

Response & Recovery Mechanism for Chemical Industrial Disaster Risk Reduction

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ABSTRACT

An expeditious and efficient response consists of many strides, which require the operating involvement of all collaborators and an immense alignment of strategic bonding between various responders and service providers. Competent preparedness will ensure rapid and efficient response, which will also be extended to rehabilitation and recovery phases. It will, in turn, mitigate both short- and long-term effects of chemical disaster activities. It requires an institutionalized framework to be developed at all levels by NDMA, SDMAs, and DDMA. The paper presents major steps of response, rehabilitation, and recovery mechanism that has been incorporated in the current administrative system for chemical industrial disaster risk reduction.

Keywords: Chemical Industrial Disaster; Response; Rehabilitation; Recovery

I. INTRODUCTION

Response

A timely and persuasive response will be based upon an emergency response procedure which will include activities and responsibilities of various partners, responders, and service providers including the individuals; aspects governing the establishment of Incident Command (IC) posts, relief centers, medical units, and specialized hospital care; and various coordination protocols. A persuasive medical response at the event site needs to be provided at the earliest. This includes main framing catastrophe at the event site, suitable care during haulage and expulsion, CBRN filter-fitted ambulance services with defined clearing routes, and their conversation linkages and coordination with other identified departments. Such a structure will decrease morbidity and mortality during any chemical industrial disastrous event. The various constituents of the chemical industrial disaster response plan are as given below.

A) Alert System and Reporting of a Chemical Industrial Disaster

The Emergency Response Procedure (ERP) will have a suitable mechanism for appropriate planning and strategy to work with different responders, crisis functionaries, and logisticians. A well-studied and standardized alert system will come up as a part of the ERP. Perpetually, the first data about a chemical industrial disaster is received from the community; still it is very essential to have an inbuilt alert system in the ERP that will activate the definitive specialized reaction to an event. The following measures will be used to initiate the plans & procedures for notification of an incident:

- i. Explosion with minimum or no structural destruction.
- ii. An instrument that disseminate mist or vapour.
- iii. Diversified casualties exhibiting same type of symptoms.
- iv. Mass casualties with no probable reason or trauma.

- v. Unusual odours, liquids, spray instruments and cylinders.
- vi. Huge number of dead animals and insects.

Based upon these measures, the primary responder will initiate the disaster risk reduction functionalities by sending the alert signals to the fire and emergency services, police, emergency medical services, district authorities, and the dangerous goods handling team. The important updates will be given to the district EOC by the event or incident commander. The EOC will pass on these details which includes safe routes for evacuation, availability of PPE, weather updates, wind direction, speed, and identified safe zones to the respective nodal officials and authorities and to all the other disaster risk reduction functionalities. The trained specialized responders will gather samples of the chemical matter as per the laid down SOPs. Simultaneously, the designated static laboratories will be asked to remain in mode of readiness to receive field samples so that confirmatory analyses can be carried out without any loss of time.

B) Situational Assessment and Initial Response to Chemical Terrorism Disaster (CTD)

It is vital to assess the conditions at the site of incidence before establishing an IC post and starting the actual response plan. In the aftermath of a chemical incident, initially the survey dangerous goods handlers will be deployed to assess the 'risk area' and give the situational identification to the control room. Dangerous goods handlers will use the field detectors appropriately at the incident (contaminated) site. The backup teams from various authorities will quickly analyse the real time situation data to give appropriate guidance to the decision makers in the control room. The system will examine all modes including field detection technologies, aerial surveys by drone, satellite imagery and direct ground level checking, depending upon the preliminary survey, etc. Other substantial components of situational assessment are:

- i. Level of response will be based upon various parameters provided by the dangerous goods handlers.
- ii. Facts & data will be collected at the event site in terms of types of targets, number of victims, meteorological conditions, and level of disaster.
- iii. On the basis of situational analysis, sites for establishing IC posts will be identified
- iv. Various teams like medical, search and rescue, communication, and law and order will be an integral part of the IC structure as per the laid down standard procedure
- v. Safety of the responders at any point during the rescue operations may not be compromised at any point of response.
- vi. The authorities providing medical facilities shall guide the movement of essential 'bricks' of medical logistics from various district storages, available experts, facilities for protection, detection and characterization, and emergency medical response mechanism.

