ORIGINAL ARTICLE

Full-scale simulation exercise—A preparedness for trauma mass casualty incident: Nepal

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Abstract

Objective: *This simulation exercise was conducted to test the functionality of the hospital incident command system, triage, treatment areas, and external coordination and communication.*

Design: *This was an observational study. Coordination, logistic, technical design, staging, and evaluation of the exercise were planned for the exercise. The exercise was conducted in six hospitals. Observations were recorded, and a validated checklist was used to score.*

Setting: *This was a semisurprise exercise in the hospital setup.*

Participants: *Simulated patients and moulage were used for the exercise.*

Intervention: *Full-scale simulation exercise.*

Main outcome: *Gaps in knowledge and skills were identified in the running incident command center, skills of patient transferal from ambulance to triage area, and external coordination.*

Result: *Out of a total score of 220 in the evaluation sheet, the mean score was 161 ± 3.2 (73.2 percent) and the median score was 161.5.*

Conclusion: *Hospital incident command system, triaging, and patient transferal are the areas that can be improved in the future.*

Key words: full-scale simulation exercise, mass casualty incident, preparedness, trauma, Nepal

Introduction

Nepal has been facing various major and minor disasters, out of which flood accounts for 68.3 percent of total disaster followed by landslides and avalanches 9.8 percent, epidemics 9.4 percent, forest fire 4.6 percent, and weather-related 5.8 percent.[1] There were 23,391 events recorded between 1971 and 2012, 31,908 deaths, and 58,210 injuries.[1] Nepal lies in a Himalayan belt between the Tibetan and Indian tectonic plates. The fault line extends from northwest-southeast oblique to Himalayan front, and the movement of these plates gives rise to tectonic earthquakes.[2,3] The great earthquake that occurred in Nepal was in 1897, 1905, 1934, and 1950 AD.[2] The most recent being in 2015 in which areas of Nepal like Gorkha, Dhading, and Sindhupalchowk (Figure 1)[4] were mostly affected.[5] So as to support these areas to build their capacity in trauma and disaster management, a program was envisioned and run in these areas. The program consisted of a training in trauma management for six hospitals in those areas which was followed by the development of disaster management plan and testing the plan by simulation exercise. Following trauma training, a disaster plan was developed in alignment with the Disaster Risk Reduction and Management Act 2074.[6] This study consists of the findings of the full-scale simulation exercise done in those six hospitals.

Method

This is a descriptive study from a full-scale simulation exercise of mass casualty incident of trauma conducted in Nepal between September 25 and October 5, 2021. The simulation exercise was implemented by Humanity & Inclusion (HI) with funding

