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# Disaster Management in Himalayan Region: Preparedness of Health Infrastructure

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**Abstract—***India is one of the most disaster prone countries in the world on account of its geo-climatic conditions and high socio-economic vulnerability. Himalayan ranges are seismically very active and whenever any major earthquake strikes here buildings collapse killing and injuring hundreds of people. In such situation health infrastructure existing in the affected region becomes the most crucial for saving lives. The research aims at the identification of necessary actions to be taken for development of health infrastructure, in order to formulate a better medical preparedness plan for earthquakes in a Himalayan region. With this purpose an earthquake scenario is considered for the Narendranagar block of Tehri Garhwal district. Assessment of building damage and consequent casualty estimation is carried out. Existing health facilities are analyzed for their structural vulnerability to earthquakes and resource potential in terms of available and required number of beds, doctors and other paramedical staff. It was found that the health facilities existing in the region exhibit high structural vulnerabilities and are highly inadequate in terms of resource capabilities. Necessary actions to achieve the same are suggested which contribute in the development of a better medical preparedness plan. The methodology evolved and strategies and guidelines suggested can be useful for other Himalayan regions too.*

## 1. INTRODUCTION

Himalayan ranges are seismically very active and if any major earthquake strikes here buildings would collapse killing and injuring hundreds of people [5, 12]. Nepal earthquake of April 2015 witnessed about 9000 fatalities and about 23,000 injuries [14]. In such situations health care becomes the most critical activity which should start functioning immediately after the earthquake strikes and hence the vulnerability assessment of existing health care facilities becomes very important. The paper presents a hypothetical earthquake scenario and two components of vulnerability assessment viz. structural vulnerability of health care facilities and availability of resources which are responsible for responding to a mass casualty situation. Recommendations suggested for reducing the assessed vulnerability should be an important step for earthquake mitigation activities in the region if implemented.

## 2. LITERATURE REVIEW

All the disasters are primarily described in terms of numbers of lives lost. This suggests that health outcomes are the most important indicators of measuring the extent of the disaster and hence should be given most attention by the disaster management personnel [2, 3, 8]. The earthquake leaves many people killed and injured and at such times provision of medical assistance to the injured should start immediately after the earthquake strikes and needs great amount of research and preparedness.

WHO [15] gives a 14 modules toolkit for analyzing disrupted health sector consisting of background studies, needs assessment, policies, financing, health care provision, management networks, human resource, pharmaceutical area, strategies, producing a health sector profile and resources. The toolkit offers ready to use guidelines for disaster situations. It is extremely useful for the emergency health personnel for analysis and actions because of its practical and experience based approach.

The studies about existing health and medical care facilities in India at macro economic level carried out by Kadekodi and Kulkarni [6] highlighted many important aspects. They state that compared to China (24.9%) or Sri Lanka (45.4%), India spends just about 17.3 percent of total health expenditure on public health. The authors have pointed towards another matter of concern as growth of health manpower and infrastructure. It is important to maintain some kind of balance in the development of both infrastructure and manpower. The government should be more careful to see that the health care delivery system is not affected by the funding mechanisms.

Sinha [11] has highlighted the importance of health services in post-disaster situation followed by various critical issues viz. emergency procedures, buildings, equipment and administration. The author indicates that the reasons of seismic vulnerability of health facilities are their complexity of facility due to multiple functions, high occupancy levels, dependence on critical supplies, availability of basic facilities, careful handling of hazardous material present and presence of a number of heavy objects and machinery. The author has provided guidelines and recommendations for assessing and reducing vulnerability of health care facilities in terms of structural vulnerability, non-structural vulnerability, administrative / organizational vulnerability and functional vulnerability.

Alahi and Izadkhah [3] have listed various critical problems in terms of structural and non structural components and distribution of all these problems in 110 hospitals of Tehran. Guidelines are proposed into two phases viz. planning for the needs and conducting the plans for both structural and non structural aspects. Recommendations for formation of specialized teams viz. support, team, information management team, search team, relief and temporary shelter team, fire extinguishing team, recovery team, reconstruction team could be important if implemented.