The response will begin by quick mobilization of trained chemical disaster responders to provide on-site assistance to local officials like health workers, police, safety and security agencies, and first responders at the site. The rescue teams will enter the incident site, analyse the area, take over victims, and eventually mobilize them to ambulance personnel or medical professionals. Important features of the preliminary response are as follows:

- i. Cordoning off the event site.
- ii. Guarding the event site and allowing movement of only authorized persons with proper PPE.
- iii. Complete control of traffic to avoid any further entry of unexposed people and vehicles at the contaminated site.
- iv. Emergency services and fire in collaboration with the dangerous goods handlers' response vehicle and PIC shall contain the incident and

try to investigate the nature of the chemical and its source.

- v. Starting communication with the PIC, and chemical and forensic laboratory.
- vi. Information centre establishment and designating a public relation officer.
- vii. Identification and marking of safe routes for entry and exit.
- viii. Triage followed by 'resuscitation' or 'decontamination' depending upon the level of contamination and severity of the injury are important aspects of medical response team. Rescue & recovery workers, in coordination with QRMTs, will carry out the decontamination. This shall be followed by BLS, administration of antidote, and evacuation to the defined hospitals.

Having analysed all decisive situational assessment variables including a multitude of health effects, ranging from acute medical effects to the possibility of psycho-social problems such as 'survival guilt syndrome', the probability of multiple secondary disasters, or neuro-behavioral disorders always persists. Thus, the mechanism of multi-dimensional risk management will be adopted based on the dynamics of changing scenarios.

C) Notification of a Chemical Incident and Scale of Disaster

The situational assessment of the chemical industrial disaster situation must be followed by notification of the chemical incident and its severity scale. This would lead to the initiation & activation of all the emergency functionaries and the establishment of the IC post.

D) Crises Response at the Event Site

Crises response is multi-centric and requires coordination between a multitude of stakeholders and service providers. It can be broadly divided into a number of functional aspects that required urgency

in terms of prompt and effective response. These functional aspects are discussed briefly as follows:

i) Management of Crowd Panic Reaction

A chemical disaster may not necessarily cause significant impact on health; however, it will certainly create extreme fright in the community, thereby aggravating the overall situation. The detection and survey teams, equipped with chemical agent monitors, would detect the level of contamination and keep the people informed and reassured, using all accessible communication systems at the incident site. The first responders, including search and rescue (SAR) teams and MFRs, will also provide psycho-social support to the affected community. Community leaders, the press and the electronic media like internet applications television and radio will also play a significant role in reducing the psychological impact of the situation through appropriate communication.

ii) Self-Protection and Conducting Decontamination Procedures

- a. Physical & composite or collective protective measures will be employed at the event site.
- b. Essential control measures will be instituted to restrict the exposure of MFRs and other responders by application of protective gear and by restricting the exposure time based upon the breakthrough time of the PPE.
- c. Protective covers, i.e., the filtration type or a Self Contained Breathing Apparatus SCBA will be used, depending upon the severity scale and SOPs for use of different types of PPE.
- d. Universal personal protective clothing, plastic wraps to cover the contaminated site or material, disposable shoe covering, and paper flooring covers are necessary to prevent any casualty among the responders themselves.
- e. The decontamination procedure will be chosen, based upon the properties and nature of the

chemical agent, form (solid, liquid, or gas) and possible time of exposure.

- f. In case of an MPI, clinical procedures like gastric lavage and others used for prompt removal of toxins (poisons) will be adopted, depending upon whether the victim, is comatose, semi-comatose, or in a fully conscious state.
- g. Temporary decontamination facilities with an enough water storage facility will be created in the safe zone of the event site. However, the exact location will be governed by various meteorological and other conditions prevailing locally.
- h. Victims & Casualties will first be shifted outside the hot zone by the rescue service providers equipped with PPE, followed by decontamination at the event site. Liquid contaminants will be removed by dry decontamination procedures.
- i. Emergency vehicles used for the evacuation of casualties will get contaminated in the course of each trip and will need to be decontaminated to maintain their custom for a longer period.
- j. Other sullied clothing and material will be decontaminated prior to disposal. The deceased will also be decontaminated prior to burial in sealed bags. In addition, all personnel, emergency vehicles, and equipment including protective clothing, gloves, caps, and masks will be decontaminated as part of the clean-up process.
- k. It is essential to follow standardized decontamination procedures for CW agents . Exposure to industrial chemicals generally requires normal decontamination procedures while taking universal safety precautions simultaneously. These procedures will be rehearsed as a part of mock-drills simulating such an incidence.

iii) Response Actions of Different Emergency Functionaries

a. Police

- Maintain law and order, cordon off the affected site, regulate traffic, ensure security and vigilance for probable & possible secondary events, and facilitate movement of various teams.
- Ensure the entry of authorized functionaries with protective gear, personal detectors, and emergency kits with prophylactic antidotes, etc.
- Establish communication with other stakeholders.

