The Cluster Approach: A Study of a New Model of Disaster Response

Maktoom Almalki, Majed Alwahabi, Salem Alammi, Yousef Alawad, and Sharafaldeen Bin Nafisah

Abstract—**Background:**

The current models of disaster response focus on international collaboration and assistance. However, little is known about the disaster preparedness and response model of the Saudi health cluster.

Aim:

This study aims to examine, in more detail, disaster response steps, and elaborates on the administrative structure, time frames, challenges, and recent lessons learned.

Methods:

We reviewed the current disaster response model of Saudi Arabia's health cluster system. Pre-planning data were reviewed, and disaster contact personnel were contacted for further details. In addition, we relate a recent, actual code brown response to an electricity failure, including early activation and subsequent evacuation.

Result:

Three main criteria for determining emergency response levels are bed capacity, the number of patients affected, and the event's propensity for escalation. Five activation levels are already in place, ranging from local hospital disaster unit response to the involvement of national response led by the kingdom's leader. Hospital readiness to receive evacuated patients was tested in a real scenario, and an uneventful evacuation was carried out to demonstrate the effectiveness of the cluster design.

Conclusion:

Overall, the new disaster response model has overcome some reported challenges. However, several challenges still exist, and a degree of system evolution is expected.

Maktoom Almalki, Majed Alwahabi, Yousef Alawad are with the Emergency Department, King Fahd Medical City, e-mail: maaktom.m@gmail.com, e-mail: Majedalwahabi@gmail.com, e-mail: yalawad@kfmc.med.sa (Corresponding author: Maktoom Almalki)

Salem Alammi, Sharafaldeen Bin Nafisah are with the Disaster Management Department, King Fahd Medical City, e-mail: Salammi@kfmc.med.sa, e-mail: Sbinnafisah@kfmc.med.sa. DOI: 10.52609/jmlph.v3i3.85.

Index Terms—**Disasters, Disaster planning, Health cluster**

I. INTRODUCTION

Establishing a health cluster for disaster response is an effective public health strategy. A higher quality of care could be expected through the cluster's coordinated and predictable response, which would prioritise actions based on needs assessment [1]. The cluster approach, developed by the World Health Organization (WHO), aims to enhance coordination and cooperation between member states, non-governmental organisations (NGOs), countries, and various health systems in addressing emergency and disaster situations in healthcare [2, 3]. Such approaches have been established in Africa, Nepal and Indonesia [1,4,5]. In the context of the 2010 Haitian earthquake, the health cluster responsible for addressing health-related issues was led by the World Health Organization (WHO) and the Pan-American Health Organization (PAHO), in close collaboration with Haiti's Ministry of Public Health and Population (MSPP). Prior to the earthquake, the PAHO/WHO team consisted of 52 personnel; immediately after the disaster, an additional 60 experts were added [6], and four days following the event, 400-plus agencies and organisations had registered with health clusters [7].

The cluster's scope is shaped around coordinating humanitarian actions with international support, whether in response to an outbreak or to natural disasters [2].

In June 2016, Saudi Arabia introduced the health cluster model as part of its effort to enhance healthcare services across the different regions of the country [8]. Several clusters emerged, within the kingdom as well as within Riyadh City, with different hospital levels in each cluster including tertiary, secondary, and primary healthcare clinics.

The cluster system in Saudi Arabia is designed to facilitate the transfer of patients between different healthcare sectors [9]. Through the centralised approach of the leading hospitals, the clusters aim to ensure accessibility to different levels of care, from primary to secondary to urgent and chronic care [10,11]. Hence, it integrates a network of healthcare providers under one administrative structure.

Implementing disaster response via a health cluster is a unique concept, as it triggers an integrated national response within a specific geographical region. However, little is known about how such response is coordinated within the cluster, and the new model deserves further exploration and description. This study therefore aims to assess the disaster response of a health cluster as a new model and suggest areas for improvement. It also aims to describe disaster response steps, and to elaborate on the administrative structure, time frames, challenges, and recent lessons learned.

II. METHODS

We reviewed the current disaster response model of the Saudi cluster system. In addition, we relate a recent, actual code brown response scenario, involving early activation and subsequent evacuation due to electricity failure. This event was chosen for its propensity for escalation and its potential impact on patient care.

