

**Non – structural seismic
vulnerability assessment of five
selected Community Health
Centres (CHCs) of Dehradun
district (Uttarakhand)**



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July 2012

Hospital
safety: Let's
work together

**Non – structural seismic vulnerability
assessment of five selected Community Health
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(Uttarakhand)**

A Report

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Foreword

Despite the harsh fact that non – structural losses during an earthquake often far surpass the structural losses, non – structural safety is often not accorded due importance. Loss of non – structural elements often hampers operational continuity of critical facilities on the aftermath of any disaster. This particularly holds good for hospitals that are expected to deliver additional services.

Contrary to the common perception non – structural mitigation is not cost intensive and greatly reduced the cost of repair and restoration in the post – disaster phase. It thus pays rich dividends and is thus an investment worth making.

This report is the result of the non – structural seismic vulnerability assessment undertaken in five Community Health Centres (CHCs) of Dehradun district. Rather than bringing forth various shortcomings this report is intended to draw attention of the Health Department authorities towards various weak links that might hamper its operational continuity of the CHCs on the aftermath of a major disaster. We are sure that the Health Department would take the report in a positive spirit and undertake various mitigation measures in a phased manner as suggested in the report.

The non - structural vulnerability assessment for any structure must however be accompanied by the structural vulnerability assessment as the behaviour of non - structural elements is dependent to a large extent upon the structural behaviour of the same at time of disaster. Structural vulnerability assessment could however not be undertaken because of non - availability of the structural drawings as also limitation of time. It is therefore recommended that the structural vulnerability assessment of the CHCs be carried out at the earliest and the recommendations of this report be modified / amended in the light of the same.

This report is the outcome of the efforts put in by the DMMC team that comprised of Dr. Girish Chandra Joshi, Ms Aneeta Salaria Ms Bhavna Karki. All are congratulated for their sincere efforts at different stages of report preparation.

Needless to say that this work would not have been possible without the support, cooperation and willingness of the Health Department and the doctors and staff of the individual CHCs. The doctors and other staff of the health centres were always ready and willing to help during the fieldwork that was undertaken between 1st and 8th June, 2012. Special thanks is owed to Medical superintendents of all CHCs who at every stage coordinated with different sections and helped the team in conducting survey within health centre premises.



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19th July, 2012
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1. Introduction

This report documents the findings of the non - structural vulnerability assessment of five community health centres (CHC) of Dehradun district. This report is intended to help the authorities of Health Department in better appreciating the vulnerability of the health centres so as to take up appropriate mitigation strategies for reducing the vulnerability.

However it must not be taken as being a substitute of comprehensive preparedness of the health centres for tackling any emergency and complete health preparedness of a hospital / health centre would depend on its structural and non - structural safety besides preparation of hospital preparedness and evacuation plans. At the same time these have to be backed by conduct of mock drills on a regular basis.

Before defining the methodology adopted for the non – structural vulnerability assessment of the community health centres, it would be necessary to establish an understanding about the seismic hazard present in the Dehradun district.

2. Seismic hazard in Dehradun district

Himalayan orogenic belt is divided into a number of tectonic blocks that are bound by regional tectonic discontinuities. Southernmost of these is Outer Himalaya that is bound to the north and south by Main Boundary Thrust (MBT) and Himalayan Frontal Thrust (HFT) respectively. Outer Himalayan tectonic unit has a number of E-W running synclinal valleys called duns. Dehradun, the capital of Uttarakhand is located in one such valley that is bound to the east and west by Ganga and Yamuna tear faults respectively (Fig. 1). Proximity to the active tectonic boundaries makes Dehradun vulnerable to seismic hazard. As per Seismic Zoning Map of India Dehradun falls in Zone IV where earthquake intensity on MSK Scale can reach VIII.

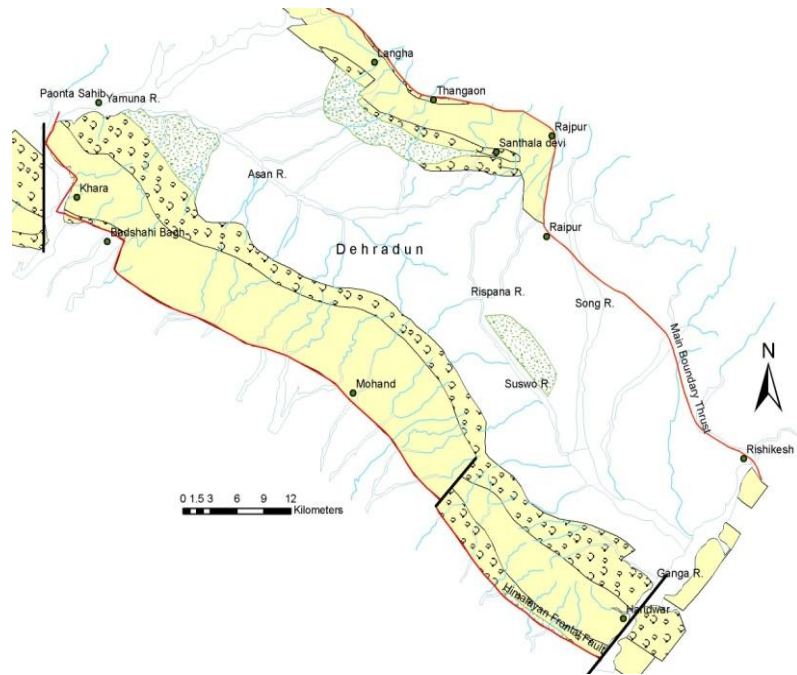


Fig. 1. Geo-tectonic setup of the area around Dehradun.

Dehradun is located at a distance of 255 km from India's capital, New Delhi and has been chosen as one of the Counter Magnets of the National Capital Region (NCR) and is being developed as an alternative centre of growth to help ease the migration and population explosion in the Delhi metropolitan area.

Dehradun also has a number of educational, research, training and corporate institutions that include Forest Research Institute (FRI), Indian Military Academy (IMA), Indian Institute of Petroleum (IIP), Survey of India (SOI), Wildlife Institute of India (WII), Oil and Natural Gas Corporation Ltd. (ONGC Ltd.), National Institute of Visually Handicapped (NIVH), Indian Institute of Remote Sensing (IIRS) and Wadia Institute of Himalayan Geology (WIHG).

In the previous 11 years, since the creation of the state, Dehradun has grown tremendously. In this period the population of Dehradun city has increased from 4, 47,808 (Census of India, 2001) to 5, 78,420 (Census of India, 2011) registering a decadal growth rate of 29.16 percent. In the same period the Municipal area of the city has increased by almost 20 percent (from 52.00 to 62.3 sq km).

With rapid growth of infrastructure and population seismic vulnerability of Dehradun has also gone up, particularly so due to non - compliance of building bye laws and other

safety related provisions. There is thus an urgent need to review the seismic vulnerability of the existing infrastructure as also to ensure compliance of the techno-legal regime.

Since hospitals are among the critical facilities that need to remain functional after any major disaster efforts needs to be made to reduce the vulnerability of the hospitals with due emphasis on non - structural vulnerability.

3. Hospital safety

Hospitals are occupied round the clock, all through the year, by large number of people and their services are all the more required on the aftermath of any disaster. It is therefore necessary to give additional importance to their safety related aspects so as to ensure that these sustain minimum loss at time of disaster and remain functional even after the impact. In view social, political and economic implications of the disruption of health facilities there is an emergent need to protect critical health facilities from disaster impact.

All the new hospitals therefore must be built with a level of protection that better guarantees their functionality and delivery of health services in crisis situations. This has also been set as one of the goals under the Hyogo Framework for Action.

Safe hospital is the need of the hour and safe hospital is one that would remain functional with the same capacity during and after a major disaster. For this planned efforts are required at three different levels that include structural safety, non - structural safety and medical preparedness related aspects.

Structural safety is basically a part of the building design and ensures that the same is able to withstand weight of the building (dead load) and that of its contents and the people (live load) together with the impact of wind and ground shaking (dynamic load). The non - structural elements include all those components that become part of building except the basic structure. These include furniture, electric and mechanical appliances, equipments, and the stored items. Therefore a safe hospital must be structurally, non-structurally and functionally sound so as to be in a position to deliver continuous services during and after a disaster.

Heavy investment is often incurred on non - structural components, particularly in a hospital and this many a times far exceeds the cost of the structure. Moreover non -

structural aspects of any hospital are vitally important for its smooth functioning. These aspects are however often neglected. So there is immediate need to focus on this very aspect of hospital safety besides the structural component of hospital buildings.

In view of the above non - structural vulnerability assessment of five selected community health centres located in Dehradun district was carried out. The aim of this study was to assess the present state of various non - structural elements and suggest mitigation measures for reducing the vulnerability. The report is thus intended to provide the Health Department with an outline so as to formulate a comprehensive vulnerability reduction strategy.

