RESEARCH REPORT

CAUSES OF DEATHS AND INJURIES IN THE 2015 GORKHA (NEPAL) EARTHQUAKE

Research Report

Acknowledgements

This research was conducted by Save the Children, in cooperation with Health Research and Social Development Forum with support from: Red Cross Global Disaster Preparedness Center, National Society for Earthquake Technology–Nepal (NSET), Risk RED, and Nepal Risk Reduction Consortium.

Authors

Dr. Marla Petal.[1], Dr. Sushil Baral[2], Santosh Giri[2], Sumedha Rajbanshi[2], Subash Gajurel[2], Dr. Rebekah Paci Green[3], Dr. Bishnu Pandey[4], Dr. Kimberly Shoaf[5] (1. Save the Children, 2. HERD, 3. Western Washington University, 4. British Columbia Institute of Technology. 5. University of Utah)

Research Team

Health Research and Social Development Forum

Sushil Chandra Baral	Santosh Giri	Sudeepa Khanal	Deepak Joshi
Bagiman Lingden	Subash Gajurel	Sumedha Rajbanshi	Sudeep Uprety
Rajeev Dhungel	Kapil Babu Dahal	Hom Nath Subedi	

National Society for Earthquake Technology

Ganesh Kumar Jimee	Surya Prasad Acharya	Surya Narayan Shrestha

Building Damage Level Photos and Validation

Beth Pratt-Situala	Dipesh Pulara	Om Dhakal

Nepal & Global Reference Group

We thank these experts who generously contributed to reviewing the research design, the survey instrument, and/or to closely reading and providing feedback on this report. None are responsible for any error or ommissions.

Ashleigh Brooks –University College London, Global Health and Development
Lydia Baker – Save the Children
Ram Prasad Bhandari – JICA Nepal Office
Amod Mani Dixit – National Society for Earthquake Technology- Nepal (NSET)
James D. Goltz – Disaster Prevention Research Institute, Kyoto University, Japan
Kristen Gentry – Oppression and Mental Health in Nepal
Katherine Haynes – MacQuarie University, Risk Frontiers
Stephen Jensen – Massey University, Joint Centre for Disaster Research, New Zealand
Dr Khem Kharki – National Health Research Council
Emily Lambie – Massey University, Joint Centre for Disaster Research, New Zealand
Assoc. Prof. Dr. Michel Landry – Duke University
Leela Mulukutla – American Red Cross
Dr. Puspa Raj Pant – University of the West of England
Assoc. Prof. Kalyani Rai – University of Wisconsin, Milwaukee
Prof. Kevin Ronan – University of Central Queensland
Dr. Emily So, CEng MICE – Cambridge University, Centre for Risk in the Built Environment
Dr. Santa Tamang – Save the Children
Danielle Wade – Save the Children
Prof. Ben Wisner – UCL Hazard Research Centre

Cover Photo: Bhagawati and her 18-month old daughter, Arati, who was badly injured when their house collapsed, stand where their village in Sindhupalchowk once stood. Source: Jonathan Hyams / Save the Children © February 2017.

Publication: **Save the Children, April, 2017, Kathmandu.**

Research Report

CAUSES OF DEATHS AND INJURIES IN THE 2015 GORKHA (NEPAL) EARTHQUAKE

Table of Contents

List of Figures

List of Tables

Executive Summary

The Mw7.8 April 25, 2015 Gorkha Earthquake in Nepal took place on a Saturday, at 11:56am local time, and delivered a maximum intensity of IX (violent) on the Modified Mercalli Intensity scale. The epicenter was east of Gorkha; its depth was 8.2km. The strongest aftershock Mw6.7 took place on May 12th, with an epicenter located between Kathmandu and Mt. Everest. The earthquake and its aftershocks killed more than 8,800 people and injured more than 22,000 people (GoN, 2015). There is an urgent need to better understand protective actions for earthquakes in Nepal and elsewhere, as Nepal will continue to experience large earthquakes in the future. Future earthquakes in Nepal are expected to have more devastating impacts unless an even *more* robust, extensive, and well-coordinated program of public awareness, and continued facilitation of risk reduction are implemented.

The purpose of this study is to identify the causes of injuries and deaths in the Gorkha, Nepal Earthquake 2015 in order to provide a scientific basis for education and training of the Nepal public in earthquake preparedness and mitigation. The Nepal Risk Reduction Consortium has, in the past, developed a set of ten common messages for disaster preparedness and ten key messages for earthquakes. This research seeks to provide evidence to validate, and, where needed, offer refinements and changes, to support a renewed process of consensus-building for public education for earthquake (and all-hazards) safety. This research is also intended to add to the global body of knowledge about earthquake epidemiology.

The research was conducted using a purposive approach with randomized elements to select 500 households in 10 of the hardest-hit Village Development Committees (VDCs) located in the 5 of the 14 hardest-hit districts. The research was conducted approximately 11 months after the earthquake.