Kadekodi and Kulkarni [6] have provided measures for the development of health sector, stating that it will be dependent on the advancement of technology, inflow of foreign capital, imports of drugs etc. In another study by Kadekodi et. al. [7] analyzed the supply and demand side of health care facilities. It is stated that the supply side scenario can be captured and analyzed in terms of the provisioning of health care facilities, while for demand side analysis, it is very important to analyze the voices of the people regarding access and utilization of health care facilities in the public and private domain. The report presents a very detailed and comprehensive primary survey and findings in terms of comparative analysis of health facilities in the states.

Pesigan [10] provides information about PHEMAP. It says that, in 2001, the WHO Regional Offices for the Western Pacific (WPRO) and South East Asia (SEARO) collaborated with the ADPC and the Japan International Corporation for Welfare Services (JICWELS) to develop an international programme to respond to a perceived need for staff training at ministries of health. Because of its regional focus, the programme was called Public Health and Emergency Management in Asia and the Pacific (PHEMAP). PHEMAP was designed as a series of integrated courses covering the technical, managerial and policy aspects of emergency management in the health sector

As per information provided by Abrahms [1] Asian Disaster Preparedness Center is also conducting training programmes on the Basic Emergency Response Course (BERC) which are aimed at developing national capacities to respond to medical emergencies.

Stopford [13] provides information about development of the National Disaster Medical System (NDMS) as an asset of the Federal Emergency management Agency (FEMA) under the Department of Homeland Security, by the United States government in 1998. NDMS is composed of personnel and specialty response teams comprised of a combination of civilian and uniformed service health and medical professionals, who serve as part-time federal employees while training or deployed. NDMS response team members include nurses, physicians, paramedics, emergency medical technicians, veterinarians, funeral directors, psychologists and other professionals integral to health and medical response capabilities. Various specialized teams under NDMS consist of disaster medical assistance teams (DMATs), disaster mortuary teams (DMORTs), Veterinary Medical Assistance Teams (VMATs), International Medical Surgical Response Teams (MSRTs), National Nurse and National Pharmacist Response Teams (NNRTs and NPRTs), National Medical Response Teams: Weapons of Mass Destruction (NMRTs) and Joint Management Team (JMT) [13].

Owens et. al. [9] has provided information about an International Medical Surgical Response Team–East (IMSuRT-E) which is developed by health care providers in the Metro-Boston area as multiple resources for the NDMS. IMSuRT-E has responded to provide aid in other disasters, such as after a super typhoon struck Guam in 2003. As stated by the author:

*"The IMSuRT-E is a highly specialized team that is capable of establishing a fully capable free-standing field surgical facility anywhere in the world. It deploys with medical supplies, pharmaceuticals, surgical equipment and a Deployable Rapid Assembly Shelter / Surgical Hospital (DRASH)"*

The Drash is a self contained field hospital complete with triage, operating room (OR), and intensive care unit (ICU) areas. At the time of deployment, the IMSuRT-E was the only team with a field hospital suitable for international deployment. The DRASH is a successful model to use in an immediate post-earthquake environment.

Owens el. al. [9] has also described the challenges of designing, maintaining and keeping a Deployable Rapid Assembly Shelter / Surgical Hospital. The important ones being preparation in terms of supplies / equipment, international travel, creating field hospital having water supply, electricity, sanitation, oxygen supply and setting up operating room with surgery table, instrument "back" table, anesthesia and others. Challenges with field surgery would be general hospital set-up, surgical personnel, surgery schedule and maintaining sterility.

WHO [16] give a detailed report of planning for health care facilities for emergency situations. The report deals with general aspects of disasters, emergencies and response and technical aspects suggesting methodologies for short term sheltering, water supply, sanitation, food safety, vector and pest control, control of communicable diseases, mortuary services, handling of dead, health promotion and community participation and human resources involved in the emergency management for health care. The report provides very realistic guidelines for dealing with health care during emergencies.

## 3. STUDY AREA

The entire Himalayan belt lies between zone IV and zone V of the seismic zoning map of India [4]. Narendranagar block of Tehri Garhwal district in Uttarakhand State of Himalayas (Fig. 1) is chosen for risk assessment of human settlements and analysis of health facilities. A population of over 1.5 lakhs is spread in 213 villages and 17 market towns.