It is however required to be noted that the structural vulnerability of these buildings is also required to be assessed before any plan for vulnerability reduction of these health care facilities is put forth.

4. Methodology

The vulnerability assessment involved inspection of all the health centres according to a format that included all the major non - structural vulnerability related components, i.e. architecture, medical equipment, furnishing, administrative system, electricity, communication, water supply, storage and clinical gases and the like.

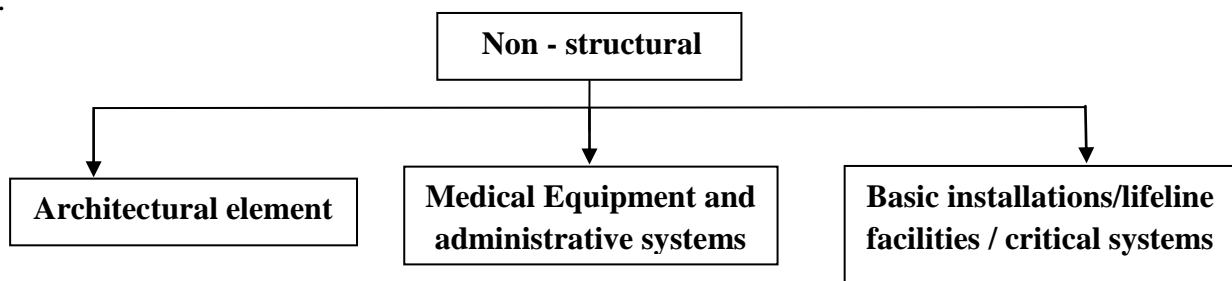
Every section of the health centres was surveyed and risk rating was given. Based on this, zones of high, medium and low risk were delineated within the health centre building. The assessment thus largely covered three aspects; architecture, equipment and services / lifelines.

5. Development of the survey format

A number of studies carried out in India and abroad on hospital safety and non - structural vulnerability assessment of hospitals were first studied with particular focus upon the preliminary data collection strategy employed in these. Based upon this a survey format was developed. It was attempted to incorporate salient features of the previous studies into this format.

Based upon the non - structural elements the survey format was split into different categories. The risk of a particular non - structural element was assigned low, moderate and high risk rating / priority depending upon the threat it would pose to life safety, economic value and operational continuity of the hospital. Based upon this suitable mitigation option was intended to be put forth.

The survey format was intentionally designed to be comprehensive so as to include almost all the non - structural elements likely to be encountered in any hospital. The categories given below were covered under the non - structural vulnerability assessment and the same were detailed in the survey format.



Architectural elements: This was intended to cover various components that include non load bearing exterior walls, partition walls, inner partition systems, windows ceilings and lighting systems.

Medical equipment and administrative systems: These include medical and laboratory equipments and also all the associated office furniture. Generally, equipment and furniture are built and installed taking into consideration their normal, everyday use. It is common therefore to observe lack of proper support or anchorage in the hospitals components as well. This increases the risk of objects tipping over or sliding during an earthquake, ground shaking.

The basic installations: This was to include electricity, communication and water supply systems in addition to the facilities for storage of water and clinical gases.

6. Community Health Centres (CHCs)

The Health Policy of India envisages a three tier structure comprising the primary, secondary and tertiary health care facilities in order to bring health care services within the reach of the people. The primary tier is designed to have three or four types of health care institutions, namely, a State Allopathic Dispensary (SAD) which is the lowest unit, a Sub-Centre (SC) for a population of 3,000 – 5,000, a Primary Health Centre (PHC) for a population of 20,000 to 30,000 and a Community Health Centre (CHC) as referral centre for every four PHCs covering a population of 80,000 to 1, 20,000. At the secondary level health care is provided by health care institutions in urban areas (district and base hospitals) which are well equipped with sophisticated diagnostic and investigative facilities. Tertiary level of health care facilities act as advanced referral centres and these are medical colleges with hospital.

Community health centres are the highest level of the rural health care institutions. These centres were required to act as referral centres for the patients requiring advance health care facilities. The objective of having a referral centre for the primary health care institutions is two-fold; to make modern health care services accessible to the rural people and to ease the overcrowding in the secondary and tertiary health care facilities. The standard CHCs in India were accordingly designed to be equipped with, i) four specialists in the areas of medicine, surgery, paediatrics and gynaecology, ii) 30 beds for indoor patients, iii) operation theatre, labour room, X - Ray machine, pathological laboratory, standby generator and the like along with the complementary medical and para - medical staff.

The CHCs surveyed in the Dehradun district are designed as per the standard set for their establishment and are similar in their setup ranging from machinery to different sections. The CHCs taken up for the non - structural vulnerability assessment are located at Doiwala, Raipur, Sahaspur, Vikasnagar and Mussoorie (Fig. 2).

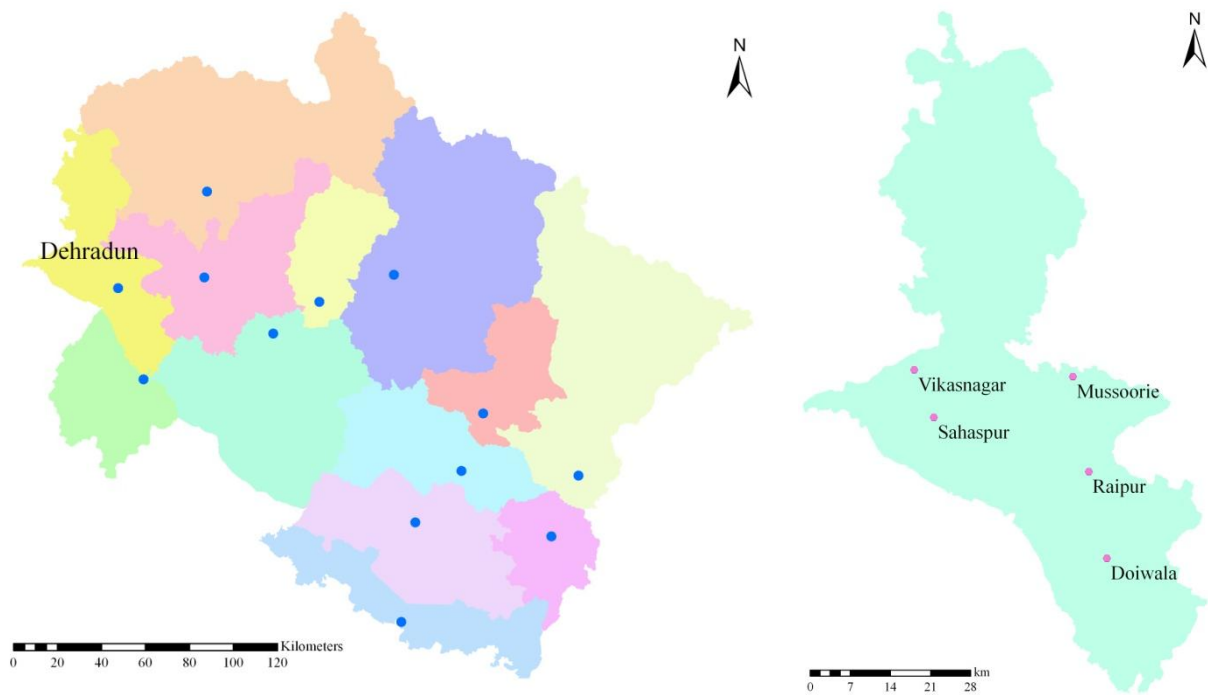


Fig. 2. Location map of the CHCs taken up for non – structural vulnerability assessment.

All the above CHCs are almost similar in bed capacity and house similar kind of equipments. Therefore instead of discussing each section of every CHC separately, different sections of all the CHCs have been clubbed together and compared with each other. This would help in building a comparative vulnerability scenario and would help in concluding whether the CHCs require more or less similar non – structural mitigation measures or these have to be dealt with separately.

The CHC Doiwala is located in Doiwala town that falls in southern portion of the Dehradun district. It is located at a distance of 21.7 km from the Dehradun city on Dehradun – Haridwar National Highway. The health centre is in close proximity both NH 7 and the railway station. It is a 30 bedded health facility catering to the needs of surrounding population. The CHC has easy accessibility as the same is located approximately 200 metres from the NH.

The CHC at Raipur is located at a distance of 7 km from Dehradun city. It is situated close to the road leading to Mal Devta and caters to the needs of surrounding rural population of Raipur block of Dehradun district. It is accessible through a well maintained metalled road.

The CHC at Sahaspur is located in the Sahaspur town and is at a distance of 21 km from Dehradun city. The health centre is situated on the NH itself and therefore it enjoys good approach and accessibility. On an average the health centre caters to the needs of around 200 patients who visit the same daily from the surrounding area.

