

# Hospital resilience after the 2015 earthquake in Nepal: results from semi-structured interviews with hospital staff

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## Research article

**Keywords:** disaster management, hospital resilience, qualitative research.

**Posted Date:** August 25th, 2020

**DOI:** <https://doi.org/10.21203/rs.3.rs-56020/v1>

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# Abstract

**Background** “Safe and resilient hospitals” are increasingly recognized as a cornerstone of disaster reduction in global policies such as the Sendai Framework for Action. However, current hospital resilience frameworks emerged from pre-disaster conceptualizations, and have not been verified in real-life disaster contexts nor in the frontlines. Our aim was to study a tertiary hospital’s resilience after the 2015 earthquake in Nepal, as experienced by its staff.

**Methods** We undertook a qualitative study in the Tribhuvan University Teaching Hospital (TUTH), where we conducted 18 semi-structured interviews with hospital staff. We inductively created themes to describe the earthquake burden to the hospital, and to analyze individual resilience of hospital staff. In addition, we deductively documented the resilience of the hospital as a system, according to the system resilience dimensions: means of resilience (redundancy and resourcefulness), and ends of resilience (robustness and rapidity).

**Results** TUTH faced material challenges, as well as challenges to healthcare provision, to management and coordination, and to hospital staff. In terms of robustness, TUTH increased its capacity for earthquake victims as elective activities were temporarily interrupted and quality of care was not a priority. Three stages of rapidity were identified: critical rapidity to address immediate needs, stabilizing rapidity until the hospital re-started routine activities, and recovery rapidity. In addition to the disaster plan, emerging adaptations played a major role in redundancy and resourcefulness. We found that individual resilience depended on three determinants: safety, meaningfulness, and sense of belonging.

**Conclusions** Hospital resilience results from a complexity of emerging and planned adaptations, as well as from interdependencies with individual resilience. Ensuring workforce safety and sense of meaning directly contributes to hospital systems-level resilience. Hospitals should establish and test disaster plans and strategies to alter standards of care, while being flexible to emerging adaptations.

## Background

Disasters are events that lead to substantial losses and disrupt the functioning of a community beyond its coping capacity.<sup>1</sup> Large scale, sudden-onset disasters occur quickly or unexpectedly, cause widespread destruction, produce high numbers of deaths and injuries, and require external assistance.<sup>1</sup> Large-scale disasters heavily strain health systems, not only due to a surge in demand but also because workforce is affected and material damages challenge provision of care.<sup>2,3</sup> Hospitals are critical in disaster response efforts to minimize loss of life, morbidity, and disability.<sup>4</sup> Community resilience depends on the resilience of its acute care organizations,<sup>5</sup> and resilient hospitals have become central in global disaster risk reduction initiatives, such as the Sendai Framework for Action 2015-2030.<sup>6</sup>

Despite a growing recognition of its importance, the concept of hospital disaster resilience remains somewhat elusive.<sup>7</sup> Hospital resilience, a concept developed by engineering sciences, is defined as the

“ability to overcome disasters with inherent capacity and adaptive flexibility, providing emergency medical services and responding to sudden increases in demand, while retaining essential functionalities”.<sup>4</sup> The four “resilience R’s” framework of hospital resilience consists of “means” of resilience – Redundancy and Resourcefulness – and “ends” of resilience – Robustness and Rapidity. Redundancy is the extent to which elements are substitutable, including the hospital itself if linkages are in place. Resourcefulness is the ability to mobilize material and human resources to meet priorities and achieve goals, including coordination measures. Robustness is the strength to withstand stress without suffering loss of function. Rapidity entails that priorities are met in a timely manner, in order to contain losses, recover functionality, and avoid further disruption.<sup>8</sup>

Building on existing frameworks, instruments that assess hospital resilience have been recently developed, but they only consider pre-disaster states<sup>9,10</sup>; it remains unclear whether they reflect processes in the context of actual disasters. A recent paper attempted to use existing frameworks after an actual disaster, but it focused on experiences at managerial levels rather than from the frontlines.<sup>7</sup> However, frontline staff are confronted with difficult situations that are often not reflected in strategic level experiences, but greatly influence overall disaster response and, ultimately, disaster impact. Only by understanding experiences of hospital staff can we design plans that target them and increase overall hospital resilience. In this paper, we study a tertiary hospital’s resilience after the 2015 earthquake in Nepal, as perceived by its frontline staff.