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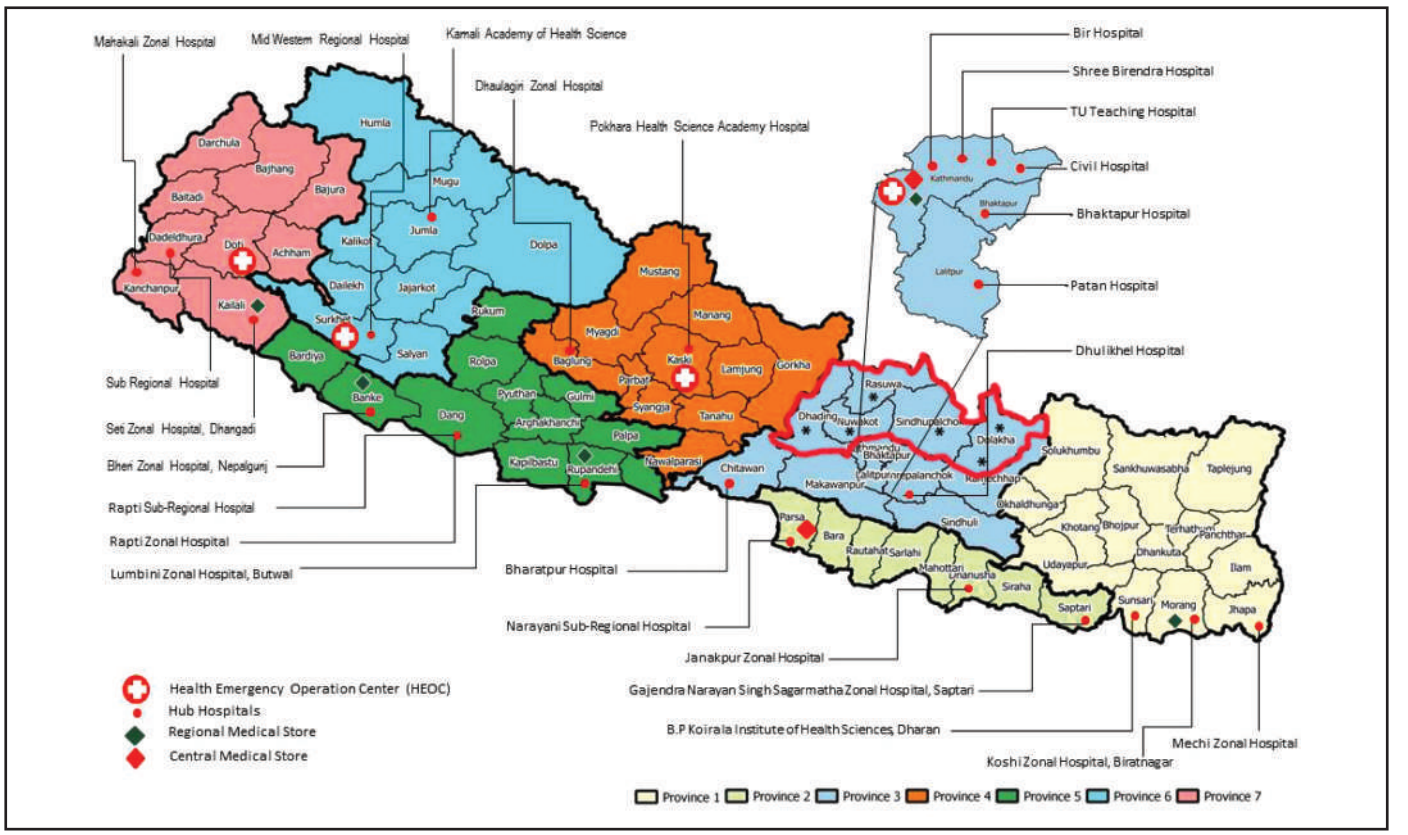

Figure 1. Map of Nepal with distribution of hub hospitals.[4] # Places where simulation exercise within red boundary and marked with '*.'

support from the Ministry of Foreign and European Affair, Luxembourg (MOFALUX). The HI is a nongovernment organization working in Nepal in the area of social inclusion, inclusive education, rehabilitation, health prevention, and disaster risk reduction.

The objective of the exercise was to test the functionality of the hospital incident command system, triaging system, treatment areas, emergency signal, patient care, and internal and external coordination-communication mechanism (Table 1). To design the exercise, WHO instructions were followed.[7] As all six sites had already undergone trauma management training, the development of disaster management plan, tabletop exercise (Figure 2), and full-scale simulation exercise (FSX) was planned at all six sites. All six sites had functional emergency service (Table 2).

Nepal has a federal governance system and is divided into seven provinces and 77 districts. Each district has an administrative head who is known as the chief district officer. The permission was taken from the chief district officer after a briefing about the simulation exercise. Each district is led by a health officer who looks after preventive and promotive health services, and the curative part is taken care by the hospital which is either provincial or local level. As for the disaster management, 25 hospitals that are in the government system and running in the capacity of emergency and surgical services were designated as hub hospitals.[4] Medical superintendent is the head of the hospital. Coordination was done with the health officer and medical superintendent, and the date of the simulation exercise was finalized; however, the nature and scale of the exercise were not disclosed. Similarly, in charge of police for the area was also informed about the simulation exercise. Then, local volunteers were identified by social workers and prepared for the simulation exercise. Drill coordinator and team with various roles required to conduct the simulation were identified and work division was done (Table 3). This was followed by a logistic purchase for the simulation exercise.