The CHC at Vikasnagar is at a distance of 40 km from Dehradun. Of all the CHCs taken up under the present study one at Vikasnagar has the largest service area and is even visited by people from across the state border; i.e. from Himachal Pradesh. Of the five only this CHC has blood storage facility. This CHC is visited by 300 to 400 patients daily and the monthly patient turn-around is about 6,000.

The CHC at Mussoorie is located near Landour. The CHC however does not have all the facilities and most work load of this centre is taken care of by Saint Marry Hospital located in the Main Bazar area. The CHC however has basic infrastructure, especially in the gynaecology and dental sections. The new building of CHC is in initial stages of construction and soon the health facilities are to be shifted there. Therefore in case of CHC Mussoorie the mitigation strategies can well be taken as guidelines that are to be adhered to while establishing different sections in the new building premises.

As concluded from the discussions held with the doctors and office staff of all the five CHCs on an average 200 to 350 patients visit these facilities daily. Most of these are from the adjacent villages and are not in a position to afford expensive treatment offered by private healthcare facilities. These CHCs mostly cater to the needs of the rural population and it is need of hour to make these safe; both structurally and non – structurally, so as to ensure that these remain functional during and after any natural disaster and continue to provide emergency services to the surrounding population.

These CHCs generally have two or three major medical equipments and in case of intense ground shaking or fire there is risk of their getting severely damaged. This would have immediate adverse effect on the treatment of patients.

This report documents the non - structural vulnerability assessment work but the structural vulnerability of these CHCs is also required to be assessed.

7. Non - structural seismic vulnerability survey of the CHCs

The survey was undertaken for all the sections of the health centre in accordance with the format developed earlier. The results have been presented with respect to the different categories of non - structural elements. The observations have subsequently been tabulated and analysed and the conclusions have been drawn on the basis of the same.

7.1 Architectural elements: The architectural elements form an integral part of any building and enhance its functionality besides improving building aesthetics. These health centres are designed to cater to the need of rural population and are intended to have minimal facilities. The survey reveals that the health centre contains certain vulnerable non - structural architectural elements. Of these fans and glass partitions are worth mentioning. It is however worth noting that the CHCs do not have an elaborate use of glass in the partitions. Only in some units aluminium framed glass partitions have been used within sections. These include neonatal care unit of CHC Doiwala, emergency service section of CHC Doiwala and some sections of CHC Vikasnagar. Absence of proper anchorage was however observed in all the CHCs. It is worth noting that most fans are placed over the patient beds and in staff room. These pose a threat to the life safety. Ceiling fans would swing during ground shaking and their snapping off could cause casualties. The swing of the fans can be limited by provision of chains / wire that would attach the fan body to the ceiling.

Most partitions in the CHCs were observed to be done using masonry walls. The use of false ceiling was not observed in any of the CHCs. However light fixtures in the operation theatres of all the CHCs are required to be checked and properly strapped and anchored as falling of such fixtures can cause danger to life safety.

7.2 Medical equipments, furnishing and administrative systems in different sections of CHC: In most hospitals equipments, furnishing and administrative systems comprise the major proportion of non - structural elements. Detailed survey of the non - structural elements of the hospital gave us an overview of the equipments placed in different sections.

Majority of the equipments used in the health centres were observed to be trolley mounted. These are required to be properly anchored or hooked.



Fig 3. View of medical storage at CHC Doiwala.



Fig 4. View of medical storage at CHC Raipur.

7.2.1 Medical store room: The medical store room is the area of the CHC where all the necessary medicines and drugs are kept for safe storage. In every CHC one room was observed to be designated as medical store room where all medicines and drugs and other supplied were placed in racks (Figs. 3 – 7). The positioning of the furniture as also racks was observed to be such that in an event of strong ground motion their toppling could block the exit (Fig. 4) or pose threat to the person sitting beneath these (Fig. 5) besides damaging the stored medicines and others. Racks in the medical stores of all the CHCs were observed to be highly vulnerable and these are required to be properly anchored. With regard to medical storage the problem is observed to be similar in all the CHCs. The racks and cupboards were not anchored to the wall and front guards and straps were nowhere observed in the racks.

In case of intense ground shaking toppling of racks and cupboards would pose threat to life safety in addition to the loss of medicines. Thus the medical store sections in all the five CHCs are identified as being highly vulnerable. However simple mitigation strategies can reduce the risk to a considerable extent.



Fig 5. Medical storage at CHC Sahaspur.



Fig 6. Medical store at CHC Vikasnagar.

7.2.2 Pathology lab: A few equipments present in the pathology labs of the CHCs under the focus of present study are essential for smooth delivery of the health services (Figs. 8 – 11). The pathology labs of all the CHCs have a few bench mounted equipments and of these incubators, a heavy piece of equipment was observed to be placed without proper support system or anchorage (Fig. 9 and 11). The anchoring with the help of brackets and angles needs to be provided at the base for all bench mounted equipment in CHCs.



Fig 7. Medicines placed in racks in CHC Mussoorie.



Fig 8. View of pathology lab of CHC Doiwala.



Fig 9. Bench mounted incubators placed without anchorage at CHC Raipur.

Proper mitigation strategy must be adopted in order to reduce risk of the incubators toppling down. Though vital for the treatment of the patients these equipments are in limited numbers in all the CHCs and thus the mitigation measures can be easily implemented without much delay.

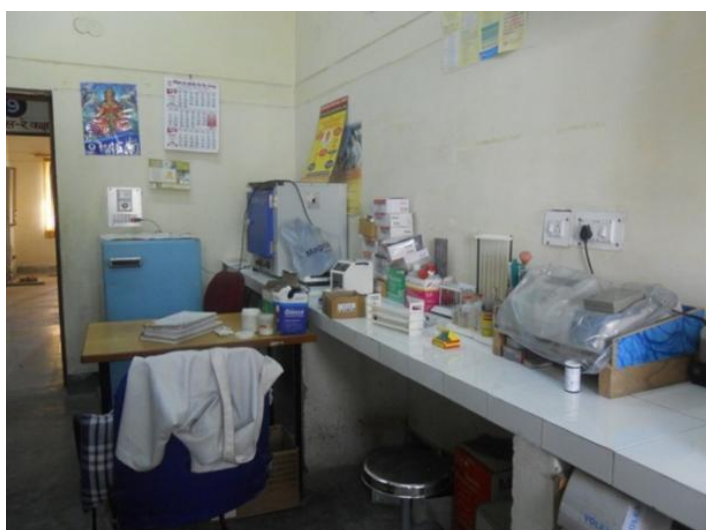


Fig 10. View of the pathology lab of CHC Sahaspur.

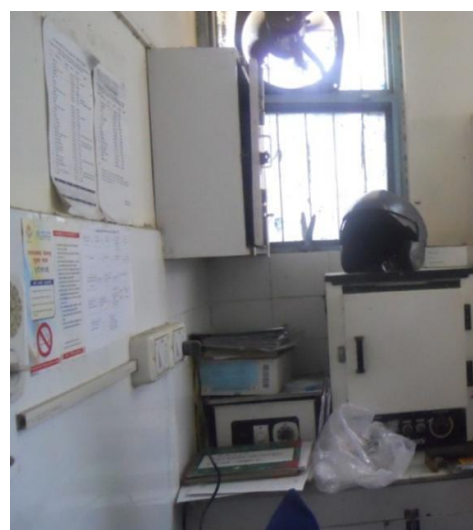


Fig 11. Incubators placed without anchorage in the pathology lab of CHC Vikasnagar.

7.2.3 X - Ray rooms: All the five CHCs taken up for the assessment, except that at Mussoorie, were observed to be equipped with the X - Ray machines (Figs. 12 – 15). X – Ray is an important piece of instrument particularly on the aftermath of a major earthquake event in which orthopaedic injuries dominate the scenario.

It was nice to note that due care has been taken in all the four CHCs to properly fix the X – Ray machine to the ground with the help of bolts.



Figs. 12 and 13. View of X - Ray machines at Doiwala and Raipur CHC respectively.

During the survey all the X - Ray machines were observed to be properly bolted to the floor to avoid the risk of falling. These thus fall under medium to high vulnerability class depending on severity of earthquake. The connections however are required to be checked to be assured of their safety. This single piece of important equipment caters to the needs of large rural population of the areas falling in the proximity of the CHCs and any fault in it on the aftermath of any major disaster would add the misery of the affected population.



Fig. 14. View of X-Ray machine at CHC Sahaspur.



Fig 15. X - Ray machine at CHC Vikasnagar.



Fig. 16. Emergency section of CHC Doiwala.



Fig. 17. Emergency section of CHC Raipur.

7.2.4 Emergency section: This section of the CHC deals with emergency cases. The composition of the non - structural elements was observed to be similar in this section of all the CHCs (Figs. 16 – 18). The main equipments observed in the emergency section of all CHCs include suction machine and oxygenator or oxygen cylinder. In addition to these some emergency supplies were observed to be present on the trolleys.