b. Survey & Detection Teams

- Skilled technical personnel from mobile technical units will deploy field detectors and identify the nature of chemical agents and find the possible dynamics of the situation.
- The mobile team along with a technical team stationed at a safe distance from hot zone maintaining linkages with emergency operation centers for real-time monitoring of the situation.
- The back-up units will be trained and kept ready with fresh PPE to provide turnover to the deployed teams for maintaining the breakthrough time standard of PPE being used by deployed teams.

c. Fire and Emergency Services

- Establish safety & secure zones, victim (casualty) collection points, and support zones.
- Firefighting especially for chemical fires which includes the containment of the spread of chemicals within the hot zone and deployment of various neutralization technologies such as mist technology.
- Formation of a temporary decontamination facility and initiate decontamination procedures for all the exposed victims.
- Runoff water from decontamination procedures should be cross checked and channelized.

d. Chemical Rapid Response Teams

- District authorities will form CRRTs who will respond effectively to chemical disaster that need

necessary antidote administration within a stipulated time frame.

- These teams will comprise of specifically trained personnel who are able to counter the effects of all types of chemical incidents. They will be equipped with the latest equipment and be able to reach the event site at the earliest.

- NDRF and SDRFs will develop teams that are ready for deployment at vulnerable areas. They should be trained in all functions of emergency services and specialized response, and be able to take over any desired function as required in a crisis situation.

e. Water Supply Department

- Maintain safe water supply to relief centers for drinking, washing, and other purposes.

- Sufficient water supply will also be made available at the incident site for bulk decontamination procedures, firefighting, and clean up actions.

f. Electricity Department

- Maintain electricity supply in the identified locations, providing power backup to all other emergency responders.

- Cut off electricity in the vulnerable areas as per the directions of the incident commander, if required.

g. Relief and Logistics Department

- Provide safe essential items and other relief materials.

- The department will provide immediate relief as well as coordinate all long-term relief and rehabilitation measures.

h. Public Health Department

- Check the food and water supplies being made available by the district authority, ensuring its safety for consumption.

- Sanitation and hygiene facilities establishment to prevent spread of contamination.

- Community Level Workers (CLWs) will provide psycho-social support to the survivors and report to

the IC post. They shall also communicate with the parent department for necessary further support.

i. Transport Department

- District authorities in association with the transport department will ensure sufficient number of CBRN filter-fitted evacuation vehicles or ambulances as part of the integrated ambulance network.

- Ensure the institution of a intact system for requisitioning all available emergency vehicles, and for their smooth movement and recycling so as to attain optimal utilization.

- Establish decontamination facilities for vehicles deployed for the evacuation of victims.

j. Communication Authorities

- Maintain an effective and strong communication backup system for the smooth & steady flow of information including internet facilities, ham radio, local mobile facilities, landline connections, and satellite based communication to ensure redundancy.

- Develop the necessary database to provide information about the location of rescue service providers using GPS monitoring.

- Provide adequate communication facilities to all the responders and service providers.

iv) Emergency Medical Response

a. The MFRs of mobile medical units and hospitals will be activated immediately by triggering the inbuilt alarm. These units will be responsible for prompt emergency medical response at the event site and during evacuation. Hospital staff, however, will be responsible for the same at the hospital.

b. QRMTs/MFRs will be equipped with proper PPE, detection/decontamination and other requisite medical management equipment, essential drugs, and antidotes.

c. They will carry out triage, BLS and first aid (including emergency psychosocial first aid), and perform essential resuscitative procedures prior to prompt evacuation.

d. The support zone, victim & casualty collection center, and ambulance parking area will be provided with collective protection and will be the working areas of QRMTs.

e. Depending upon the severity of symptoms that the patients exhibit, they will be sent to the earmarked health care facility. However prior to evacuation, casualties will be placed in casualty evacuation bags fitted with NBC filters/protective gear and suits.

E) Evacuation of Chemical Casualties

Casualties will be evacuated in specialized ambulances fitted with CBRN filters. Other concerns include:

- i. Medical and paramedical personals including ambulance drivers shall be provided with PPE.
- ii. Proper SOPs will be prepared for care of chemical disaster casualties, training paramedics, drivers of ambulances and rescue vehicles, etc.
- iii. Sufficient supply of filtered air/oxygen and life-support systems will be provided in the specialized ambulances.
- iv. Availability of adequate BLS measures, antidotes, and facilities for physical trauma management during evacuation will be ensured.