## Methods

### Study setting

On April 25th 2015, a powerful earthquake hit Nepal, killing nearly 9,000 people. It was followed by recurrent aftershocks, the strongest on May 12th.<sup>11,12</sup>

Our study focuses on a referral tertiary hospital in Kathmandu: the Tribhuvan University Teaching Hospital (TUTH). TUTH was established with funds from Japan, had earthquake-resistant constructions, was member of the Hospital Preparedness for Emergencies (HOPE) Network, and had a disaster plan in place.<sup>13</sup> TUTH was continuously functional and admitted more than 500 earthquake victims, mostly with orthopaedic injuries and surgical needs.<sup>14</sup> Non-injury-related admissions were significantly lower in the weeks after the earthquake, as priority was given to resource-intensive earthquake injuries.<sup>15</sup>

### Data collection

The first author, a non-Nepalese female Medical Doctor, conducted 18 semi-structured interviews with hospital staff. Interviewees were purposively selected to obtain a diverse sample in terms of profession, gender, and seniority. A sample size was estimated according to available resources, but saturation was reached. The hospital director and/or administrative chief invited them to participate directly or through their direct supervisors, who gave them permission to participate. Participants had no previous contact with the interviewer.

The interviewer followed an interview guide that focused on experiences before, during, and after the earthquake at personal, professional, and organizational levels (Supplementary file 1).

Interviews took place in May 2018 in a quiet room at TUTH during working hours. For seven interviewees less comfortable to express themselves in English, an external interpreter facilitated communication. Interviews lasted on average 60 minutes, ranging between 40 and 100 minutes.

At the start of each interview, study participants were informed about the researcher's background and the content of the research. They were given the opportunity to read the informed consent form before signing it. Upon participants' approval, all interviews were audio recorded, transcribed ad verbatim, and, if applicable, translated to English. Notes were taken during the interviews, and were incorporated in the initial coding. Interview transcripts were returned to participants, but no changes were requested.

### **Data analysis**

Following recommendations for qualitative data analysis in health services research, we combined deductive and inductive thematic coding.<sup>16</sup> The first author coded the data, and themes were discussed among the research team.

We first inductively created themes to describe the earthquake burden to the hospital, as perceived by the respondents. Then, in order to document the resilience of the hospital as a system, we extracted parts of the data that thematically aligned with the four dimensions of hospital resilience, the theoretical framework that defined our starting codes: Redundancy, Resourcefulness, Robustness and Rapidity. Some hospital adaptations could be categorized in multiple dimensions. We followed the definitions proposed in the literature,<sup>4,8</sup> but establishing clear distinctions was sometimes difficult. In such cases, we categorized the content in multiple dimensions and explain how it aligns with each.

Finally, we found that individual resilience of hospital workers was an important component of hospital resilience, but could not fit in the "4R's" since they are conceived for systems, not individuals. We undertook inductive coding to analyze individual resilience of hospital staff, and three themes emerged: safety, meaningfulness, and sense of belonging.

We handled and coded the data using NVivo software, 12th edition. In our results, we present quotations to support our statements, some of which were slightly modified for clarity. Because interviews were conducted in one hospital and touched sensitive issues, we present quotations without participant information to prevent identification. We complied with the Consolidated Criteria for Reporting Qualitative Research (COREQ).<sup>17</sup>

## **Results**

### **Characteristics of study participants**

We interviewed 18 hospital staff of different functions and demographic characteristics, presented in Table 1.

Table 1  
Characteristics of interviewees

Characteristics	Number
<i>Profession</i>	
Medical Doctor (Departments: orthopaedics, gastroenterology, anaesthesiology, emergency department)	4
Nurse (Departments: intensive care unit, operation theatre, maternity ward, administration)	4
Physiotherapist	2
Pharmacist and Dietician	2
Radiology and Laboratory Technician	2
Security and Housekeeping	2
Finance and Administration	2
<i>Gender</i>	
Male	11
Female	7
<i>Age Group (at time of the interview)</i>	
30–40	7
41–50	4
51–60	7

## Burden

### Material challenges

While TUTH's infrastructure had only minor damages, non-structural problems arose: road network disruptions challenged access, overloaded phone networks hampered communication, and interruptions of central energy supply threatened activities, aggravated by an unforeseen fuel crisis.