Vulnerability of this section therefore ranges between medium to high. The equipments placed in this section can be easily anchored to reduce the vulnerability.



Fig 18. View of Emergency section of CHC Vikasnagar.

7.2.5 Patient wards: Each community health centre is 30 bedded. Except for CHC Mussoorie all were observed to be running to their capacity. Upon admission the patients were observed to be placed in the wards as per the requirement of their treatment. No equipments were observed to be placed in the wards. The observed cause of concern in the wards includes wheel mounted beds and normal glass windows alongside the patient beds (Figs. 19 - 22).



Fig 19. Patient ward at CHC Doiwala.



Fig 20. Patient ward at CHC Raipur.

Glucose / saline / blood supply stands in all the CHCs were observed to be placed close to the patient bed. These are sure to fall down during any major ground motion. These are therefore immediately required to be anchored to the patient beds.



Fig. 21. View of the patient ward CHC Sahaspur.



Fig 22. View of the patient ward at CHC Vikasnagar.

7.2.6 Labour room: Labour room forms one of the important sections of the CHCs (Figs. 23 – 29). The people living in the areas surrounding these CHCs do not have good

economic condition and therefore they are not in a position to afford private nursing homes for maternity relief. Women from the adjoining areas visit these CHCs for this facility.



Figs. 23 and 24. View of the labour room at CHC Doiwala. Unanchored oxygenator, baby incubators and oxygen cylinders can be observed in the photograph.

Key equipments observed in this section include light, oxygen cylinder / oxygenator, suction machines, supplies on trolley and small boilers. The labour rooms of all the CHCs thus have common equipments and these were observed to be unanchored.



Figs. 25 and 26. Views of the labour room of CHC Raipur.

The unanchored equipments placed in the labour rooms are likely to topple and get damaged during strong ground motion. This would disrupt functioning of this important section that would be required even on the aftermath of a major disaster.



Fig. 27. Views of the labour room of Sahaspur CHC.



Fig. 28. View of the baby incubator placed in the delivery room of CHC Vikasnagar.

These equipments can be anchored using simple techniques and thus both loss of functionality and economic loss can be avoided. And this is not going to be a resource intensive affair. Therefore proper mitigation measures must be adapted in these sections. By reducing the risk of loss of the equipments the vulnerability of this section can be reduced to a considerable extent.



Fig. 29. View of the labour room of CHC Mussoorie.

7.2.7 Operation and pre-operative section: The operation theatre section is always considered to be a very critical section of every health unit (Figs. 30 – 34). It is all the more required to remain functional during and after any emergency situation. Therefore utmost care is required to be taken to ensure safety of this section.

Anaesthesia machines are inseparable part of any operation theatres and their safety is a must for ensuring functionality of the operation theatre. Anaesthesia machines in the CHCs were however observed to be placed on particularly tall and narrow trolleys. Strong shaking can cause these to slide or topple off the trolleys.



Figs. 30 and 31. View of operation theatre section of CHC Doiwala. Wheel mounted OT lights and ventilators placed on trolleys can be observed in the photographs.

Operation theatre has to be at the same time well lit. These are therefore provided with special lights. These lights were observed to be wheel mounted (Figs. 30, 33 and 34) in all the CHCs except the one at Raipur where it was observed to be mounted on the roof (Fig. 32).

Strong shaking can cause wheel mounted lights to slide past, topple and get damaged. These can also break off their support and fall. If not secured properly the roof mounted light can also fall apart and break.

After an earthquake many patients might require surgery and therefore it is a must to ensure that the operation theatre remains functional even after experiencing strong ground motion.



Fig. 32. View of the operation theatre of CHC Raipur. OT light has been fixed to the ceiling.



Fig. 33. Wheel mounted OT lights and supplies on racks in CHC Sahaspur.

This section is of immense importance during and after any emergency and therefore all the equipments and other fixtures have to be properly secured to ensure their safety even during a major ground shaking. The non - structural mitigation measures suggested for the operation theatre sections have to be therefore implemented with proper guidance and as per health centre's convenience.



Fig. 34. OT section of CHC Mussoorie.

7.2.8 Cold storage / deep freezer / ice lined refrigerator: The scale of operation of the CHCs is quite low as compared to the secondary health care facilities. These are however the main centres catering to the health care related requirement of the rural population. The CHCs at the same time have limited stock of medicines. Of these some of the important ones have to be kept under refrigeration for maintaining their quality, efficacy and potency. For this purpose CHCs have been provided with refrigeration units (Figs. 35 – 38).



Figs. 35 and 36. View of the freezers at CHC Doiwala that have no anchorage support and the placement of the cupboards in this unit pose life risk to the staff sitting close by.

In the CHCs the refrigeration units were observed to be placed without any anchorage support (Figs. 35, 37, and 38). In case of intense ground shaking there exists possibility of these equipments skidding and getting overturned. This would lead to the loss of the important medicines and drugs that would adversely affect the functional and operational continuity of these centres.

The refrigeration units are therefore required to be anchored to the ground with the help of bolts. Apart from the safety of the refrigeration units it is necessary to ensure safety of the persons working in this important section. It was observed in CHC Doiwala that cupboards were placed close to the sitting area and unsecured supplies were kept over these (Fig. 36). This practice needs to be discontinued immediately as the supplies kept over the cupboards can slip past even by slight non – seismic disturbance as also during

strong ground motion. In both the cases life safety of the persons sitting close to the cupboards can get jeopardised.



Fig. 37. View of the refrigeration unit at CHC Raipur.



Fig. 38. View of the refrigeration unit at CHC Mussoorie.

7.2.9 Blood Bank section: Amongst all the community health centres taken up under the present study only CHC Vikasnagar has blood storage facility. A small freezer has been provided for this purpose and the same is placed in the blood bank section of the CHC (Fig. 39). In case of strong ground motion there exists a possibility of this important piece of equipment skidding and toppling and thus getting damaged.



Fig. 39. View of the refrigeration unit of the Blood bank unit at CHC Vikasnagar.

In case of emergency supply of blood is vital and the loss of this important facility would adversely affect the functional continuity of the centre. In order to avoid such a situation it must be properly anchored. To reduce the vulnerability of this section, the freezer is required to be anchored at the base with the help of brackets and bolts.



Fig. 40. View of the dental chair placed in CHC Raipur.

7.2.10 Dental section: Dental section forms an important part of the CHCs. As the PHCs do not have this facility people from far and wide visit the CHC for addressing their various dental ailments. The safety of this section is thus required to be given extra attention. This section was observed to be laid out in the same pattern in all the CHCs (Figs. 40 – 42). Dental chair was observed to be the main equipment in this section. The dental chair was not wheel mounted but the same was also not properly anchored to the ground.

There thus exists possibility of sliding and damaging other equipments during strong ground motion. The chair must therefore be properly anchored to the floor with the help of bolts. Moreover it is an immovable item and therefore can easily be anchored to reduce chances of damage.



Fig. 41. View of the dental section of CHC Raipur.



Fig. 42. View of the dental section of CHC Mussoorie.

7.2.11 Staff room and OPDs: Safety measures in both OPD and staff room are often taken casually. It however needs to be realised that OPD is one of the most crowded areas of any health care unit and any exigency in this section can jeopardize the safety of a number of human beings.

Staff room is the place where the medical and para – medical staff of the hospital relax and unsafe conditions in this section can disrupt the hospital functions even though the hospital does not sustain any technical problem related to its operability. The safety of these sections is thus required to be accorded high importance.



Fig. 43. View of the staff room of CHC Doiwala.



Fig. 44. Cupboard placement in CHC Raipur poses a risk to life safety.

The problems with the staff room and OPD of all the CHCs were observed to be similar in all the CHCs (Figs. 43 – 47). The placement of cupboards and racks in these sections was observed to be faulty. In the event of strong ground motion these could block the exit routes besides jeopardising life safety. It was observed during the survey of the CHCs that wrong placement of furniture and other items have made many sections of the CHC highly vulnerable. Besides the staff room these include medical store section and cold storage section. The sitting arrangement in these sections was observed to be such that in case of intense shaking it would pose risk to life safety.



Fig. 45. Placement of cupboard might lead to blockage of exit and risk to life safety at CHC Sahaspur.



Fig. 46. View of the CHC Vikasnagar where placement of the cupboards can injure to the staff.

The OPDs of majority of the CHCs were however observed to be relatively less vulnerable due to the absence of elaborate non - structural elements except for a table and chair for the doctor in charge.

But the staff rooms and other spaces where the staff usually sits were observed to be highly vulnerable as far as risk to life safety is concerned (Figs. 43 – 47). The vulnerability can however be easily lowered by relocating the elements and providing these with additional anchorage support.

Relocation is required to be undertaken immediately wherever toppling of the cupboards is likely to block the exit or threaten life safety.