The data were collected from the Ministry of Health's data set (up to date at the time of writing), from a disaster response point of contact, and from existing reports. Pre-planning data was reviewed, and disaster contact personnel were contacted for further details. The names of the hospitals were omitted; they were described according to their capacity and distance from one another. The study was approved by the IRB committee, with approval number 22-461.

III. RESULT

Code brown activation:

In mid-August of 2022, at 5:56 PM, the health cluster's Emergency Operations Center (EOC) was contacted by Hospital A's Hospital Emergency Planning and Preparedness Unit (HEPPU) to activate a response to a loss of electricity. Hospital A had a 47-bed capacity, of which only four beds were occupied; in addition, it had two ambulances comprising part of the hospital-based emergency medical service (EMS) system. To activate the response, further information was required regarding the scope and extent of the power outage, the expected outage period, whether any people were affected, the number of patients currently admitted, and whether any additional resources or lifesaving expertise were needed. Nonetheless, the scale of assistance required was beyond Hospital A's capabilities.

Escalation level:

Upon activation of the disaster protocol, the health cluster's EOC led the disaster response and the incident command system was activated. The incident commander of the leading hospital was the cluster's chief executive officer (CEO). On the recommendation of the planning unit, evacuation was deemed the most plausible action.

There are three main criteria for determining the level of emergency response: bed capacity, the number of patients affected, and the event's propensity for escalation. This incident was categorised as a level two event, granting the cluster disaster unit full authority to respond. Fortunately, the situation did not escalate any further, and the sequence of events remained under the control of the cluster disaster unit until the recovery phase.

To elaborate, a level one disaster response would be led by the HEEPU of the hospital experiencing the incident. Under level two, the response is managed by the Emergency Operations Center (EOC) of the cluster. A level three response would be led by the disaster management centre of the General Directorate of Health Affairs, which can resolve the incident by communicating with other clusters and governmental agencies, and by using all the region's resources. A level four response is led by the Ministry of Health's National Health Emergency Operations Center (NHEOC), whereas level five requires a national response managed by the kingdom's leader. Furthermore, each level activates a standby of the next level in case of escalation of events, under-response, or failure to respond (Table 1).

War and terrorism are special situations which mandate immediate level-five activation, led by the kingdom's leader.

Table 1. Disaster response levels within the health.

	Level one	Level two	Level three	Level four	Level five
Responsible	HIPPU	EOC of the cluster	Directorate of Health Affairs	NHEOC in MOH	National level
Accountable	EOC of the cluster	Directorate of Health Affairs	NHEOC in MOH	National level	
Consultant	Directorate of Health Affairs	NHEOC in MOH	National level		
Informed	NHEOC in MOH	National level			
	National level				

EOC: Emergency Operations Center; HIPPU: Emergency Planning and Preparedness Unit; NHEOC: National Health Emergency Operations Center

Command and control room:

As a command and control room, the NHEOC coordinates and implements the Ministry's directions in disaster scenarios. It also acts as an official and timely link between the Ministry of Health and other ministries. The NHEOC is empowered to exercise control and management over the resources of all the kingdom's healthcare sectors, including public, private, and military domains. During the disaster event and if level four is activated, the centre will take control of, and communicate with, other governmental agencies. It also ensures prevention and mitigation by analysing the causes, creating action plans for future responses, and contingency planning.

Internal versus external incidents:

In the event of internal incidents, communication commences from the relevant hospital's HEPPU, which subsequently notifies the cluster's EOC. The EOC then establishes communication with the Health Crisis and Disaster Management Center at the General Directorate of Health Affairs in Riyadh. Ultimately, this centre informs the National Health Emergency Operations Center (NHEOC) about the ongoing situation.

In the case of external incidents, the Health Crisis and Disaster Management Center at the General Directorate of Health Affairs is responsible for notifying the cluster's EOC to initiate an appropriate response from hospitals within the cluster. Consequently, the cluster's EOC takes charge of coordinating and communicating the incident response with the respective HEPPU units.

Response - Incident Action Plan:

A size-up was conducted; the objective was to identify evacuation and transport requirements, and determine how and to where patients should be evacuated and their estimated time of arrival at other hospitals. The priorities were patient safety, incident stabilisation, and complete restoration of the hospital's operation.