F) Treatment at the Hospitals

All hazard hospital DMPs shall list out specialized facilities for the management of chemical victims & casualties, which include fixed decontamination facilities, availability of burn beds, and a well-trained team of specialists. The hospital DMP should also cater to a contingency plan wherein the hospital itself is affected by the terrorist attack. Adequate PPE should be stocked in the hospitals. The specialized staff of these hospitals will be trained to use PPE and other international safety precautions laid down in the Hospital DMP. Special attention will be paid to the following:

- i. Laboratory facilities creation in the earmarked hospitals for detection and characterization of the chemical contamination in biological samples.

ii. Creation of facilities at the hospital for mass decontamination.

iii. Availability of adequate numbers of lifesaving equipment like ventilators and defibrillators, adequate stocking of oxygen, antidotes, and other life-saving drugs.

iv. Clinical care will be initiated based on the reassessment and reaffirmation of the clinical status of the casualties by specialized medical teams.

v. Critical care will be given to all victims those who are severely injured and require specialized facilities like burn centers, blood transfusion facilities, trauma centers, specialized laboratory networks and other ancillary services.

vi. An inter-hospital and inter-services communication network will be established at all levels to increase the regional capacity to handle mass casualties, both in terms of optimal bed utilization and for effective and coordinated treatment, including the resources of private hospitals.

vii. Psycho-social support and mental health care shall form part of the general medical treatment.

viii. Special care will be given for the immediate delayed effects both during and in the aftermath of chemical attacks.

ix. Long-term effects of chemical agents on the environment will be monitored and an appropriate medical officer nominated by the medical authority to be a part of such survey teams.

x. The consumption of contaminated food and water at all levels will be prevented by developing quality checks under the supervision of the medical officer.

xi. Adequate mortuary facilities will be created at the earmarked hospitals.

G) Management of Long-Term Health Effects of Chemical Disaster

Dissemination of information and imparting knowledge regarding the long-term effects of chemical agents or leakage of chemicals on the exposed population will help in managing the disaster and preventing panic and chaos. Depending upon the type of chemical event, follow-up treatment of the patient will be monitored and provision for necessary medical care made. Regular follow up of such victims is essential to monitor and manage them. Victims with chemical burns will be provided facilities for treatment of contracture and other complications. Follow-up for taking care of the after-effects on various body parts like eyes, respiratory, and nervous systems will also be monitored and attended to at specialized centers already defined in the DMP. Necessary steps will be taken to examine the contamination levels of air, water reservoirs, and ground water. Necessary measures will also be initiated for mitigating effects on livestock, flora, and fauna.

II. REHABILITATION AND RECOVERY

In case of a chemical disaster, rehabilitation and recovery phases require a proactive, multi-pronged and inter-sectoral approach with the active participation of the community at all levels. In the first week after the disaster, the pattern of health needs will change rapidly, from casualty management to more regular primary health care. The emergency services must be re-organised as many permanent facilities may have been severally damaged. Priority will also shift from health care to environmental health measures and temporary shelters. The important activities are as follows:

i. It is essential to develop efficient provision for relief to affected communities of CTD, both in terms of financial and other support to help, cope with and compensate for the loss of life and damage to property. Minimum standards will be developed with the due diligence of all

stakeholders and a uniform policy will be formulated at all levels.

- ii. The structure for reconstruction and restoration of basic infrastructure will be established by the states to bring life back to normalcy using appropriate community centric strategies.
- iii. Medical rehabilitation includes long-term medical care for vulnerable groups, psychosocial care, and vocational rehabilitation, for which an adequate financial strategy will be worked out in the pre-disaster phase itself.
- iv. The rehabilitation and recovery process should be based upon the specific indicators and standards for long-term follow-up of the survivors of the attack and their families. The experience available with various responders in terms of providing short- and long-term rehabilitation to different groups of society will be further fine-tuned based on past experience and lessons learnt from mock-exercises, based on different types of simulated scenarios.
- v. A mechanism will be developed to reestablish normal health services, and to assess, repair, and reconstruct damaged facilities.
- vi. Psycho-social support and mental health care will be given to all the victims.
- vii. Efficient provisions will be made for the continuous availability of basic amenities like safe food, water, and maintenance of appropriate hygiene and sanitation levels as per minimum standards.
- viii. Proper bio-waste disposal facilities will be ensured by authorities.
- ix. A record and registration system will be created at each medical unit to store relevant information on the chemical incident, agents, their effects, and details of the treatment and care provided to the victims, including their prognosis.
- x. The long-term fallout of the disasters is projected that one per cent of the victims will suffer from severe brain damage, paraplegia, amputations,

chronic sepsis, etc. An important mechanism will be developed to take care of such patients.