Table 1. Objectives of full scale simulation exercise		
S. no.	**Objectives**	**Description**
1.	Hospital Incident Command System (HICS)	• Establishment of incident command center • Designation of roles (Incident commander, Planning, Operation, Logistic, Finance) • Incident documentation
2.	Triage	• Establishment triage • Transfer of victim to triage • Appropriate triaging of the victim
3.	Treatment areas	• Establishment and functionality of red, yellow, green, and black areas • Roles and responsibilities designation for each area
4.	Emergency signal	• Mechanism of message receiving at hospital • Activation of the disaster upon receiving message
5.	Patient care	• Logistic supplies • Interdepartmental transferal • Referral to other center
6.	Internal and external coordination mechanism	• Communication of HICS within the hospital • Communication of HICS with stake holders outside the hospital • Media briefing • Information to relatives

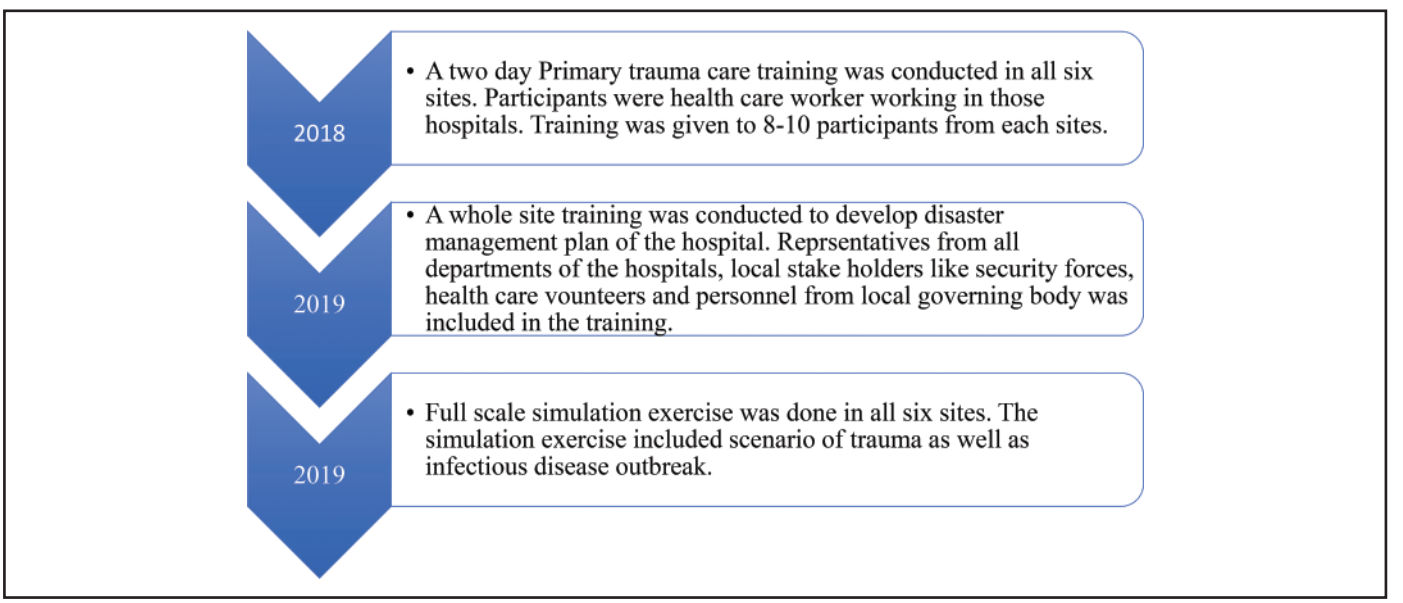

Figure 2. Foundation of full-scale simulation exercise conducted in 2021.

A day before the simulation exercise, the hospital was visited and presimulation checklist was filled up (Appendix Table 1). On the day of the simulation exercise, simulators were briefed about the exercise and their roles, and consent was also taken with the simulators at the same time. After preparing the simulators, they were taken to the site where a road traffic accident incident was designed. Once the simulators were in position, information was sent to the local rescuer. As there is no provision of prehospital