Fig. 47. View of pharmacy room in CHC, Mussorie

7.3 Basic installations / lifeline facilities / critical systems: This covers the electrical supply lines, generators, geysers, air conditioning facility, control panels and transformers besides the water supply and clinical gas storage facility (oxygen cylinders) and fire protection system.

Leaks from clinical gas supply lines could pose a fire hazard. The electrical and mechanical equipment are a necessary to keep the health centre functioning. All these are at the same time vulnerable to earthquake damage. It is therefore necessary to get all these systems regularly checked for any faults.

7.3.1 Electric and water supply: The electric supply of the CHCs is through common transformer of the locality. Some of the CHCs however have generators to maintain electric supply during emergency. CHC Sahaspur however does not have generator facility. The generators in other CHCs were observed to be anchored but these are required to be provided additional support so as to rule out the possibility of their falling down (Figs. 48 and 49).



Fig. 48. View of the well fenced and covered generator at CHC Raipur. Additional support at the base would ensure that it does not slip past.



Fig. 49. View of the generator at CHC Vikasnagar. It is required to be anchored to the floor to avoid the danger of its falling down.

Only a few geysers and air conditioners were observed in the CHCs. These are however required to be properly anchored (Fig. 50).



Fig. 50. View of the geyser at CHC Sahaspur.



Fig. 51. View of electric panel at CHC Raipur.



Fig. 52. View of electric panel at CHC Sahaspur.



Fig. 53. The electric wires must be properly covered if not it will lead to short circuit , CHC Doiwala.

Electric wiring was generally observed to be proper and most of the distribution boxes (DBs) were observed to be covered. However at some places wiring was not proper and proper conduiting was required (Figs. 51 – 54). This issue is required to be addressed immediately as it could lead to short circuiting and other electrical hazards.



Fig. 54. DB box and the open electric wires at CHC Vikasnagar.



Fig. 55. Unanchored roof water tanks at CHC Vikasnagar.

The water supply in all the CHCS was observed to be through roof top water tanks. These tanks were nowhere observed to be anchored (Fig. 55). It must be kept in mind that water is going to be scarce resource in case of any emergency and therefore every

care must be taken to ensure that the storage tanks are not damaged in case of an emergency. In order to prevent toppling down of these tanks and to prevent injury to anyone due to their falling down these must be properly anchored.

7.3.2 Oxygen cylinders: The CHCs generally don't have a large requirement of oxygen cylinders and therefore only a few were observed to be placed in different CHCs. It was informed that these cylinders are refilled from outside and as such there is no earmarked storage space for the oxygen cylinders in the CHCs.

The cylinders were however observed to be placed without any kind of anchorage or hook chain system (Figs. 56 – 59). These can easily topple and roll around in case of intense ground motion. This has the potential of damaging the other equipments kept in the surroundings besides injuring somebody and posing risk of leakage, fire and other secondary hazards. It is therefore necessary that these be anchored properly and this should not be difficult as there are not many oxygen cylinders in the CHCs.



Fig. 56. Cylinders placed without anchorage at CHC Doiwala.



Fig. 57. The unanchored cylinder and suction machine at CHC Raipur.



Fig. 58. Unanchored oxygen cylinders outside OT at CHC Vikanagar.



Fig. 59. The Framed oxygen cylinder lacking support from wall at CHC Mussoorie.

7.3.3 Fire Extinguishers: Except for CHC Doiwala two fire extinguishers were observed to be installed in the CHCs for tackling fire related exigencies. These were however not observed to be properly mounted (Figs. 60 and 61).

In case of strong ground shaking there is a possibility of their falling down and rolling past to some other place. Therefore to avoid such a situation during an emergency the fire extinguishers in all the CHCs are required to be properly anchored.



Fig. 60. View of the improperly mounted fire extinguishers at CHC Doiwala.

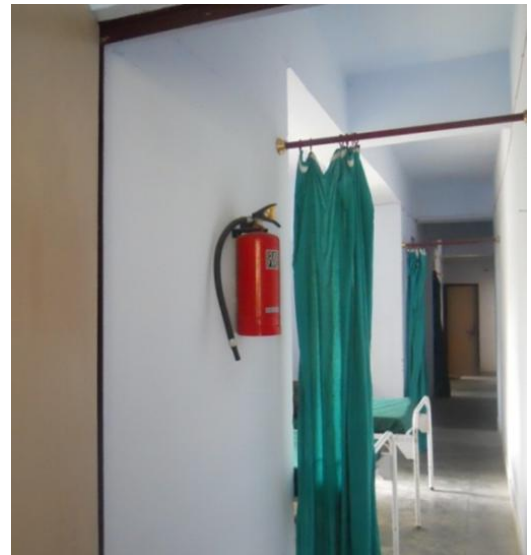


Fig. 61. View of CHC Mussoorie. The fire extinguisher need anchorage



Fig. 62. View of the autoclave at CHC Raipur.



Fig. 63. View of the sterilizers in CHC Sahaspur.

7.3.4 Autoclave / high pressure sterilizer section: Autoclaves are required for sterilizing the surgical instruments and laboratory equipments placed in sterilization room. Functioning of this section has therefore direct implications on the functioning of various other sections. This section is therefore important for ensuring operability of the CHC and therefore the safety of this section cannot be compromised.



Fig. 64. View of the Sterilizer at CHC Vikasnagar.

The autoclaves in all the CHCs (Figs. 62 – 64) were however observed to be unsecure. In the event of strong ground shaking these can topple down which might damage the autoclaves. In the absence of this important equipment the health centre would not be able to sterilize the equipments which a necessary pre-condition for performing various operations.

The legs of the autoclave must therefore be anchored to the floor with the help of brackets or the bolts. Option of concreting the base of the autoclaves can also be exercised as it is not movable equipment and can be fixed to the ground permanently for reducing the vulnerability.

8. Summary of the vulnerability assessment

Based on the survey carried out and the analysis of the same a table has been prepared to put forth the summary of recommendations (Table 1). It is intended to be utilised for ease of reference while undertaking the mitigation measures in the CHCs. Because of the similarity in the design as also constitution of different sections of the surveyed CHCs combined and comprehensive mitigation measures are being put forth. These are thus applicable for all the CHCs.

Table 1: Vulnerability of different sections and the recommendations to be adopted for CHCs.

Sl. No.	Aspect	Recommended strategy
1.	Vulnerability of architectural elements	
a)	Glass used and the windows	In all CHCs plain glass has been used everywhere in the windows. On breaking this glass tends to split and convert into sharp shards that might cause injury besides hindering smooth movement. The glass can however be replaced especially in the operation theatre and the wards where the windows are located adjacent to the patient beds.
b)	Partitions	Aluminium glass composite partitions have been used in

		<p>some sections of CHCs. During strong ground shaking the partitions might separate from the supporting channels and overturn or the glass might get dislodged. Both the situations would result in a major threat.</p> <p>It is therefore recommended that the partitions be checked for their stability by an engineer and the glass used in the same be secured with the help of plastic lamination.</p>
c)	Light fixtures	<p>False ceiling has nowhere been used in the CHCs.</p> <p>Light fixtures are however present, especially in the OT section of the CHCs. Fluorescent tubes used in the light fixtures can also fall out and break during an earthquake.</p> <p>The light fixtures attached to the ceiling should therefore be provided with independent support. Swinging of light fixtures during an earthquake can further be limited by providing wires that attach the fixture to the body of the ceiling.</p>
d)	Ceiling fans	<p>Anchorage and Support</p> <p>All the fans need extra support to decrease the risk to life safety.</p>
2.	Vulnerability of sections and medical equipments	
a)	Operation theatres	<p>Anchorage and support</p> <p>Majority of the equipments in OT being wheel mounted these are highly vulnerable. The equipments used in the operation theatres need to be mobile and therefore possibility of their permanently being fixed is ruled out.</p> <p>Anchoring has therefore to be done in the OTs in a manner that provided for the needed mobility and at the same time ensuring safety.</p> <p>Such an anchoring has to ensure that the equipments are fixed during the operation at the required place and these can be secured at appropriate places afterwards.</p> <p>Tying all the equipments to a steel frame can reduce the vulnerability of the section. Providing anchor bolt both in the ceiling as well as in the floor can help in placement of</p>