The 500 households surveyed represent 1,855 household members who were present in the VDC at the time of the earthquake and comprised the sample frame. Of these individuals, 88% (1,627) were uninjured, 10% (190) were injured, and 2% (38) died. Complete surveys were received for 76% (1403) of those individuals, and were not obtained for 17% (452). Other family members only felt knowledgeable enough to report on the circumstances concerning about 50% of those who had died.

The districts were selected to represent a variety of construction types and terrains, to be sufficiently accessible and have sufficient population density to undertake effective enumeration. Most of the households sampled were stone and brick masonry construction, referred to as *gārowālā* in Nepal (as distinguished from *pillarwālā* construction which is typically reinforced concrete or masonry and has a frame or columns).

Our initial questions were:

- What specific risk factors are associated with injuries of different severity?
- What hazards in the built environment and building typologies have specific risks for human casualties?

- What specific risk mitigation efforts will decrease deaths and injuries?
- What specific behavior during and after an earthquake may decrease deaths and injuries?
- How important is rapid search and rescue and medical treatment to injury outcomes?
- What disaster preparedness measures are identified by earthquake survivors as both feasible and effective?

Based on previous earthquake epidemiology a wide range of variables were examined: the seismic event itself, individual and behavioral, built environment, mitigation actions and response variables. Significant findings include:

The hazard

- **The 25 April M7.8 Gorhka earthquake occurred at a depth of 15km and lasted for 56 seconds.**
    - The epicenter was 80 km NW of Kathmandu. The Modified Mercalli Intensity of the earthquake in the districts studied was 7 in Bhaktapur, Kathmandu, Nuwakot, and Sinhupalchok, and 6 in Khavrepalanchok.
- **The 25 April 2015 Gorkha earthquake was unusual, and unexpected in terms of the characteristics of the ground shaking. However, the impacts of this particular type of ground shaking on buildings were as expected.**

    SHAKING FREQUENCY
- The ground shaking could be described as *slow and gentle*, taking 4-5 seconds to complete a cycle of back and forth motion. When the cycle of shaking matches the natural shaking of a building, that is when the worst damage occurs. At 4-5 seconds, high-rise buildings tend to experience the most severe damage.
- This earthquake did not damage well-built, low-rise reinforced concrete buildings less than 6 stories high, because these buildings sway back and forth every 0.3-0.6 seconds.
- Had the ground shaking been faster, it would have matched the natural sway of low-rise, reinforced concrete buildings, and could have caused significantly more damage.

    GROUND ACCELERATION:
- Adobe and stone buildings begin experiencing severe damage with just 0.10g. The peak ground acceleration (PGA) was estimated as being at least 0.2g and therefore these buildings were heavily damaged.
- The PGA of the earthquake was very low, compared to more typical earthquakes of similar magnitude and depth. Because of this, damage to well-constructed buildings was not observed. Even poorly-constructed reinforced concrete buildings did not sustain much damage.

    GROUND DISPLACEMENT:
- The displacement of the ground, from shaking, was as much as 95cm. This was sufficient to cause damage to flexible structures like older buildings with mud brick walls and wooden floors, as well as tall slender temples. This also caused people indoors on higher floors to feel substantial swaying.

- Future earthquakes are expected to have more typical shaking characteristics that include higher ground acceleration; these earthquakes are likely to cause much great building damage and, with it, greater rates of deaths and injuries.

Individuals and behavior

- **There was no significant difference in rate of death for men and women in our sample.**
  - National figures indicate that 55% of deaths were females and 45% were male, which may be related to more males working outside of the areas most affected by the shaking.
- **Pre-school children and people over the age of 70 were most likely to be injured or killed. The least likely to be injured were people between the ages of 15 and 50.**
  - Location of preschoolers and older people may have been more likely to be indoors.
  - Pre-school children and people over the age of 70 may have had less ability to make small adjustments, and to take protective action as soon as the shaking was felt.
  - It is important to make sure that the spaces that are occupied by the very young and older people are safe.
- **The incidence of physical and sensory disability and health and mental health problems more than doubled, compared to before the earthquakes, in our sample.**
- **There were no significant differences in deaths and injuries based on education level in our sample**.

The buildings

- Traditional adobe and stone constructed buildings in affected rural areas are made of low strength materials, and experienced expected damage.
- Traditional adobe and stone low-rise construction needs many specific anti-seismic mitigation measures to ensure that the building's walls, floors and foundation move together during an earthquake, rather than shake apart.
- **The most deadly buildings were those that were *totally collapsed*, or *heavily damaged*.**
  - ALL deaths were in totally collapsed buildings, in our sample.
  - No one died in buildings that were slightly, moderately, or even heavily damaged.
  - THE most important thing to do to reduce casualties is to ***prevent building collapse***.
- **People were much more likely to be injured in *very heavily damaged* and *collapsed* buildings, in our sample.**
  - 17% of those in heavily damaged buildings were injured.
  - 58% of those in totally collapsed buildings were injured.
  - Minimum retrofit is important to prevent collapse, deaths, and severe injuries.
- **People were injured even in buildings that had *moderate*, *light*, and *no damage*.**
  - 8% of those in undamaged buildings and those in light/moderate damaged buildings were injured, and 9% of those in moderate/heavily damaged buildings were injured.
  - It is important to implement non-structural mitigation measures to prevent injuries caused by building non-structural elements and furnishing and equipment.