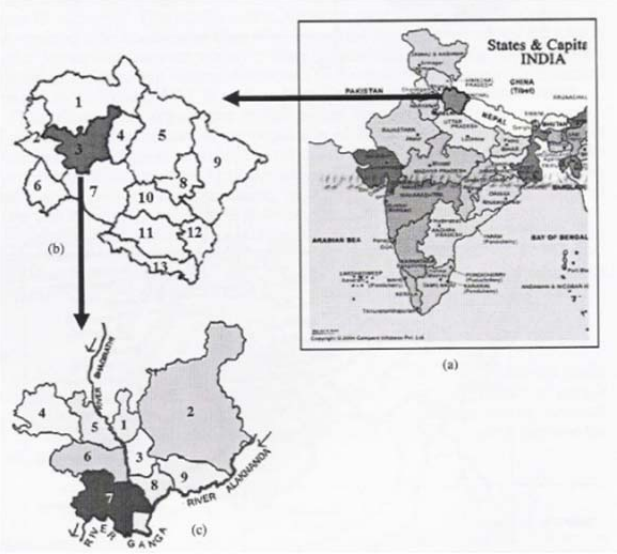


**Fig. 1: (a) Location of Uttarakhand state in Map of India (b) Location of Tehri Garhwal district in Map of Uttarakhand. (c) Location of Narendranagar block within Tehri Garhwal district.**

**Notes In (b): (1) Uttarkashi; (2) Dehradun; (3) Tehri Garhwal; (4) Rudraprayag; (5) Chamoli; (6) Haridwar; (7) Paudi Garhwal; (8) Bageshwar; (9) Pithoragad; (10) Almoda; (11) Nainital; (12) Champawat; (13) Udhamsingh Nagar; in (c): (1) Pratapnagar; (2) Bhilangana; (3) Jakhnidhar; (4) Jaunpur; (5) Thauldhar; (6) Chamba; (7) Narendranagar; (8) Devprayag; (9) Kirtinagar**

## 4. A HYPOTHETICAL EARTHQUAKE SCENARIO IN STUDY AREA

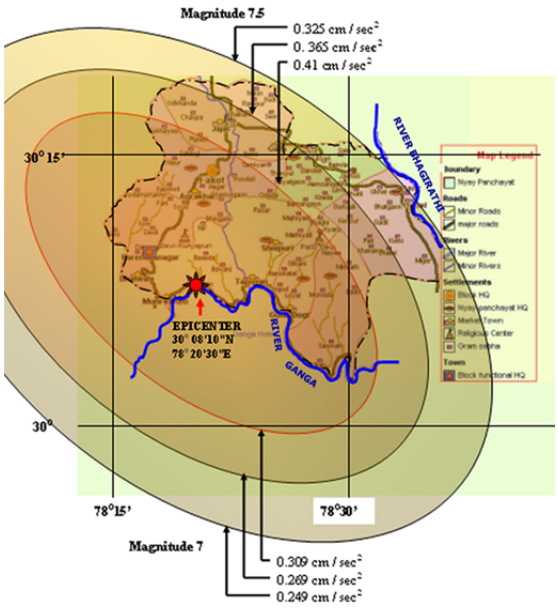


**Fig. 2: Acceleration contours with epicenter at Tapowan ($30^0$ 08'10"N and $78^0$ 20'30"E) for different hypo-central distances elongated parallel to the trend of Main Boundary Fault. [5]**

Gupta et. al [5] have generated an earthquake scenario in the study area. A hypothetical epicenter for earthquake of magnitude 7.5 is considered near Tapowan at $30^0$ 08'10"N and $78^0$ 20'30"E. Peak Ground accelerations (PGA) are computed for different hypo central distances covering the selected region. Iso acceleration contours plotted are elongated parallel to the trend of Main Boundary Fault to account for regional tectonics (Fig. 2). The intensity levels are determined considering the topographic effect.

### 4.1. Damage Assessment and Casualty estimation

The building damage assessment and casualty estimation given by Gupta et.al [5] is given in Table 1 and 2. It was found that almost 58 percent of house buildings of Narendranagar block are at risk of facing moderate to heavy damages. This risk increases if the earthquake magnitude is larger, and may be even higher in the vicinity of faults, riverbeds, intersection of fault and river and in the areas of higher population.