Disrupted supply chains, business closures, and panic buying intensified shortages of supplies in high demand at TUTH. Surgical, rehabilitation, and protective equipment were particularly needed; other important supplies included medicines and laboratory reagents. Moreover, as businesses were closed, feeding everyone present became problematic.

## **Health service provision**

A high number of injured victims started arriving almost immediately after the earthquake, heavily straining TUTH. Many dead bodies also arrived, but the capacity to accommodate them was limited – many were initially left outdoors.

Most victims treated at TUTH had orthopedic injuries, and interviewees reported seeing an unprecedented amount of blood. There were also referrals of patients with rhabdomyolysis, acute kidney injury, sepsis, or surgical and pregnancy complications. Besides being a referral hospital, the lack of functioning health services in the periphery explains the surge of patients at TUTH. Different interviewees reported a high demand for radiology, surgery, and physical rehabilitation.

*There were five orthopedic surgeons, and I asked them... “I’ve never seen so much blood, it’s really getting hard...”. I was squeezing on the cotton and bandages, and treating another patient. I remember Dr. X said “as a surgeon neither I have seen this much blood in my life.”*

Chronic disease patients lost access to their routine medication and could not purchase them anywhere. TUTH assumed the responsibility to provide their treatment, but it further strained staff and stocks. The earthquake also carried mental health consequences: outpatient consultations captured cases of earthquake-related panic and anxiety disorders, post-traumatic stress, and depressions.

## **Management and coordination**

Interviewees recalled a highly chaotic situation. Besides the massive inflow of injured victims and relatives, the earthquake occurred on a Saturday and senior staff were absent, leaving junior staff handling the response. In addition, external organizations rushed to TUTH, including volunteers, Non-Governmental Organizations (NGOs), and, later on, foreign medical teams. This organizations inflow challenged coordination, and allowed for the infiltration of thieves and fraudulent schemes in the crowd.

*During the time of earthquake many volunteers were distributing tea, biscuits and many other things. People threw waste anywhere.*

## **Emotional and physical impact to hospital workers**

Hospital workers faced an increased workload in difficult working conditions, while they were simultaneously concerned about their friends and relatives; some also relocated due to damaged housing and recurrent aftershocks. Interviewees felt unequally prepared, with many reporting they did not know how to act.

## **Ends of System Resilience at TUTH**

### **Robustness**

TUTH continuously provided healthcare and avoided substantial loss of function, demonstrating robustness.

## **Material robustness**

TUTH's resistant structure allowed for immediate provision of emergency care. Sustained electricity flow ensured continuous activities, but unsystematic fixing and retrofitting led to disruptions like disconnection of equipment, falling of objects, or mixing of supplies.

## **Robustness of health service provision**

TUTH maximized its capacity to provide emergency treatment, but at the expense of routine activities. Interviewees acknowledged potential collateral impacts, such as patients discouraged to travel to TUTH even after re-start of routine services. Deliveries in TUTH reportedly decreased with the earthquake and remained low, possibly because women preferred closer health facilities.

Staff prioritized treating as many patients as possible over quality of care. However, interviewees believed quality at TUTH was high compared with other hospitals in Nepal. Finally, although the May 12th aftershock produced additional injuries, TUTH was less affected, as everyone was more prepared.

*During that time we were not focusing on quality of care. (...) We had a lot of wound infections, we were not taking care of sterility properly... We just needed to provide care, we were focusing on life-saving and limb-saving activities.*

## **Rapidity**

Our analysis identified three stages of rapidity, as TUTH regained different functions at different times.

### **Critical rapidity**

Immediately starting essential work and assisting injured victims, while also self-organizing, was critical to minimize loss of life. The first surgeries started two hours after the shake, but more days were needed to optimize coordination, as being a Saturday challenged critical rapidity due to most senior staff being absent.

### **Stabilizing rapidity**

Once TUTH reorganized, a new rhythm emerged to address earthquake-related surges, until the hospital re-started routine activities and reobtained a "normal look", without patients outdoors and with fewer external organizations. The major aftershock seemed to have had limited impact; stabilizing rapidity was rather influenced by delays in task completion due to increased workload and equipment challenges.

### **Recovery rapidity**

After the situation was stabilized and the hospital re-started routine activities, time was needed to end the phase - and feeling - of emergency, which was very subjective. Administrative staff and those caring for earthquake victims reported longer times to recovery. Although they often mentioned it, interviewees struggled to elaborate on the concept of "recovery" - some even referred that they were "*still recovering, and not recovered*".