Table 2. Description of six government hospitals where simulation exercises were done					
S. no.	**Hospital**	**Level***	**Emergency service**	**Basic imaging†**	**Trauma surgery‡**
1.	Chautara Hospital	Province hospital	Available	Available	Previously available but was not available during time of simulation
2.	Charikot Hospital	Province hospital	Available	Available	Available
3.	Dhading Hospital	Province hospital	Available	Available	Available
4.	Jiri Hospital	Local level hospital	Available	Available	Previously available but was not available during time of simulation
5.	Nuwakot Hospital	Province hospital	Available	Available	Available
6.	Rasuwa Hospital	Province hospital	Available	Available	Not available

*Nepal has central hospitals, provincial hospital, and local level hospitals, as Nepal is divided into seven province and 253 local level governance system.
†Basic imaging means availability of x-ray facility.
‡Trauma surgery done either by general practitioner or general surgeon or orthopedic surgeon. Specific trauma team and specialized surgeries like cardiothoracic and neurosurgery were not available in all six sites.

care in the area where the simulation was conducted. The event is initially responded by a local responder who would activate Nepal Police followed and local healthcare volunteers. Ambulances are run by local organizations who respond to the call. Therefore, information was sent to Nepal Police who responded transferred patients to the hospital with ambulance and healthcare volunteers.

The plot of the exercise was on head on collision of two vehicle carrying passengers. The local responder would respond to the accident and rescues the victim. Information would then be sent to the hospital by a local healthcare volunteer. A total of 16 simulators were prepared for each simulation exercise, and there were three red, five yellow, five green, and one black patients prepared for simulation; additionally, there were one visitor and one reporter also prepared for simulation. A tag was made for each simulation where three parameters were kept: respiration, pulse, and mental status (RPM). Any patient with the abnormality of RPM would be red and no abnormality in RPM but unable to walk would be yellow, and normal RPM with able to walk would be green as per simple triage and rapid treatment (START) triage.[8]

These simulators were transferred in two vehicles and available ambulances. Once simulators were in the hospital, a designated safety officer took care of their safety. The safety officer was also responsible for the safety of the real patient who come to the hospital. Immediately after the simulation, hot debriefing was done in the hospital. The total simulation duration planned was 30 minutes, so that it would not affect hospital's regular activity.

The checklist of actions before simulation was prepared. The simulation exercise was evaluated by an evaluation tool developed by Pan American Health Organization 2021, WHO, which was used to evaluate the drill, Appendix Table 2.[9] The checklist for four domains were emergency signal, HISC, patient care, and media-relative-security. The total score of the checklist was 220, and the score of each domain was 15, 60, 95, and 50, respectively. Each item under every domain was rated from 1 to 5 where one would mean the action was not done at all and 5 would mean that

Table 3. Organization structure of simulation program	
Title	**Responsibility**
Coordinator	• Establish and coordinate the teams. • Oversee internal and external coordination before and during the exercise, including with authorities and community leaders from the place where the drill will occur. • Coordinate the self-evaluation of the overall process of organizing the exercise and prepare relevant reports. • Stop the drill should a real emergency occur.
Logistic	• Ensure that all resources needed for the drill can be procured efficiently and in a timely manner, including the purchase of necessary supplies and materials.
Technical design	• Develop the overall plot and all components of staging and script, including the human and material resources required. • Choose, together with the coordination team, the location for the drill. • Define and communicate to the staging team any necessary props and special effects for simulating the events. • Prepare instructions for the participants. • Prepare evaluation instruments for the different situations that take place in the exercise.
Staging	• Prepare, in conjunction with the technical design team, the scenario, and special effects necessary to simulate events. Carry out an inspection visit to the site where the drill will be held. • Install and organize items for staging different components of the exercise and install devices for special effects. • Ensure adequate preparation and training of simulators and test the operation of devices for special effects.
Evaluation	• Prepare an evaluation instrument based on the objectives of the exercise in conjunction with the technical design team. • Identify, convene, and train the evaluation and observation teams. • Lead the pre- and post-event evaluation process. • The evaluation coordinator is responsible for the synthesis and presentation of the final evaluation report.
Control	• Review the methodology and procedures for the drill in conjunction with the coordinating committee and the evaluation team. • Conduct an inspection visit to the areas where the drill will take place for familiarization and to verify that the locations are appropriate for the script. • Carry out the exercise and control the script sequence and timing of activities.
Finance	• Coordinate with the logistics team to procure necessary supplies, materials, and food for participants. • Prepare financial reports.
Security	• Design and coordinate a plan for the safety of all participants, including alerts in the event of an actual emergency during the exercise. • Make an inspection visit to the area where the drill will be held. • Coordinate and control all aspects of security during the exercise, including control of access and the perimeter.

everything was done well and excellently above the standard. The construct validation of the checklist was done by the team involved in the simulation. Further subjective evaluation was collected from expert and debriefing meeting which was held at each hospital immediately after the completion of the simulation exercise. The verbatim collected was categorized under five headings of objectives and analyzed by two authors.