**Table 1: Damage to the house buildings of the Narendranagar block [5]**

| Damage category | Description | Number of buildings in villages | Number of buildings in towns | Total Buildings | Percentage |
|---|---|---|---|---|---|
| G1 | No / Slight damage | 1490 | 1089 | 2579 | 12.36 |
| G2 | Minor damage | 3904 | 2393 | 6297 | 30.18 |
| G3 | Moderate damage | 4804 | 1979 | 6783 | 32.51 |
| G4 | High damage | 3137 | 992 | 4129 | 19.79 |
| G5 | Collapse | 887 | 187 | 1074 | 5.16 |
| Total | | 14222 | 6640 | 20862 | 100 |

**Table 2: Casualty estimate for hypothetical earthquake scenario in Narendranagar block [5]**

| Injury Cate-gory | Injuries | Village | | Market Towns | |
|---|---|---|---|---|---|
| | | No. | % | No. | % |
| Type I | Dead or unsavable | 801 | 1.1 | 189 | 0.6 |
| Type II | Life threatening injuries needing immediate medical attention | 1201 | 1.6 | 283 | 0.9 |
| Type III | Injury requiring hospital treatment | 1201 | 1.6 | 283 | 0.9 |
| Type IV | Light injury not requiring hospital treatment | 801 | 1.1 | 189 | 0.6 |

## 5. EXISTING MEDICAL FACILITIES

According to primary survey conducted in the Narendranagar Block and information provided by the District Hospital at Narendranagar there are total 52 health facilities located in 29

different settlements and shared by 210 villages of the block. The distance of a village from its nearest health care facility varies from 0 to 21 kms. Fig. 3 shows the locations of all these medical facilities and villages showing different distances from nearest health facility.

### 5.1. Structural Vulnerability assessment of health care facilities

Strengthening structures of health care facilities for confronting earthquakes is one of the most crucial issues that should be emphasized as a top priority in the disaster management planning [3]. An primary survey of structural vulnerability of health care facility structures considering various aspects viz. age of building, structure type, materials used and incorporation earthquake resistant design features, suggest that 40% health facilities show high structural vulnerability, 31% show moderate structural vulnerability, whereas only 29 % show low structural vulnerability (See Fig 4, 5, 6 and 7). If these vulnerable health facilities collapse after earthquake then the entire medical preparedness plan would fail.

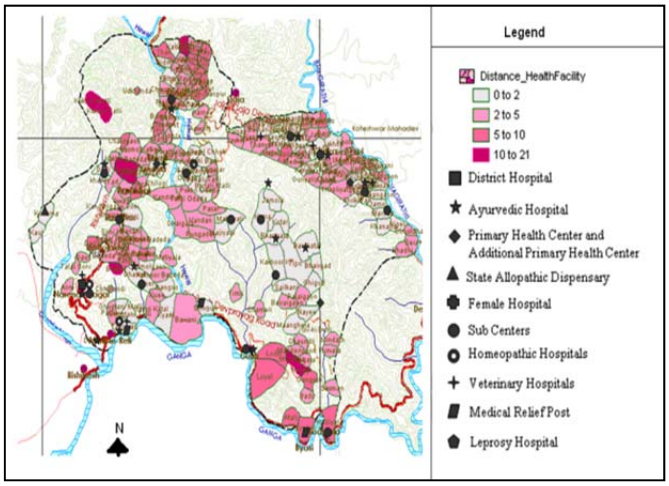


**Fig. 3: Locations of existing health facilities and distance of villages from nearest health facility**

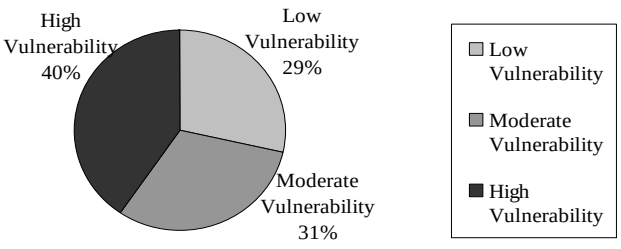


**Fig. 4: Structural vulnerability of health care facilities**

**(a)** **(b)**

**Fig. 5: Health Facilities with low structural vulnerability (a) Suman Hospital - District Hospital, Narendranagar (b)Primary Health Care Center, Fakot**

**(a)** **(b)**

**Fig. 6: Health Facilities with moderate structural vulnerability**

(a) Government Ayurvedic Hospital, Narendranagar
(b) Government Ayurvedic Hospital, Chaka

**(a)** **(b)**

**Fig. 7: Health Facilities with high structural vulnerability**
(a) Government Ayurvedic Hospital, Bhangala
(b) Veterinary Hospital, Andarfigaon.