## **Means of System Resilience**

## **Redundancy**

TUTH found suitable alternatives to disrupted elements. While redundancies to certain challenges were established prior to the earthquake, others emerged as new problems arose.

### **Redundancy to material challenges**

Services from slightly damaged facilities moved to earthquake-resistant areas, and the fuel-supplied generator provided electricity as central supply was interrupted. However it only had a 24-hour autonomy, and Kathmandu was facing a fuel shortage. To solve this, TUTH coordinated with the army to ensure fuel supply (which demonstrates resourcefulness – see further).

### **Redundancy to health service provision**

After the earthquake, “step-down centers” rehabilitated and cared for patients no longer requiring hospital care. TUTH staff actively looked for patients they could transfer in order to accommodate more victims, and a mobile team ensured patient follow-up outside the hospital.

*The concept of step down center came immediately. On the second or third day we started sending the patients. (...) We used to go on a vehicle to take a round of all patients. “This patient is serious, we can bring him back to our hospital. This patient is fine, please carry on”*

Reports regarding referrals from TUTH to other hospitals were conflicting: some were unaware they existed, while others affirmed they were in place but patients were reluctant to move to unsafe buildings.

*This hospital wanted to refer, and those doctors they wanted to take the patients. But those patients would say “that structure is so scary, we don’t want to go to that hospital!”*

Staff conducted tasks that differed from their usual work or qualifications. Task shifting could be a feature of both redundancy and resourcefulness; we considered redundancy when hospital workers explicitly switched tasks to replace overwhelmed colleagues.

*The surgeons were limited in number, they had to go to the OT (...).So we did the dressings, and we were helping them in keeping the records and discharging the people...*

## **Resourcefulness**

TUTH was resourceful in mobilizing external and internal resources. Some aspects were specified in the disaster plan, but many adaptations were spontaneous, compensating for a perceived lack of coordination.

### **Resourcefulness to material challenges**

Despite having containers with emergency supplies, TUTH faced shortages of essential supplies. Interviewees reported rationing and reusing equipment, but also that such strategies could be harmful. Fortunately, there was a massive inflow of external donations. Even if storage was initially challenging,

TUTH handled donated surgical and rehabilitation equipment easily; donated medicines were more complicated to manage due to expiration date. Charity groups prepared meals to distribute among staff, patients and patient families, removing a substantial burden from TUTH.

### **Resourcefulness to health service provision**

TUTH immediately started mass casualty triage, consisting of four categories: green (minor injuries), yellow (patients who did not require admission), red (severe injuries), and black (deceased). Only red cases received immediate and/or surgical care.

Elective services were halted, stable non-earthquake patients were discharged earlier than in normal circumstances, operation theaters were continuously functioning, and care for earthquake victims was free of cost. Neurosurgery and orthopedic surgery monopolized operation theatres, and post-operative rooms were rearranged to accommodate more intensive care beds. Staff reorganized duties and worked longer hours to ensure uninterrupted services.

We categorized task shifting as resourcefulness when staff adapted tasks to address new health needs or high patient numbers. For instance, non-medical staff performed first aid, applied plasters and even resuscitated patients; and doctors and nurses conducted psychological counselling during unrelated consultations when they identified mental health needs.

Interviewees were satisfied with volunteer work from patient relatives, local communities, and students. Proximity to the university facilitated the integration of students in hospital work, but this required additional supervision. Nevertheless, foreign surgical teams from western countries were unwelcome, since their presence was felt as undermining TUTH's competence.

*We didn't allow any outsiders to intervene in the OTs. (...)Because we were confident that we are competent.*

### **Resourcefulness to management and coordination**

Some interviewees believed the day of the earthquake was well managed, despite reports of a highly chaotic situation. After the first day, the director's team held regular assessment meetings and gave instructions to different departments. The presence of external donors and volunteers also strained TUTH as it led to accountability issues, overflow of supplies, abuse of charity, and theft. Hence, coordination was essential. Most interviewees underlined the importance of having, or finding, a role after the earthquake, but not all were familiar with the disaster plan or aware of pre-earthquake drills. Those without assigned roles often acted spontaneously, and those unaware of decision-making systems made more spontaneous decisions.