A complexity analysis revealed that the power outage was expected to prolong, and that the emergency generator would work for a maximum of two hours. The uncertainty of the timing of power restoration made evacuation imminent. The incident was confined to the affected hospital; hence, evacuation roads were safe and nearby hospitals were operating normally. Communication was not affected, and direct communication was maintained for the duration of the incident through cellular phones and radio channels. The choice of hospitals for evacuation was based on their proximity, their capacity, the patients' required level of care, and the need for advanced care and equipment en route. EMS plans and coverage for each hospital are decided according to the distance between hospitals within the cluster, and the distribution of the patients is often agreed upon before such disasters, according to the hospitals' facilities.

Hospital A, at the time of the incident, had four admitted patients. None of the cases required intensive care, oxygen, or ongoing dialysis; thus, no special equipment was needed during the transfer. Nearby hospitals were notified and asked to report their capacity and available ambulances for prompt receipt. The cluster used a unified reporting platform, "Tahob تأهب", launched in 2019. ("Tahob" means "preparedness" in Arabic.) This platform aims to help the incident commander keep abreast of the response

level, the number of beds occupied/available in each hospital, available blood units, stockpile availability, ambulances, mortuary details, and oxygen cylinder and oxygen tank consumption.

Hospital B reported its readiness to receive two cases, and sent three ambulances. Hospital C reported readiness to receive one patient. Table 2 illustrates the bed capacity of the three hospitals involved.

A subsequent situational awareness update revealed a possible resolution of the power outage. However, while the electricity returned at 7:17 PM, it completely shut down again at 8:44 PM, and the backup generator failed to function. As a result, hospital A declared a complete shutdown and diverted all incoming cases to other centres.

The first evacuation, to hospital C, took 32 minutes. The second and third cases were sent to hospital B, which took 42 and 45 minutes, respectively. The fourth case refused the evacuation and was discharged against medical advice. Paper-based documentation was used during the response to endorse the cases to the other hospitals.

The time frame is illustrated in Table 3, while Figure 1 shows the distance between the hospitals. Electricity was ultimately restored at 3:00 AM; the response level was downgraded to level one and managed by the hospital itself.

IV. DISCUSSION

At the time of this writing, this is the first article to describe the cluster model for disaster response. The cluster has been put to the test, both in simulations and in various real response scenarios. For example, the power outage scenario examined the timeliness of the response, the integration of other hospitals, and the virtual Incident Command System (ICS) in place. The response involved coordination between various healthcare sectors and the mobilisation of ambulances to transport patients to and from the affected hospital. Thus, it differs from the WHO cluster approach in that the scope of response is based on national, rather than international, support. Nonetheless, the response levels share similarities with international incident management systems in that an escalation of events triggers a higher and broader level of response, in a stepwise fashion [12].

In the power outage incident discussed here, level two entailed an escalated response when the affected hospital required assistance, while the cascade of events did not mandate assistance beyond the cluster disaster unit.

The cluster approach presents a unified administrative structure whose disaster plan is based on the number of critical beds, type of patient distribution, workforce distribution according to the cluster's need, and an EMS plan for transporting patients within the cluster. It also includes communication strategies, a standardised record-keeping system, a specialised referral unit assigned to one cluster centre, and various mutual aid agreements. The budget is distributed across the cluster according to the number of beds and patients served [13].

Each hospital in the cluster has its own disaster unit (HEPPU) responsible for preparedness and response, which reports to the cluster's EOC disaster units. The unit ensures integrated communication, ease of patient transfer, acknowledgement of bed capacity, and accessible equipment. However, from a public health perspective, the cluster's preparedness has been impeded by challenges in defining the roles and responsibilities of each entity with regard to response, communication, and delivery of supplies; as well as the possibility of logistical chaos [14].

The use of response levels appears to significantly overcome such challenges, especially when coordination between different hospitals in the cluster requires an open channel of communication and a contact point. The current cluster has a known point of contact and a hierarchical chain of command distributed across, and known by, different hospitals within the cluster.

On a macro level, each cluster falls under the Ministry of Health. Ensuring the continuity and sustainability of communication channels is crucial, and each level should escalate to the next if an event is forecast to escalate. By following the communication plan, the MOH can ensure that information regarding emergencies and crises reaches the highest levels of authority in a timely, organised, and effective manner. This collaboration and reporting structure has allowed for swift decision-making, resource allocation, and implementation of appropriate measures to mitigate the impact of disas-

Table 2. Hospitals involved in the disaster response.