## 6. PLANNING NORMS

The quantities of manpower and material resource requirements suggested for the health infrastructure preparedness of settlements are derived by developing norms based on discussions with various experts, administrative functionaries and many others who are involved in the emergency operations and practical aspects of disaster management (Table 3). The minimum numbers in the table indicate the emergency requirements in the existing and proposed health facilities. These adopted norms can also be used as planning norms in the formulation of earthquake preparedness plans for similar hilly settlements.

**Table 3: Norms adopted and suggested for quantities**

| S. No. | Resource Type | Mini-mum Num-ber | Suggested Average (Refer Table 1 and 2 for Damage and Injury Category) |
|---|---|---|---|
| 4 | Number of Doctors | 1 | (Type I/ 10) + (Type II/ 10) + (Type III/ 20) + (Type IV/ 30) |
| 5 | Number of Nurses | 2 | Number of Doctors X 2 |
| 6 | Number of Paramedical Staff | 5 | Number of Doctors X 5 |
| 7 | Number of Beds | 4 | (Type I / 2) + (Type II) + (Type III / 2) |
| 8 | Number of Rescue Kits | 1 | (Total estimated Number of G4 and G5 Buildings) / 3 |
| 9 | Number of Stretchers | 2 | (Total estimated number of Type I and Type II persons) / 8 |
| 10 | Number of Body Bags | 2 | Estimated Number of Type I persons |

## 7. CAPACITY ASSESSMENT OF HEALTH CARE FACILITIES

In this section the capacity of health facilities is analyzed for the dependent population they might have to serve in case of the assumed earthquake. The analysis deals with 29 different settlements where health facilities exist. These health facilities might serve as medical camps for the victims of the earthquakes. These medical camps would have to serve the populations from the nearby villages, which have them as the nearest health facility. When these Fig. s are analyzed against the existing health facilities it was found that the health facilities in the block are far below requirement during the assumed emergency situation. The analysis results in an estimated requirement of 350 doctors against available 37, estimated requirement of 448 other medical staff against available 114 whereas estimated requirement of 2100 beds against the available 131. Fig. 8, 9, 10 and 11 represents these statistics for the 29 settlements with health facilities.