*Spontaneously everything was being managed, but personal spontaneity, not like we underwent any kind of drills. Nothing was working clockwork... It was spontaneous chaos.*

### **Resourcefulness to challenges to individuals**

As staff adapted to the new context, they divided teams in shifts, allowing everyone to take time off without interrupting services.

*We divided our team into two groups to cover days and nights. (...) One team would come in the daytime, do the cases, go home, and the other team would come in the nighttime.*

To summarize system resilience at TUTH, we present schema of hospital functionality and adaptations, over time, in Fig. 1.

Figure 1: Diagram relating hospital functionality, adaptations, and time, based on information from interviews.

### **Individual resilience**

Staff were essential to TUTH's adaptive capacity, but were constantly exposed to suffering and living a work-family dilemma. Interviewees recalled feeling fear, worry, and sorrow, sometimes even reporting "mental instability" and "depression"; but they also reported feeling pride and love for TUTH, and even recalled feeling "extra powers" to work. Inactivity or difficulties in contacting relatives often promoted negative thoughts, and "overworking" was a frequent strategy to avoid this.

*You try to compensate with overworking or doing something else, so that you do not feel depressed.*

Some interviewees were trying to forget their experiences or denying the possibility of future events, but did not elaborate on this during the interviews despite different probes. Such interviewees had apparently implemented fewer adaptations at home, and were less confident about their experiences.

*This type of disaster is not happening again and again, I pray the god. Because that time was terrible, everyone was panicking, crying, things were destroyed ...*

### **Determinants of individual resilience**

We identified three major determinants of hospital staff resilience: safety, meaningfulness, and sense of belonging.

#### **Safety**

Feeling safe helped managing negative feelings: for instance, knowing TUTH was earthquake-resistant allowed staff to continue working despite recurrent aftershocks. At home, interviewees reported improving safety by retrofitting and preparing emergency bags. The absence of safety and disaster prevention measures on a national level contributed to a persistence of fear.

*We were terrified, but we knew that we were safe in the ICU, because that building was safe.*

#### **Meaningfulness**

Many interviewees felt their work was essential and contributed to a selfless aim, which helped them making sense of the tireless work and putting family second. Interviewees alienated from this meaning often felt trapped in their jobs and frustrated with the administration. Professional visibility seemed to influence this: technicians often felt overlooked and questioned the sense of their dedication, while those who directly cared for victims, or who had been recognized by the hospital, more often found their experiences meaningful.

*One of my cousins, (...) he was found dead. (...) I couldn't even get there to say a few words on their sorrow and grief. What sort of job do I have, I am not even free to go there and express my sorrow!*

*Now they have understood our importance. If there is work to do, they call us. If there is a meeting (...), they call us. Before, they never cared.*

### **Sense of belonging**

In order to focus on work without feeling guilty, hospital workers often left loved ones with extended families or friends, which was often described as a relief. Interviewees were proud of the family cohesiveness in Nepal, which they thought largely contributed to success. Extended community support also contributed to an inspiring sense of belonging. Another example was team spirit, as co-workers comforted each other, and organized shifts so all could spend time with their families.

*After the second day I shifted my family to my uncle's house (...). They had like a family get-together. And I was free to work.*

*In my house, there were 3–4 families: doctors from this hospital, whose house had been damaged, they were in my house. We were like in a big hostel. (...) So time passed gossiping.(...) it was an enjoyable time actually.*

To summarize all our findings, we present a synthesis of the earthquake-related burdens and hospital and individual resilience in Table 2.