Result

Overall, all sites performed well in the simulation exercise. It was found that the basic concept of the simulation was understood at all six sites. Gaps in the knowledge and skills were identified in some specific areas inside the hospital like running incident command center, skills of patient transferal from ambulance to triage area, and external coordination. The total score of the checklist showed that the hospital incident command system (HICS) was the lowest scored area (51.1 percent), and patient care (86 percent) was the highest scored area (Table 4). The major challenge for the hospital was change in staffs who were trained in disaster. On-site, there was a gap seen in the skill of triage and spine protection during transportation.

Evaluation from the expert suggested that out of six sites, one of the sites showed quick on-site response and mobilization of first responders; however, over other five sites, there was a relative delay in onsite coordination. The skills of on-site first responders in triaging the patient and stabilizing the spine were not found to be adequate. Debriefing of all sites identified that hospitals were aware of disaster management plan; emergency response was activated immediately in all six hospitals; triaging was done; red, yellow, green, and black area were identified; personal protective equipment were used; and routes to each area were identified. However, a designated area for media addressing was not found in all six hospitals though media person was identified. One out of six hospitals had good coordination with the local authority. Patient dropping zone from the ambulance was difficult with two-way traffic in five out of six hospitals. Proper functioning of hospital incident command center as a coordinating team was not observed in all six hospitals, though incident commander, planning officer, logistic officer, and operational officer were designated in all six hospitals.

Discussion

Full-scale surprise/unexpected simulation exercises are useful when sites are fully prepared, equipped, and have been doing semisurprise and expected simulation exercises. At all six sites, this was the first time; therefore, surprise or unexpected exercise did not seem feasible as it would compromise the safety of other patients in the hospital. Surprise exercises can be done in the form of drills in these hospitals. Surprise drills to test a small set of skills have been found to be effective.[10] It will be effective to put a surprise drill on triaging and patient transferal after training staffs of these hospitals. Semisurprise exercise done at present has helped in evaluating the system as well as given opportunity to staffs to practice disaster in a controlled scenario. Therefore, it is highly recommended to practice semisurprise full-scale simulation exercises to test hospital emergency setup. As of report published in 2015 that includes a survey done in 16 hospitals in Kathmandu, Nepal, 33 percent of private hospitals and 57 percent of government hospitals had the disaster plan and policies.[11] After 2015, the development of disaster management plan was put in fast track, and Hospital Disaster Preparedness

Table 4. Average scores and percentage given by expert in various domains during full scale simulation exercise, Nepal

Areas analyzed (total score)	Mean	Standard deviation	Median
Emergency signal (15)	12 (80 percent)	1.1	12 (80 percent)
Hospital Incident Command Center (60)	30.8 (51.1 percent)	0.4	31 (51.7 percent)
Patient care (95)	81.7 (86 percent)	1.5	82 (86.5 percent)
Media relatives crowd control and security (50)	36.5 (73 percent)	6.1	37 (74 percent)
Total (220)	161 (73.2 percent)	7.3	161.5 (73.4 percent)

and Response workshop was conducted for all hub and satellite hospitals in all seven provinces of Nepal. So, at present, many hospitals in Nepal have a disaster management plan.[12] Nepal has 25 hub hospitals, and hospitals surrounding the hub are satellites. These satellite hospitals run in various capacities. The minimal service is from the emergency room to specialized care hospital. The component of the epidemic outbreak plan was added after conducting a full-scale simulation exercise of the epidemic outbreak at Patan Hospital, Nepal in 2018.[13] However, most of the hospitals need refresher training and simulation exercises. It is equally important to publish reports of the simulation exercise, as there is paucity of information on such exercises in Nepal (Table 5).