		<p>equipment rack close to the OT.</p> <p>At the same time provision of appropriate anchor bolts should be provided in the walls of operation theatre so that the equipments could be secured when not in use.</p>
b)	Wards	<p>One ward of the CHCs consists of only 4 or 5 beds. There are minimal non - structural elements on the walls.</p> <p>The glucose / drip stands placed alongside the beds need anchorage. The oxygen cylinders if being used in the ward must be placed in a sturdy frame that should be attached to the wall with the help of hook and chain.</p> <p>The wards of the CHCs are very small and there is no machinery and equipments housed in these. Existing vulnerability of the wards can therefore be significantly reduced by adopting a few mitigation measures.</p>
c)	Medical equipments (X – Ray, ultrasound and suction machines, incubators, ventilators, oxygenators, and freezers)	<p>Even though there are only a few medical equipments in the CHCs risk of their being damaged has to be minimised as these cater to the needs of the surrounding rural population and there do not exist alternative health care centres in the surroundings. It is therefore necessary to undertake simple mitigation measures.</p> <p>Hooking, strapping and anchorage</p> <p>Development of proper anchorage system using chains and hooks can reduce the vulnerability of the sections having wheel mounted equipments. For example ventilators and anaesthesia machines in the operation theatre of CHCs are wheel mounted and provision of chains on the walls to hook these can effectively help in reducing their vulnerability.</p> <p>Only a few oxygen cylinders were observed in the CHCs. These have however to be properly hooked wherever these are placed.</p> <p>The emergency supplies were observed to be on the trolleys. All the supplies must be properly strapped and the trolley hooked to the wall with help of chains.</p>

		<p>Only CHC Vikasnagar has the blood bank section. It is provided with a small freezer that has to be properly anchored with the wall as well as floor with help of L brackets and angles. Ensuring the safety of the freezer is a must as blood would be a vital requirement during emergencies. If not properly anchored it would lead to loss of blood and thus jeopardize life safety and effect on the operational continuity of the health centre.</p> <p>The freezers provided for storing medicines and drugs have also to be anchored properly to the floor to avoid loss.</p>
d)	Staff room, medical store and OPD	<p>Removal, relocation and strapping</p> <p>The strapping must be resorted to for all the medicines placed in the chemist shop as well as in the store room of the CHCs. The racks housing the medicines and drugs must be provided with front guards and proper anchored to the walls.</p> <p>Similarly in OPDs there aren't much of non - structural elements the placement of cupboards needs to be changed at some sections.</p> <p>It has been observed that the cupboards and racks in the staff room and other sections of the CHCs are so placed that these might jeopardise life safety besides blocking the exit routes. The placement of these is therefore required to be changed. These are also required to be appropriately anchored to the walls.</p>
3.	Basic installations/lifeline facilities / critical systems	
a)	Generators	<p>All CHCs don't have facility of generators. The ones that have this facility have however to ensure their proper anchorage.</p> <p>Restricted mobility / anchorage</p> <p>The generators must be anchored to the ground with the help of bolts and fasteners so as to ensure that these do not slip and topple during strong ground motion.</p>
b)	Geysers	The CHCs have only a few geysers that are mounted on the

		<p>walls. Toppling of geysers can lead to breakage of water and electricity supply lines and cause electrical hazard.</p> <p>The simple anchoring of geysers to the walls as observed in the health centres would not be able to resist the earthquake forces. Therefore these should be provided with strapping. The geysers must have straps around top and bottom and these should be bolted to the wall.</p>
c)	Air conditioners	<p>Operation theatre is the only place in the CHCs where air conditioners have been provided.</p> <p>Anchorage and support</p> <p>Strong shaking would cause the air conditioners to fall apart. These have therefore to be provided proper anchoring.</p> <p>The AC units were observed to be placed close to the edge of the ceiling. These therefore pose a falling hazard. These should therefore be relocated. The AC units could additionally be provided with straps running across the body so as to anchor these to the ground.</p>
d)	Fire extinguishers	<p>Anchorage</p> <p>The fire extinguisher must be properly anchored to the wall with the help of chains in a way that it permit movement but does not allow the fire extinguisher to fall.</p>
e)	Autoclaves / gas tanks	<p>Anchorage (concreting at the base)</p> <p>The heavy autoclaves / sterilizers placed in the CHCs need to be properly anchored to the floor. Since these are the immovable items concreting would be the appropriate strategy. Proper anchoring is also required for the legs of the sterilizers.</p>

The vulnerability of the CHCs is observed to range between low and high. Since the CHCs have limited equipments the number of non - structural elements is greatly reduced. A few equipments are however necessary for the functioning of these centres. Damage to these would hamper the operational continuity of the health centres and therefore appropriate mitigation measures are required to be undertaken at the earliest.

Moreover these CHCs mostly cater to the needs of the surrounding rural population and there are no alternative health care facilities available in the vicinity these CHCs have to remain functional during and after any major disaster event.

9. Risk assessment

Risk assessment helps in identifying the vulnerable areas in the CHCs on the basis of the loss to life, function or property in the event of damage. The risk assessment involves not only rating the risk but also the suggestive options to reduce the risk. Thus the assessment helps in prioritising the mitigation process in the CHCs.

In order to identify the type of risk associated with the various components in case of an earthquake, all the individual equipments in every section of the health centres were surveyed in detail. The surveyed components were then given risk ratings with regard to two different earthquakes; a medium sized earthquake of intensity VI to VII in Modified Mercalli Intensity (MMI) scale and a severe earthquake of intensity VIII to IX in MMI scale. The type of risk was accordingly ascertained. There are basically three types of risk associated with non - structural damage. All of these have been discussed in detail in the sections below.

- i) **Life safety:** This risk is associated with the non - structural element falling on people and capable of causing injury. An element which can cause death, serious or moderate injury would possess risk of life safety.
- ii) **Loss of function / operational continuity:** The damage to medical equipments in a CHCs would hamper their effective functional continuity after a disaster. Many a times there is a risk that non - structural damage would make it difficult to carry out the necessary functions within the CHC premises.
- iii) **Loss of property / economic continuity:** Most medical centres house costly medical equipments in their premises. Damage to non-structural element of the CHC building can therefore lead to substantial economic loss. While assessing the individual component of the CHC this aspect has been taken care of. The sections having costly and heavy machinery have been accordingly given high risk rating since their loss would cause the CHC significant

economic loss (to be incurred in repair or replacement) besides disrupting its functional continuity. It must however be noted that the property loss related factor would accompany every individual component. This risk has therefore been taken as existing with every component. The intensity of the same might well vary and this has been considered while giving priority to various components.

Thus life safety and functional loss related risk have been assigned to all the individual components depending upon their location and the present status. An element which can cause injury or death is placed in high and very high risk grade and would be the first priority. The functional loss of a certain equipment would affect the functionality of the hospital and therefore it has been given risk grading ranging between high to very high and accordingly the priorities have been fixed.

The risk assessment involves the assessment of all medical equipments, administrative systems and the electric and water supply system of every CHC. Since the CHCs have almost same constitution in terms of different sections and equipments, the risk categorisation places all the CHCs at the same level. The operation theatre, medical store and staff rooms remain the most critical and highly vulnerable areas in every CHC.

Placement and anchoring of the cupboards is one of the non - structural elements which requires immediate attention in all the CHCs. Positioning of the cupboards in all the CHCs is such that it could pose risk to life safety besides blocking the exit.

Since the assessment parameters are the same and similar kinds of equipments are installed in the CHCs, the mitigation strategies to be followed are mostly similar. Prioritization of mitigation measures has not been done in the present assessment because the CHC units are relatively small and the measures are simple. The mitigation measures for the entire CHC can therefore be implemented together.

9.1 Criteria adopted for rating risk in the assessment of medical and electric equipments: Risk to medical / clinical and electric equipments present in the CHCs has been assessed on the basis of the outline summarised in Table 2.

Table 2: Description of the criteria adopted for risk rating.

Sl. No.	Aspects considered in an individual equipment	Risk type		Moderate (VI - VII on MMI scale)	Severe (VIII – IX on MMI scale)	Remarks
				Risk rating		
		LS	LF			
1.	Anchorage					
	No anchorage			VH	VH	
				H	VH	
	Poor anchorage			VH	VH	
				H	VH	
	Properly anchored			L	L	
2.	Importance of equipment					
	Hospital cannot function without the device / equipment			VH	VH	Generators, roof top water tanks, anaesthesia, X - Ray, operation table, lights ventilators, blood bank refrigerators, autoclaves, OT lights all are necessary for maintaining hospital functionality.
	Necessary for maintaining operational continuity			H	VH	Dental chair and computers.
	The loss of equipment will not affect the operational continuity for significant time			L	L	This mainly includes the cupboards and medical records placed in a section where there is no danger to life safety and they contain records and files without which hospital can work for some time period.

3	Location of equipment					
	Near doors			VH	VH	The equipment are placed at a position which can block the exit routes.
				VH	VH	
	In corridor / near the staff room section			VH	VH	The cupboards are placed in staff room adjacent to chairs.
LF = Loss of functionality LS = Life safety VH = Very high H = High L = Low						

9.2 Non - structural vulnerability assessment of the CHCs in Dehradun district: Even though all the CHCs are almost similar in lay out and the equipments and others the non – structural aspects of every CHC have been summarised separately in the tables below together with the suggested mitigation measures (Tables 3 – 7) . Hope this helps the Health Department in reviewing the vulnerability of individual CHC and compare the same amongst the five taken up under the present study.