Table 2  
Overview of earthquake burdens and system and individual resilience

Burden	System resilience (the "4 R's")			
	"Means" of resilience		"Ends" of resilience	
	Redundancy	Resourcefulness	Robustness	Rapidity
<p>Material damages</p> <p><b>Structure</b></p> <p><b>Electricity</b></p> <p><b>Equipment and supplies</b></p>	<ul style="list-style-type: none"> <li>• Offices in damaged area moved to resistant part</li> <li>• Electricity generator, fuel for 24 hours</li> </ul>	<ul style="list-style-type: none"> <li>• Pre-existing disaster plan: use of open-space</li> <li>• Army intervened for fuel supply</li> <li>• Rationing and reutilization of equipment</li> <li>• External donations BUT challenges (storage, validity)</li> </ul>	<ul style="list-style-type: none"> <li>• Structure resisted despite minor damages</li> <li>• Objects fell due to unsystematic fixing and retrofitting</li> <li>• Emergency activities continued</li> </ul>	<ul style="list-style-type: none"> <li>• Ability to function immediately (critical rapidity)</li> <li>• Management of equipment may have caused delays (critical and stabilizing)</li> </ul>
<p>Health service provision</p> <p><b>Massive influx of earthquake victims</b></p> <p><b>Chronic disease patients</b></p> <p><b>Mental health (MH)</b></p>	<ul style="list-style-type: none"> <li>• Linkages with other health services</li> </ul>	<ul style="list-style-type: none"> <li>• Emergency triage</li> <li>• Free healthcare for victims</li> <li>• Interruption of elective activities, early discharges</li> <li>• Rearrangement of surgical and ICU services</li> <li>• Long working hours</li> </ul>	<ul style="list-style-type: none"> <li>• Increased capacity for EQ victims</li> <li>• Decreased quality of care?</li> <li>• Health needs addressed</li> </ul>	<ul style="list-style-type: none"> <li>• Surgeries in 2 h (critical rapidity)</li> <li>• 2–3 weeks to address all victims (stabilizing rapidity)</li> </ul>

Burden	System resilience (the “4 R’s”)			
	“Means” of resilience		“Ends” of resilience	
	Redundancy	Resourcefulness	Robustness	Rapidity
Management and coordination <b>Saturday and mostly junior</b> Chaos <b>Inflow of external organizations</b> <b>Second earthquake</b>	<ul style="list-style-type: none"> <li>Spontaneous individual decisions by individuals</li> <li>Establishment of assessment meetings and decision channels (although unclear for some)</li> <li>Transfer of burden to external actors</li> <li>Unclear coordination</li> <li>Second earthquake:               <ul style="list-style-type: none"> <li>Better coordination</li> <li>Prepared staff</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Victims were assessed (triage) and surgeries occurred</li> <li>Decreased quality of care?</li> <li>Unclear if following disaster plan</li> <li>Hospital able to focus on core activities</li> <li>Second earthquake:               <ul style="list-style-type: none"> <li>Improved response</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Delayed critical rapidity</li> <li>External support - critical and stabilizing rapidity</li> <li>Second earthquake:               <ul style="list-style-type: none"> <li>Quicker response: limited impact on stabilizing rapidity</li> </ul> </li> </ul>	
Emotional and physical impact to individuals <b>Concern with family</b>	<ul style="list-style-type: none"> <li>Split groups so everyone had time to check on family</li> </ul>	<ul style="list-style-type: none"> <li>Staff showed up and ensured continuous work</li> </ul>	<ul style="list-style-type: none"> <li>Contact with family and private life adaptations influenced critical rapidity</li> </ul>	
<b>Feelings of “torture”</b> <b>Exposure to suffering</b> <b>Increased workload</b>	<b>Individual resilience</b>			
	Safety	Meaningfulness	Sense of belonging	
	<ul style="list-style-type: none"> <li>Important to keep working despite aftershocks</li> <li>Absence of national policies and safety measures contribute to persistence of fear</li> </ul>	<ul style="list-style-type: none"> <li>Making sense of the tireless work and prioritizing it over family</li> <li>Dependent on job visibility</li> </ul>	<ul style="list-style-type: none"> <li>Support from families, co-workers and communities</li> <li>Key to focus on work without concerns</li> </ul>	

## Discussion

Our study was among the first to apply a hospital resilience framework in a post-disaster setting using staff experiences. We illustrated how the earthquake generated a complexity of events that challenged a tertiary hospital in Nepal, many of which were addressed with emerging adaptations. We found that

functional challenges, not material, were major disruptors of hospital resilience, and because they are highly dependent on human behavior, individual staff resilience plays a major role.

Our analysis captured a richness of experiences that did not exactly fit in the proposed definitions of the “4R” dimensions. This framework was first developed in the engineering sciences, and initially thought for a hospital’s material properties,<sup>8</sup> only later adapted to capture functional capacities.<sup>4</sup> Moreover, these frameworks originated from pre-disaster conceptualizations, which also explains the difficulty to use them in a real-life disaster setting. We found the framework does not differentiate emerging adaptations from pre-disaster preparedness, but this adaptive flexibility<sup>4</sup> was the only solution as new, unforeseen problems arose. Categorizing emerging adaptations as resourcefulness or redundancy was not always straightforward, as was the case with task-shifting.