During simulation exercise at all six sites, it was found that the concept of hospital incident command was in place, and the components are functional; however, it seems that this will work with short events like a road traffic accident. There had been longer events like 2015 earthquake, it seems difficult to work as the command center, which was not established, and an incident action plan was not made. Despite the fact that the drill was conducted after almost 18 months of the COVID-19 pandemic, it is of concern that the incident command not to function as expected. HICS is the core to management to any type of disaster;[14] therefore, it is necessary to work on strengthening HICS in hospitals by developing standard operating procedures of HICS, training, and exercise at the level of tabletop and drill. This will also help in strengthening external coordination that is between hospitals and local stakeholders like local administration, security, and community. Management of information is very crucial in a disaster. Accuracy of information from patient care area, logistics, administration, and through external communication is important for the management of disaster. This complex network of health intelligence can be achieved through strong HICS.[15]

In a hospital-based study reported from 2015 earthquake, an injured patient attending medical college hospital of western region of Nepal stated that 52 percent of their hospital visits were due to trauma.[16] During trauma, spine injury is not uncommon, and specifically, cervical spine injury may lead to death of the patient if care is not taken during transportation. A national survey from US trauma center in 1999 states that the overall incidence of all types of cervical spine injury in trauma was 4.3 percent, without spinal cord injury 3.0 percent, and with spinal cord injury 0.70 percent. Similarly, a study published from tertiary care center of Nepal states that road traffic accidents are the most common cause of spine injury, and cervical spine injury was the most common (66.7 percent) form of spine injury.[17] Therefore, we can save those cervical spine injuries who do not have spinal cord injury with proper transportation. From the gaps observed from this simulation exercise, it is felt necessary to train and develop transporting team in the hospital and community.

Triaging was yet another area of gap identification. Triage is not a regular practice in hospitals of Nepal; therefore, when there is no triage on regular days, it becomes difficult to do triaging in disaster specially when there are too many victims. The concept of triage was found in all hospitals with the preparation of triage tag and designation of triage officer. However, the accuracy of triage depends on regular practice and audit of the process[18]; therefore, rather than a short training, implementing triage as a regular practice in normal days needs to be focused on. The same issue was also identified in on-site, and this can be addressed by training and capacity building.

The limitation of this observation is the findings of the on-site response. This exercise was explicitly designed to test the system of the hospital. Therefore, there may be several confounders that might have been in place for the observation found in this exercise.

Conclusion

The result of this study has highlighted the fact that full-scale simulation exercises should be conducted regularly to find out the preparedness of a hospital. Hospitals should be guided to prepare disaster management plan, which needs to be tested with tabletop exercise before going into full-scale simulating exercise. Refresher trainings also seem to be equally important. This exercise also highlighted on the fact that the future direction for strengthening hospital

Table 5. Outcome as per objectives of full scale simulation exercise			
Objectives	**Outcome**	**Gaps in knowledge/skill/ resources**	**Possible mitigation**
Hospital Incident Command System	• Concept of HICS was in all six hospitals with designation of roles. • Identification of command center physically. • Incident documentation was not seen.	• Fair knowledge was observed in all hospitals regarding HICS but sill to operate was lacking.	• Hands on skill training on HICS and refresher trainings.
Triage	• Triaging was done in all hospitals using START triage. • System of transferal from triage to black areas was not adequate.	• Sufficient human resources were not deployed to transfer patient to black area. Knowledge to address this issue and legal aspects was lacking.	• Allocating specific human resources for this and orientating those staffs on legal provisions or connecting this team to the team who looks after legal provision in hospital.
Treatment areas	• Identification of red area for sick, yellow are for those who are injured and cannot walk, and green for walking injured were done. • There was identification of black area for dead. • Responsible person in each area was identified. • Printed information indicating specific area was missing.	• Hospital staffs knew about the area but this was not in practice in regular emergencies; therefore, identification board was not available which would define the area.	• The skill of designating patients to definitive areas for the management must be practiced in regular emergencies.
Emergency signal	• Emergency response was activated immediately in all hospitals. Mechanism of receiving message was not consistent in hospitals. It was not clear who would receive message at first instance.	• Skill in receiving message and acting on the basis of the information were lacking.	• Trainings and refresher trainings to manage information.
Patient care	• Supplies were adequate at all sites. • Referrals were done appropriately. • Record of stock that has been used was not available.	• Skill for recording and tracking patient was lacking.	• Incorporating this practice in regular emergency can be helpful.
Internal and external coordination mechanism	• Internal communication: There was good communication within the hospital with healthcare workers regarding patient number, stock, and referrals. External communication: • Identification of media spokesperson, place to address media, and visitors was not seen. • Communication with stake holders was not adequate.	• Lack of knowledge and practice of media briefing were seen. • Communication with stake holders was missing as it was not a specific skill that was in practice every day.	• Preparedness in terms of simulation exercises is important.