Table 3: Analysis of the assessment made and suggested mitigation measures for CHC Doiwala.

Non - structural element	Earthquake	Risk rating	Type of risk	Mitigation option	Remarks
Anaesthesia (OT)	Moderate	H	LF	Anchorage and strapping	
	Severe	VH			
Ventilators	Moderate	H	LF	Anchorage	
	Severe	VH			
OT lights	Moderate	H	LF	Hooking	Operation lights on trolleys can cause life danger.
	Severe	VH			
Blood / glucose / saline stands	Moderate	H	LF	Hooking	The stands must properly be hooked with the bed.
	Severe	H			
Autoclave	Moderate	H	LF	Anchorage	Need Anchorage at base
	Severe	VH			
Suction machines	Moderate	H	LF	Anchorage	
	Severe	VH			
Supplies on trolleys	Moderate	M	LF	Hooking and strapping	The emergency supplies on trolleys can be strapped as well as hooked to the wall with help of chain
	Severe	H			
Cupboards	Moderate	VH	LS	Anchorage	The cupboard needs to be properly anchored to reduce life safety risk. The staff section

	Severe	VH			cupboards as well as pathology section all are so placed that they not only block the exit route but also a risk to the life safety of the staff sitting there.
Racks	Moderate	VH	LS	Anchorage	
	Severe	VH			
X ray machine	Moderate	L	LF	Anchorage	The X - Ray machine is properly fixed to the ground.
	Severe	M			
Dental chair	Moderate	H	LF	Anchorage	The chair is although not on rollers still it needs to be checked for proper anchoring
	Severe	VH			
Oxygen cylinder/oxygenator	Moderate	VH	LF, LS	Hooking	Only one or two oxygen cylinders are placed they need proper anchorage
	Severe	VH			
Bench mounted equipment	Moderate	M	LF	Strapping	Very small bench mounted equipment ,placed in pathology lab can be easily anchored
	Severe	H			
Refrigerators / freezers	Moderate	H	LF	Anchorage	The cold storage freezer need proper anchoring since it contains life saving drugs storage
	Severe	VH			
Geysers	Moderate	H	LF	Anchorage and support	Need proper anchoring also strapping along its circumference
	Severe	VH			
Air conditioners	Moderate	H	LF	Anchorage and support	
	Severe	VH			
Fire extinguishers	Moderate	H	LS	Anchorage	Need support with the help of hook and chain method.
	Severe	VH			
					LF = Loss of functionality LS = Life safety VH = Very high H = High L = Low

Note: For CHC Doiwala the mitigation strategy must follow the following order:

- Operation theatre and labour room
- Placement of cupboards especially in staff rooms and cold storage section.
- Dental section
- Others

Table 4: Analysis of the assessment made and suggested mitigation measures for CHC Raipur.

Non - structural element	Earthquake	Risk rating	Type of risk	Mitigation option	Remarks
Anaesthesia (OT)	Moderate	H	LF	Anchorage and strapping	
	Severe	VH			
Ventilators	Moderate	H	LF	Anchorage	
	Severe	VH			
OT lights	Moderate	VH	LF	Hooking	The operation theatre light in the Raipur CHC is attached to the ceiling. Therefore it must be properly screwed down to avoid the danger of falling down and adding risk.
	Severe	VH			
Blood / glucose / saline stands	Moderate	H	LF	Hooking	The stands must properly be hooked with the bed.
	Severe	H			
Autoclave	Moderate	H	LF	Anchorage	
	Severe	VH			
Suction machines	Moderate	H	LF	Anchorage	
	Severe	VH			
Supplies on trolleys	Moderate	M	LF	Hooking and strapping	The emergency supplies on trolleys can be strapped as well as hooked to the wall with help of chain
	Severe	H			

Cupboards	Moderate	VH	LS	Anchorage	It need to be anchored to not incur loss of records The cupboard needs to be properly anchored to reduce life safety risk. The staff section cupboards as well as pathology section all are so placed that they not only block the exit route but also a risk to the life safety of the staff sitting there.
	Severe	VH			
Racks	Moderate	VH	LS	Anchorage	The position of racks is such that will cause injury to the persons especially in medical storage section
	Severe	VH			
X ray machine	Moderate	L	LF	Anchorage	The X Ray machine is properly fixed to the ground.
	Severe	M			
Dental chair	Moderate	H	LF	Anchorage	The chair is although not on rollers still it needs to be checked for proper anchoring
	Severe	VH			
Oxygen cylinder/oxygenator	Moderate	VH	LF,LS	Hooking	Only one or two oxygen cylinders are placed they need proper anchorage
	Severe	VH			
Bench mounted equipment	Moderate	H	LF	Strapping	
	Severe	VH			
Refrigerators	Moderate	H	LF	Anchorage	The cold storage freezer need proper anchoring since it contains life saving drugs storage
	Severe	VH			
Geysers	Moderate	H	LF	Anchorage and support	Need proper anchoring along with strapping
	Severe	VH			
Air conditioners	Moderate	H	LF	Anchorage and support	
	Severe	VH			
Generator	Moderate	M	LF	Anchorage	The generator is properly caged and shade is provided ,an extra support with floor is required to prevent it from toppling down.
	Severe	H			

LF = Loss of functionality
 LS = Life safety
 VH = Very high
 H = High
 L = Low

Note: The CHC Raipur comes under high to very high risk rating with respect to the non - structural elements placed in it. Although the numbers of non - structural elements are very few, in view of their importance for the functioning of the CHC mitigation measures are required to be undertaken immediately. These can be implemented together but in case these are to be taken up serially the following sequence can be adhered to:

- Operation theatre and labour room
- Placement of cupboards in medical store section
- Dental section
- Others

Table 5: Analysis of the assessment made and suggested mitigation measures for CHC Sahaspur.

Non - structural element	Earthquake	Risk rating	Type of risk	Mitigation option	Remarks
Anaesthesia (OT)/ventilator	Moderate	H	LF	Anchorage and strapping	
	Severe	VH			
OT Light	Moderate	H	LF	Hooking	Operation lights on trolleys can cause life danger
	Severe	VH			
Blood/glucose stands	Moderate	H	LF	Hooking	The stands must properly be hooked with the bed.
	Severe	H			
Autoclave	Moderate	H	LF	Anchorage	

	Severe	VH			
Suction machines	Moderate	H	LF	Anchorage	
	Severe	VH			
Supplies on trolleys	Moderate	M	LF	Hooking and strapping	The emergency supplies on trolleys can be strapped as well as hooked to the wall with help of chain
	Severe	H			
Cupboards	Moderate	VH	LS	Anchorage	It needs to be anchored to not incur loss of records The cupboard needs to be properly anchored to reduce life safety risk. The staff section cupboards as well as pathology section all are so placed that they not only block the exit route but also a risk to the life safety of the staff sitting there.
	Severe	VH			
Racks	Moderate	VH	LS	Anchorage	
	Severe	VH			
X ray machine	Moderate	L	LF	Anchorage	The X Ray machine is properly fixed to the ground.
	Severe	M			
Ultra sound machine	Moderate	H	LF	Hooking	The machine is wheel based need proper support
	Severe	VH			
Dental chair	Moderate	H	LF	Anchorage	The chair is although not on rollers still it needs to be checked for proper anchoring
	Severe	VH			
Oxygen cylinder/oxygenator	Moderate	VH	LF,LS	Hooking	Only one or two oxygen cylinders are placed they need proper anchorage
	Severe	VH			
Suction machines	Moderate	H	LF	Anchorage	
	Severe	VH			
Bench mounted equipment	Moderate	M	LF	Strapping	Small equipments in pathology lab can easily be anchored
	Severe	H			

Refrigerators	Moderate	H	LF	Anchorage	The cold storage freezer need proper anchoring since it contains life saving drugs storage
	Severe	VH			
Geysers	Moderate	H	LF	Anchorage and support	Need proper anchoring along with strapping
	Severe	VH			
Air conditioners	Moderate	H	LF	Anchorage and support	
	Severe	VH			
					LF = Loss of functionality LS = Life safety VH = Very high H = High L = Low

Note: CHC Sahaspur falls in high to very high risk grade. The risk can however be lowered with proper implementation of mitigation measures and since this centre has limited equipments it would not be taking very long to implement the measures. The mitigation measures can however be taken up in the following sequence:

- Operation theatre and labour room
- Placement of cupboards in medical store section.
- Dental section
- Others

Table 6: Analysis of the assessment made and suggested mitigation measures for CHC Vikasnagar