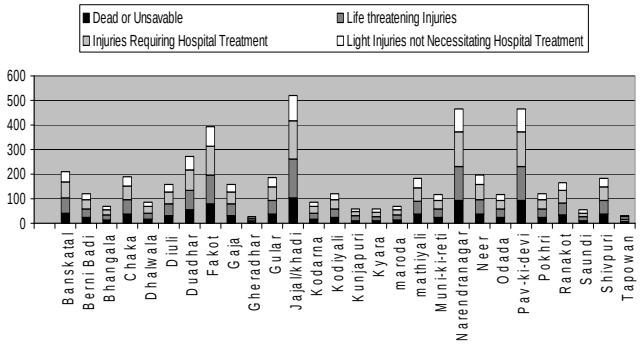


**Fig. 8: Number of casualties under each settlement with medical facility**

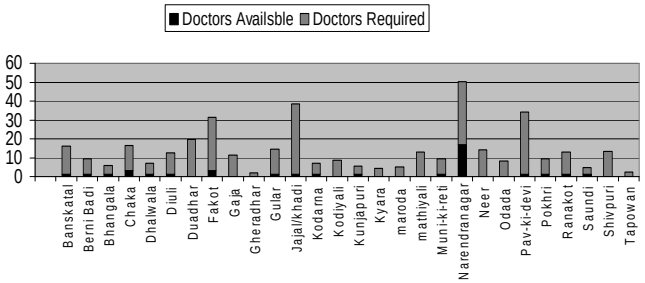


**Fig. 9: Required and available number of doctors in medical facilities**

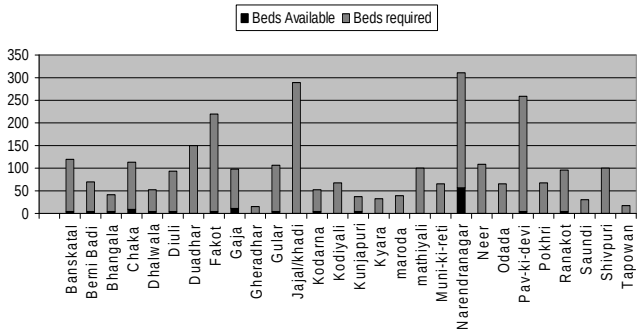


**Fig. 10: Required and available number of beds in medical facilities**

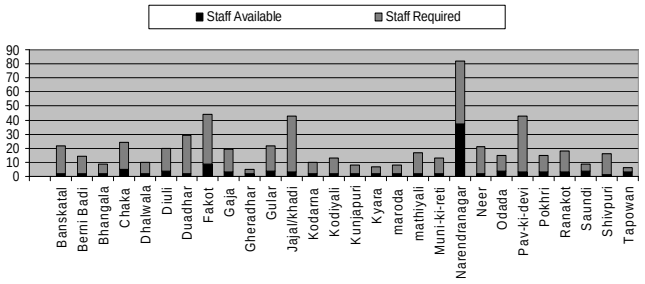


**Fig. 11: Required and available number of other medical staff in medical facilities**

## 8. NECESSARY ACTIONS

The analysis suggests many important actions to be taken immediately for better emergency management in the event of an earthquake. They include:

All the present health facilities with high earthquake vulnerability should be made earthquake resistant through appropriate retrofitting measures and reconstruction. New health facilities should be developed for the villages of Timli, Mindath, Maun, Loyal, Bedadhar, Nauga, Agrakhal, Hindolakhal, Kukhai and Byasi for their high estimated casualties and total lack medical facility.

Sub centers of Mathiyali, Kaudiyala, Maroda, Duadhar and Neer should be upgraded to medical facility with doctor and infrastructure required for setting up medical camps during emergencies.

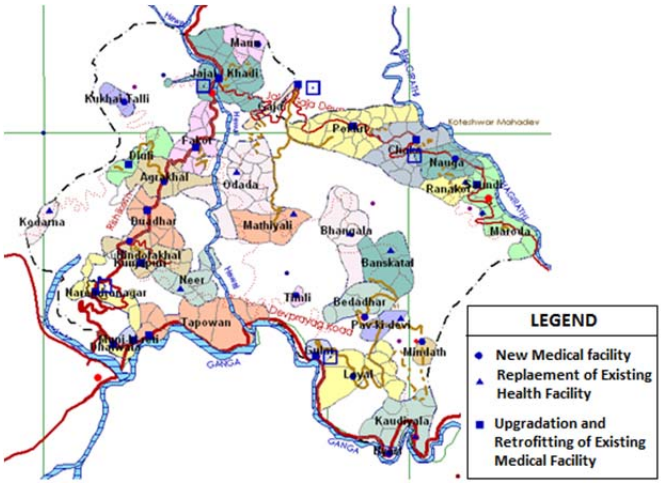


**Fig. 12: Medical camps with recommended medical facilities and dependent villages**

The establishment of medical camps during emergency situation should be in 34 settlements viz. Mathiyali, Timli, Mindath, Maun, Kodarna, Dhalwala, Banskatal, Kaudiyala, Pav-ki-devi, Bedadhar, Loyal, Maroda, Ranakot, Saundi, Nauga, Chaka, Pokhri, Odada, Gaja, Khadi, Fakot, Agrakhal, Diuli, Duadhar, Hindolakhal, Neer, Narendranagar, Tapowan, Kukhai Talli, Bhangala, Muni-ki-reti, Byasi, Gular, Kunjapuri (Fig. 12). These locations are decided for their better accessibility, approachability of dependent villages, already existing medical facility and manageable extent of damage during emergencies. Five control centers should be located at Narendranagar, Jajal, Gaja, Chaka and Gular owing to their strategic locations for procurement and distribution of emergency medical relief.

Doctors from other regions should be identified and suitably trained for emergencies during the pre disaster phase. The Disaster Management and Mitigation Center, which is the state level disaster management authority should identify and train the voluntary organizations working within the region, to supplement the emergency manpower requirements in the health sector.

## 9. CONCLUSION

Assessment of health facilities in a selected micro region of highly vulnerable Himalayas has highlighted their inadequacy because of structural vulnerabilities and scarcity of resources. The Himalayan settlements face such challenges basically because of inaccessibility of settlements. There has to be an optimum level of preparedness for any probable earthquake disaster in the region. At the same time resources from outside need to be identified and their provision in an emergency situation need to be planned on an urgent basis. This pilot study carried out for a seismic micro zone has the potential to be extended for the rest of the seismically vulnerable Himalayan region.

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