direct contact with radioactive materials [49].

Environmental Controls: To reduce the spread of contamination within the radiology department, extra care should be taken. This might involve setting up closed access areas, designating specific routes for contaminated patients, and putting in place cleaning protocols for tools and surfaces used in imaging tests.

The radiology department can safely perform radiological tests on possibly contaminated patients by identifying contamination isotope after a catastrophe by following certain preventative steps as example Perform bioassay measurements as necessary for patients thought to have been exposed to radioactive contaminations, which also reduce the danger of radiation exposure for staff members and patients [50].

10. Conclusion

To sum up, the radiology department is essential to hospital environments and is crucial to the early treatment and handling of victims in emergency situations and natural catastrophes. The department's innovative imaging technology and experience provide quick and precise diagnosis, allowing for prompt intervention and treatment options for those impacted.

The Radiology Department is at the forefront of patient care in emergency scenarios, including mass casualty crises and natural disasters, offering vital diagnostic services to prioritize and triage patient requirements. Radiological imaging is essential for improving patient outcomes and reducing morbidity and death, from spotting potentially fatal injuries to directing surgical procedures.

In addition, the partnership between the Radiology Department and other medical specialties including trauma surgery, emergency medicine, and critical care promotes a multidisciplinary approach to patient treatment, guaranteeing smooth coordination and communication under pressure.

In the end, the Radiology Department's critical role in emergency response and disaster management is highlighted by its quick deployment of imaging resources, flexibility in responding to changing conditions, and capacity to preserve operational continuity. Even in the most difficult situations, radiology professionals demonstrate their dedication to providing excellent patient care by maintaining the highest standards of quality and safety.

Abbreviations

MCE: Mass Casualty Event
POCUS: Point-of-Care Ultrasound
ALARA: As Low As Reasonably Achievable
PPE: Personal Protective Equipment
UPS: Uninterruptible Power Supply
MRI: Magnetic Resonance Imaging
CT: Computed Tomography
EMS: Emergency Medical Services

Author Contributions

Gupta Lalit Kumar: Conceptualization, Resources, Formal Analysis, Validation, Investigation
Panda Mamta: Supervision, Visualization, Writing – original draft, Writing – review & editing
Kour Varshdeep: Formal Analysis, Visualization, Project administration
Jha Ranjit Kumar: Visualization
Singh Dalbir: Visualization

Conflicts of Interest

The authors declare no conflicts of interest.

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