Non - structural element	Earthquake	Risk rating	Type of risk	Mitigation option	Remarks
Anaesthesia (OT)	Moderate	H	LF	Anchorage and strapping	These equipments must be placed with in OT but since the team was not able to look in to OT section because of ongoing surgery the analysis has been made s per consultation with doctors and the setup in other CHC's
	Severe	VH			
Ventilators	Moderate	H	LF	Anchorage	
	Severe	VH			
OT Light	Moderate	H	LF	Hooking	Operation lights on trolleys can cause life danger
	Severe	VH			
Blood/glucose stands	Moderate	H	LF	Hooking	The stands must properly be hooked with the bed.
	Severe	H			
Autoclave	Moderate	H	LF	Anchorage	
	Severe	VH			
Suction machines	Moderate	H	LF	Anchorage	
	Severe	VH			
Supplies on trolleys	Moderate	H	LF	Hooking and strapping	The emergency supplies on trolleys can be strapped as well as hooked to the wall with help of chain
	Severe	VH			
Cupboards	Moderate	VH	LS	Anchorage	It needs to be anchored to not incur loss of records The cupboard needs to be properly anchored to reduce life safety risk. The staff section cupboards as well as pathology section all are so placed that they not only block the exit route but also a risk to the life safety of the staff sitting there.
	Severe	VH			
Racks	Moderate	VH	LS	Anchorage	

	Severe	VH			
X ray machine	Moderate	L	LF	Anchorage	The X Ray machine is properly fixed to the ground.
	Severe	M			
Dental chair	Moderate	H	LF	Anchorage	The chair is although not on rollers still it needs to be checked for proper anchoring
	Severe	VH			
Oxygen cylinder/oxygenator	Moderate	VH	LF,LS	Hooking	Only one or two oxygen cylinders are placed they need proper anchorage
	Severe	VH			
Suction machines	Moderate	H	LF	Anchorage	
	Severe	VH			
Blood bank freezer	Moderate	H	LF	Hooking	In blood bank section
	Severe	VH			
Bench mounted equipment	Moderate	H	LF	Strapping	Incubators placed In pathology section
	Severe	VH			
freezer	Moderate	H	LF	Anchorage	The cold storage freezer need proper anchoring since it contains life saving drugs storage
	Severe	VH			
Geysers	Moderate	H	LF	Anchorage and support	Need proper anchoring along with strapping
	Severe	VH			
Air conditioners	Moderate	H	LF	Anchorage and support	
	Severe	VH			
Generator	Moderate	H	LF	Anchorage and support	
	Severe	VH			
					LF = Loss of functionality LS = Life safety VH = Very high H = High L = Low

Note: Amongst the ones taken up under the present study CHC Vikasnagar caters to the most number of patients. It serves a large rural population that visits it from far flung areas. Non – structural vulnerability related problems are observed to be similar but increase in the number of patients enhances the magnitude of risk. The survey team was not able to inspect the operation theatre area due to an ongoing operation at the time of its visit to the CHC. Therefore the mitigation strategies relating to the OT must be employed in accordance with the ones recommended for other CHCs. The implementation of mitigation measures can be taken up in the following order:

- Operation theatre and labour room
- Placement of cupboards in medical store section.
- Blood bank section
- Dental section
- Others

Table 7. Analysis of the assessment made and suggested mitigation measures for CHC Mussoorie.

Non - structural element	Earthquake	Risk rating	Type of risk	Mitigation option	Remarks
Anaesthesia (OT)	Moderate	H	LF	Anchorage and strapping	
	Severe	VH			
Ventilators	Moderate	H	LF	Anchorage	
	Severe	VH			
OT Light	Moderate	H	LF	Hooking	Operation lights on trolleys can cause life danger
	Severe	VH			
Blood / glucose / saline stands	Moderate	H	LF	Hooking	The glucose stands must be properly hooked with the bed
	Severe	VH			
Autoclave	Moderate	H	LF	Anchorage	
	Severe	VH			

Suction machines	Moderate	H	LF	Anchorage	
	Severe	VH			
Supplies on trolleys	Moderate	H	LF	Hooking and strapping	The emergency supplies on trolleys can be strapped as well as hooked to the wall with help of chain
	Severe	VH			
Cupboards	Moderate	VH	LS	Anchorage	The cupboards placed in life safety section as well as medical storage section need proper anchorage to reduce the vulnerability of the hospital.
	Severe	VH			
Racks	Moderate	VH	LS	Anchorage	
	Severe	VH			
Dental chair	Moderate	H	LF	Anchorage	The chair is although not on rollers still it needs to be checked for proper anchoring
	Severe	VH			
Oxygen cylinder/Oxygenator	Moderate	VH	LF,LS	Hooking	Only one or two oxygen cylinders are placed they need proper anchorage
	Severe	VH			
Suction machines	Moderate	H	LF	Anchorage	
	Severe	VH			
Supplies on trolley	Moderate	M	LF	Hooking	In Operation theatre and emergency section
	Severe	H			
Freezer	Moderate	H	LF	Anchorage	The cold storage freezer need proper anchoring since it contains life saving drugs storage
	Severe	VH			
Geysers	Moderate	H	LF	Anchorage and support	Need proper anchoring along with strapping
	Severe	VH			
Fire extinguishers	Moderate	H	LS,LF	Anchorage	Need support with the help of hook and chain method.
	Severe	VH			
Inverter	Moderate	H	LF	Anchorage	
	Severe	VH			

LF = Loss of functionality LS = Life safety VH = Very high H = High L = Low

Note: The Community health centre of Mussoorie has been surveyed but as per discussions with the staff the health centre is not running to its full capacity and the new building is under construction. The facilities would therefore soon be shifted to the new premises. This assessment would however act as guideline for the health centre and appropriate non – structural mitigation measures can be adopted in the new centre.

10. Conclusion

The aim of this report is to assess non-structural seismic vulnerability of community health centres falling in the Dehradun district and to suggest the best possible simple mitigation measures for improving earthquake resilience of existing government health infrastructure.

CHCs play an important role in the delivery of health services, particularly in the rural and proto-urban areas. These serve as the referral centres for the PHCs and are equipped with major equipments to deal with emergencies. Smooth functioning and quality service delivery by these can greatly reduce the burden of work of secondary and tertiary healthcare services. These are therefore required to remain fully functional during any major emergency. Both structural and non – structural safety of these centres is therefore required to be addressed.

In the present report both medical equipments and the basic installation present in every health centre have been provided risk rating from low to very high. Since there are less number of equipments present in the health centre instead of undertaking section wise assessment and analysis the same has been done with respect to equipments, administrative and critical facilities located in each health centre.

For the ease of the concerned health authorities assessment table has been prepared for each CHC which clearly indicates the measures to be followed with respect to a particular section. The surveyed non-structural components have also been given ratings with respect to the risk posed to these in two earthquakes of differing intensities; moderate earthquake of intensity VI to VII in the MMI scale and severe earthquake of intensity VIII to IX in the MMI scale.

As the CHCs are small units and elaborate mitigation measures are not being recommended priority for undertaking the mitigation measures has not been provided for individual CHCs and all mitigation measures can be implemented in a single stretch. However an order has been advised for carrying out the mitigation process in these health centres at the end of the non-structural vulnerability assessment table of each individual CHC. It has to be noted that the CHC Mussoorie is to be shifted to the new building which is under construction the findings of this report can act as

guideline for administration to follow while setting up services in the new building premises.

Both the design and functions of the CHCs as also their equipments and sections were observed to be similar and therefore same sections of all the CHCs are described together in the report. All the CHCs fall under high to very high risk class even in case of moderate earthquake. In their present state these would not be in a position to deliver health services on the aftermath of a major disaster. So beside the mitigation measures CHCs are required to be strengthened in terms of both medical and para – medical staff as also medicines and drugs.

The mitigation measures suggested in this report are applicable for all the CHCs and the concerned authorities can implement the measures as per the individual assessment tables. Particular care has been taken to suggest simple and basic mitigation measures that would be cost effective. The investment made is sure to pay rich dividends in the form of reduced cost of repair and restoration in the aftermath of any disaster.

The purpose of this report is to help the health department in effectively responding to major emergencies. This is to be noted that implementation of the suggested mitigation measures alone is not going to make the CHCs seismically resilient. In order to achieve holistic hospital safety a well defined strategy has to be formulated to address all the three major aspects that include structural, non - structural and preparedness. The building designs of the CHCs must be reviewed to assess the structural safety of the same. In case some shortfalls are observed retrofitting should be resorted to.

In combination with the structural vulnerability assessment and a well defined health centre preparedness plan, this report would help in achieving the aim of hospital safety. Besides other things health centre preparedness plan should clearly define the charter of duties of both doctors and other staff in case of emergency. Periodical assessment of health centre vulnerability is also necessary to update the mitigation plan as and when required. It is advised that the non - structural mitigation measures as suggested in this report must be included in the maintenance and inspection manual.

The implementation of the suggestive mitigation measures will surely help in reducing risk but work has to be done in all related sectors to develop environment of safety and resilience.

The measures can be more refined through discussions with all the concerned parties.