- xi. Surveillance of diseases should be continued until the normal reporting system is restored.
 - xii. Mass casualties resulting from such attacks leave behind a large number of orphaned children who need to be taken care of by governmental and non-governmental initiatives.
 - xiii. During such events, the resources budgeted for the years are depleted in a short span of time. To re-establish normal health services, extra resources will be required and must be planned for.
 - xiv. The rehabilitation period also allows creating an opportunity for making major changes in the normal health care methods, since people during this time are receptive to new ideas that are effective and economically viable.
 - xv. Setting an appropriate structure for the engineering sector is essential for assessment, repair, and reconstruction of damaged facilities and buildings. The assessments made will be developed as projected plans with estimated costs to obtain necessary funding.
 - xvi. All essential services like water supply, sewage, solid waste disposal, electricity, communication, etc., should be restored on a priority basis.
 - xvii. Plans must include strengthening environmental surveillance and health services to ensure that the risk of disease does not increase.
 - xviii. Water quality includes routine testing and chlorination, which should be carried out immediately after the disaster, till the municipal water system is restored.
 - xix. Areas where food is cooked and supplied from should be monitored to ensure hygienic conditions.
- II. The process is comprehensive and requires efforts at multiple levels, and of many stakeholders, to bring life back to normalcy.

Documentation is an important part of post-disaster management for analyzing the consequences of disasters, and identifying initiators and factors that affect mortality and morbidity with respect to time variables. In view of this, necessary SOPs for the complete documentation of the chemical incident will be laid down as a part of DDMPs. The complete details about post-disaster documentation will specifically include the following:

- i. The concept of post-disaster documentation and derivation of important lessons will be instituted. SOPs for reporting, development of case studies, and critical analysis will be devised.
- ii. Details about the incident will be recorded, including causes, effects, capacity, and capability of the management system, adequacy of response, and lessons learnt during mock-exercises.
- iii. In the documentation, certain issues pertaining to CTD particularly will include:
 - b. Quality of PPE provided to first responders.
 - c. Adequacy and efficiency of decontamination.
 - d. Timely availability of antidotes.
 - e. Evacuation of casualties.
- i. Medical documentation will begin with an identification number assigned to the chemical casualty, to be used as a reference for all medical management procedures. This documentation will help in the post-disaster analysis by the designated relief management teams of the state/district.
- ii. Activity-wise documentation and evaluation of data including mortality and morbidity indices, number/types of cases, age, sex, general occupation of the victims, clinical profiles of cohort groups with the same or similar medical problems, and specific medical cases observed during long-term management will help in evolving SOPs for future management.
- iii. The lessons learnt from studies of previous incidents indicate essential inputs that dictated the success or failure of DM plans for CTD in a real-time occurrence or attack. Important and

Post-Disaster Documentation

relevant extracts of all such documentation shall be shared with stakeholders for improving the management of such incidents in their respective areas.

- iv. Based on the lessons learnt, certain study models will be developed, which can be taken in a pilot project mode to improve the overall emergency management planning.

III. CONCLUSION

The overall strategy followed by National Disaster Management Authority, National Disaster Response Force, Ministry Of Home Affairs, and Government of India in providing Response, Rehabilitation and Recovery in mitigating effects of chemical disaster is quite recommendable. The approach followed and provided above leads a proper path and provides a threshold to various stakeholders like district administration and other line departments to efficiently initiate recovery processes. The effect of chemical disaster sometimes goes beyond the coping capacity of local responders wherein the requirement of key stakeholders and systematic methods are compulsory to follow. The roles and responsibilities of each line departments play a vital role in synchronized approach to mitigate the chemical disaster. Even the minute indicator cannot be ignored and certain other parameter like public health, food, evacuation, psycho- social effects, and post disaster need assessment, documentation, incident response system largely affects the overall process of response, rehabilitation and recovery of chemical disaster.

This paper has made a contribution to the debate on preparedness level of government machineries along with first responders. Public policies for attenuating chemical disasters impact must be more focused , more focus on rehabilitation after chemical disaster should be followed specially for those living in more vulnerable areas and in implementing disaster mitigating mechanisms for keeping elements

considered in the disaster risk reduction measures that are affected due to these shocks. Additional research could focus on the micro level implementation of these strategies to mitigate post chemical disaster.

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