Hospitals	Hospital A	Hospital B	Hospital C
Bed capacity	47	174	179
ICU beds	5	10	21
Available beds	43	122	97

Table 3. Time frame of disaster response, from activation to evacuation.

Time	Variables
5:56 PM	Time of first call
7:17 PM	Electricity temporarily restored
8:44 PM	Time of second electricity failure
9:24 PM	Time of evacuation

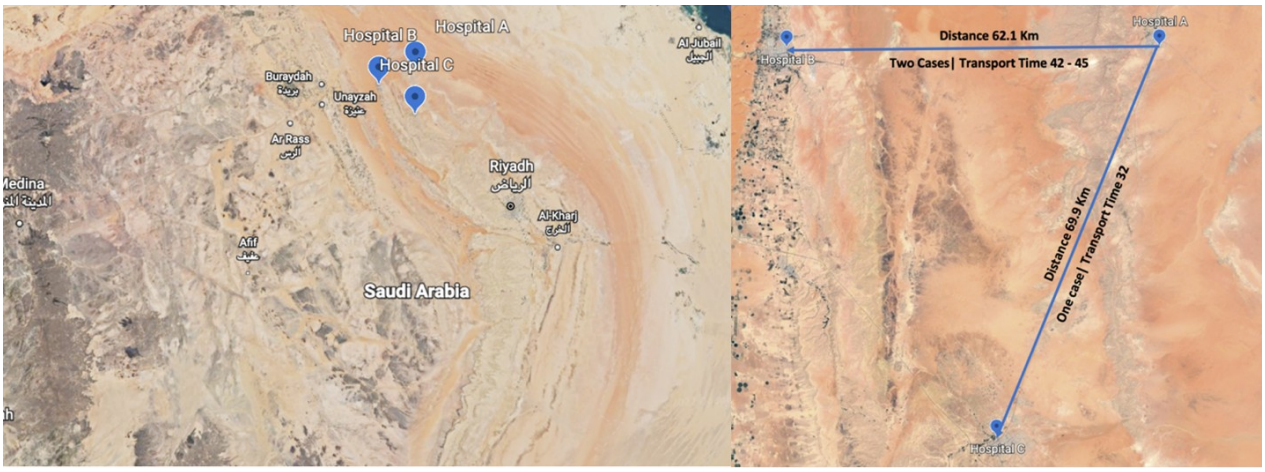

Figure. 1. A satellite image of the hospitals and the distance between them.

ters and crises on public health. However, identification of hazards within the community, and vulnerability analysis and preparedness for less common hazards, might not be the goal of the cluster as such. Nevertheless, the centralised management of the early warning system and identification of possible hazards will require each cluster to be ready for response.

Given that the healthcare cluster is a relatively new concept, one potential challenge that may arise is the need for effective communication and integration among the different hospitals within the cluster. Integrating disaster response within a healthcare delivery system is likely to face challenges concerning policies, procedures, interaction models, roles, and contingencies — especially when the healthcare sectors are in different provinces and include multi-tier healthcare delivery. Additionally, the successful integration of clusters, including timely information sharing and resource allocation, will require a higher level of commitment. Such challenges result partly from the transition from a hospital response to a multi-sector response, and partly through creating a congruent model aligned with national health sector plans.

V. CONCLUSION

Overall, disaster response mandates the development, testing and continual improvement of contingency preparedness plans. Ideally, different scenarios should be rehearsed and coordination should be tested via real-time simulation. Training is essential through tabletop as well as field exercises.

Protecting the health system requires identifying every possible gap and striving for idealism. Planning should be context-specific and ensure an all-hazard approach. Hence, more emphasis on less

common but high-impact scenarios could be sought. The new healthcare cluster system in Saudi Arabia shows a higher level of preparedness in various aspects, including administrative structure, workforce, sub-specialties within the cluster, methods and levels of communication, planning, and drills. However, disaster preparedness is an ongoing process that requires continuous improvement. Further research plays a crucial role in enhancing disaster preparedness globally.

VI. ACKNOWLEDGEMENTS

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