While spontaneous adaptations were essential, they may have influenced the quality of care. Crises understandably lead to altered standards of care, but decision-making should be based on harmonized strategies,<sup>18</sup> not on individual assumptions. Hence, training of all staff members, including recent recruits, in disaster response is necessary.

Our results also demonstrated that being a Saturday influenced disaster response, as initial absence of seniors hindered centralization of coordination. Moreover, external resources were key to disaster response, but created collateral nuisances. A clear plan should set coordination mechanisms and standards of work, and should actively engage junior staff.

Finally, we demonstrated the importance of staff in ensuring continuity and quality of services. Previous studies have shown that hospital workers undergo a double burden during disaster response, and struggle between responsibilities towards their family and hospital duties.<sup>19,20</sup> We found that interviewees were generally more positive when they felt safe, attributed a meaning to their experiences, and felt a sense of belonging to a supportive community. According to the Sense of Coherence, when an individual perceives a difficult situation as meaningful, he/she will feel it is worth the commitment, rather than a burden.<sup>21</sup> The literature also reports that safety strongly influences healthcare and relief workers’ commitment to work and reduces family concerns.<sup>22,23</sup>

Our findings suggest that hospital resilience and individual staff resilience are interdependent, as the conditions at the hospital affect the individual, and the individual’s performance influences the effectiveness of adaptations. Hospitals and communities must value hospital staff, and incorporate strategies that will improve their well-being and performance. Hospitals should take staff safety seriously – and staff should feel that – by guaranteeing structure resistance and providing adequate equipment.<sup>22</sup> Strategies that help individuals find a meaning to their experiences, such as encouraging participation in suggestions for improvement, have been proposed to stimulate meaningfulness.<sup>23</sup> Working can also be an individual coping strategy, simply letting staff work can effectively lead to good results.

## Limitations

A selection bias may be present, since interviewees were contacted by the hospital director and administrative chief. This may have also inhibited interviewees to fully express themselves. Because interviews were conducted three years after the earthquake, testimonies are subject to recall bias, but we believe its influence was minimal given the magnitude of the event. In addition, language and cultural biases may have influenced our results. We had planned to validate our results through a participative approach with hospital staff, but the COVID-19 pandemic prevented this. Finally, TUTH has a Japanese-donated earthquake-strengthened structure and is a tertiary, university hospital, and findings must be handled carefully before generalizing to other settings.

## Conclusions

Hospital resilience results from emerging and planned adaptations that prevent substantial loss of function and promote a quick re-start of interrupted activities. Yet experiences from health workers deeply influence the effectiveness of adaptations, and their individual resilience must be considered to achieve overall hospital resilience. To minimize the human impact of large-scale disasters, hospital disaster plans should incorporate strategies to alter standards of care while being flexible to emerging adaptations, as well as ensure that the workforce feels safe and appreciated.

## List Of Abbreviations

4R: Hospital system resilience framework consisting of four dimensions (Robustness, Rapidity, Resourcefulness, Redundancy)

COREQ: Consolidated Criteria for Reporting Qualitative Research

TUTH: Tribhuvan University Teaching Hospital

## Declarations

### **Ethics approval and consent to participate**

This research was approved by the Ethics Committee of the Tribhuvan University's Institute of Medicine, case number 381(6-11-E)<sup>2</sup>/074/075. Interviewees provided written informed consent to participate.

### **Availability of data and materials**

The data that support the findings of this study are not publicly available due to them containing information that could compromise research participant privacy.

### **Competing interests**

The authors declare that they have no competing interests.

## ***Funding***

The field work for this study was funded by a research mobility grant from the Education, Audiovisual and Culture Executive Agency of the European Commission through the EMMPHID project and by the USAID/OFDA through the EM-DAT project (agreement n° AID-OFDA-A-15-00036). MMA's PhD scholarship was funded by the USAID/OFDA and the UCLouvain Special Research Fund. The funding bodies had not involvement in the design of the study and collection, analysis, and interpretation of data, in writing the manuscript, and in decision to publish.

## ***Authors' contributions***

MMA, JvL, DPM, DGS and IA conceived the study. MMA, DGS, and IA obtained research funding. MMA, SST, KCK and DPM supervised the conduction of the interviews and data collection. KCK and DPM recruited participants. MMA conducted and recorded the interviews, transcribed interviews conducted in English, and sent transcripts to all interviewees for validation. MMA coded the data and discussed themes with IA and JvL. MMA drafted the manuscript and all authors contributed to its revision. MMA takes responsibility for the paper as a whole.