should focus in coordination and communication by strengthening hospital incident command and standard operating procedures in administrative and clinical areas.

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Appendix Table 1. Checklist of action before drill		
Organizational aspects	**Status**	**Action required**
All exercise assumptions and parameters are clearly defined according to the elements to be tested.		
Person responsible for documentation of lessons learned in exercise has been designated.		
General script and components of the staging have been established.		
Methods and procedures for the exercise have both been reviewed.		
Status of budget for the exercise.		
All arrangements have been made with the different actors (participating institutions, relevant authorities, community leaders, etc.).		
Participants have been identified.		
Visits have been made to sites where exercise will take place.		
Requirements for make-up and special effects to simulate events have been defined.		
Necessary equipment and materials have been acquired.		
Date has been selected for drill.		
Evaluation instruments for different scenes of the drill have been developed.		
Evaluators have been selected and given instructions.		
Simulators have been selected and given instructions.		
Teams for filming and photography have been arranged.		
Food and drink for participants have been arranged.		
Arrangements for participation of the media have been made.		
Identification badges for participants have been made.		
Medical and safety plan for real emergency has been developed and coordinated with relevant agencies.		

Appendix Table 2. Evaluation tool for drill					
Please score 1 if it was not done at all.					
Score 2 if done, but not according to the standard.					
Score 3 if done, but only partly according to the standard.					
Score 4 if everything was done well according to the standard.					
Score 5 if everything was done well and excellently above the standard.					
Emergency signal	1	2	3	4	5
Were the call and information documented correctly?					
Were message and information complete and precise?					
Was the early warning system activated using appropriate procedure?					
Incident command center					
Was the incident command activated without delay?					
Was communication established with all agencies?					
Was PHEOC informed?					
Was the necessary person assigned to incident command post?					
Were the request resources obtained?					
Was update provided regularly, accurately, and frequently?					
Was a unit established for administrative and financial operations?					
Was the incident documented in noticeboard?					
Were resources used to control event?					
Was chronological record event kept?					
Was any method used to control rumor?					
Was situation report maintained?					
Patient care					
Did all units of personnel arrive at scene without delay?					
Was operation chief clearly identified?					
Was there a clear line of command control?					
Did operation chief communicate with other departments?					

Appendix Table 2. Evaluation tool for drill (continued)					
Was transferal of the patient to triage done appropriately?					
Was triage appropriately done?					
Was secondary triage carried out in victim?					
Did health personnel use safety equipment properly?					
Were supplies properly distributed?					
Did supplies come immediately without delay?					
Was patient care appropriate?					
Was there arrangement for blood transfusion?					
Was radiology department priorities patient properly?					
Was internal transportation appropriate?					
Was appropriate referral done?					
Were logistics such as triage card, mattress, and IV stands well planned?					
Were role and responsibilities stated in plan followed?					
Was the WHO standard used for transport of dead bodies?					
Was temporary morgue established using WHO standard for the management of dead bodies?					
Media, relatives, crowd control, and security					
Was place to address media identified?					
Were media given information timely?					
Was place to identify relatives identified?					
Were relatives given timely and adequately information?					
Was one way flow of the patient maintained?					
Were there adequate security personnel?					
Was there a plan to mobilize police/fire brigade?					
Was patient in OPD properly channelized to exit?					
Was crowd control appropriate?					
Was the record of the patients regularly updated and posted?					