## ***Acknowledgements***

We thank Surya Gaire for his support during the interviews in Nepali and for translating the recordings, Dr. Kirsten Vanderplanken for her insights and support in optimizing the use of NVivo, and all the hospital staff who participated in the interviews.

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## Figures

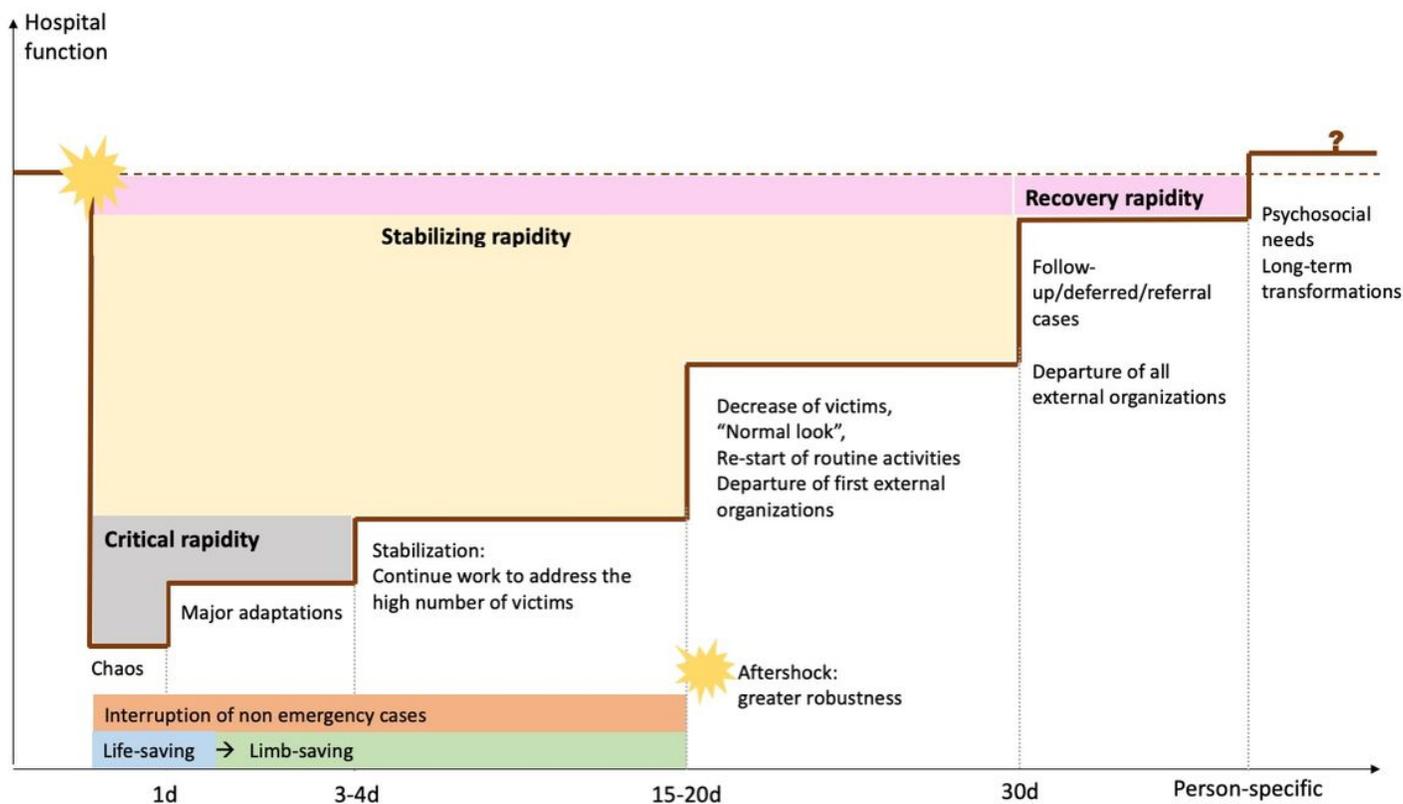


Figure 1

Diagram relating hospital functionality, adaptations, and time, based on information from interviews.

## Supplementary Files

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