- **People in or near the most heavily damaged buildings are the most likely to be severely injured or killed.**
    - At least 27% of the people injured in our sample were in totally collapsed buildings
    - At least 18% of all the people injured in our sample were in very heavily damaged buildings.
    - Less than 10% of the all the people injured in our sample were in buildings that sustained slight, light, and moderate damage.
- **People were just as likely to be injured inside vs. outside, close to the damaged buildings**.
    - Unsafe structures are hazardous not only to occupants but also to anyone nearby.

The injuries

- **People who had crushing, head, and chest injuries were most likely to die.**
    - For those who died, 75% had injuries to head, 58% to chest, 42% to back, and 41% to legs.
    - To avoid fatal injuries, it is important to protect your head, neck, and chest.
- **For people who had non-fatal injuries, the predominant parts of the body injured were legs, knees, feet, and toes.**
    - The most frequent injuries are superficial bruises and abrasions, sprains, deep wounds, crushing, head injuries, and fractures.
    - To prevent unnecessary injuries, drop to the ground, make yourself small, and position yourself away from falling, sliding, and flying objects.
- **The vast majority of people who were entrapped and rescued alive were extricated by people nearby (85%) while the remainder extricated themselves.**
    - In our sample none were rescued by external SAR teams or professional responders.
    - People can prepare to help one another by learning skills in response organization and light search and rescue
- **Two-thirds of those injured sought medical treatment.**
    - Of the people who sought treatment, 80% were treated and released, 10% were hospitalized for less than a week, and 10% for longer than a week.
    - Nearly half of those who sought treatment received it from a public hospital and the remainder from community response teams, private hospitals, and health clinics.
- **The mean transport time to receive treatment was 4.7 hours.**
    - Almost half of the injured walked to receive treatment.
    - People can prepare to help one another by providing first aid and safe transportation skills.
- **Emotional injuries were reported by 35% of people in our sample, with about 1/3 of these reporting moderate or severe emotional impacts.**
    - A year later, about half felt they had recovered and the remainder were slowly getting better, with about 7% staying the same and 2% getting worse.

Protective action

- **Almost all of the injuries and deaths take place during the shaking.** Ninety-six percent of injuries and 100% of deaths took place during the main shaking rather than afterwards or while awaiting help or during search and rescue.
- **The odds of being injured were highest for those moving, lowest for those taking cover, and in between for those staying in place.**
    - 53% of people (802) moved. Of those moving, 15% (122) were injured. (This included moving others, moving to other locations, or moving to outside.)
    - 41% of people (631) remained in place. Of those staying in place, 12% (73) were injured. (This included sitting, standing, lying down, or falling down.)
    - 6% of people (88) took cover. Of those who took cover, only 9% (8) were injured and none died. (This included in an open space, under furniture, in a doorway, against a wall, next to furniture or a safe area.)
    - People were likely to be injured when taking cover, compared with moving or doing nothing.
- **People who were lying down, sitting, or standing, were more likely to be injured than those who were cooking, walking, or anything else.** This suggests that people in active positions may sense and be more ready to take small protective actions to step out of harm's way when the shaking starts.
- Respondents were asked if they could possibly and safely have exited within 5, 10, or 15 seconds. Only 50% of survivors perceived that it was both possible and safe to exit the building within 15 seconds. Most people regarded it as either *not* possible, or *not* safe to exit in a shorter period of time.

Mitigation and preparedness measures

- At the time of the survey 39% of families (187) had a family safety plan and 52% (249) planned to have one (52%). A smaller number, 13-14% (60-69) had plans at work or school.
- Whereas prior to the earthquake only 3% (13) families reported having taken measures to strengthen their homes, at the time of the survey, 24% of respondents (116) had moved to what they considered to be a safer home and more than 50% (236) more planned to do so. A smaller number, 9% (41) had reconstructed what they believed to be a safer home, while 56% (267) planned to do so, and 35% (170) planned to retrofit.
- At the time of the survey, 16% of households (78) reported that they had secured tall furnishing and equipment and 57% more (271) planned to do so, compared to 3% (16) who reported that they had secured tall furnishing and equipment before the earthquake.
- Of those who took measures before the earthquake, such as storing food and water, having flashlights and batteries, a first aid kit, battery-operated radio, learning post-disaster response skills such as organization, first aid, and putting out a small fire, the overwhelming majority (80-93%) found these to be effective. Those who did not take these measures similarly believe that these would have been effective (80-90%). Most people (58-80%) also thought that other measures

such as a family safety plan, building strengthening, and securing tall furniture, would also have been effective.

- The most frequently cited reason for not taking measures was "not knowing what to do" (53%) and "being too busy" (15%).
- Sources of information for households were radio (60%), family and friends (59%), and TV (52%). However, only 10% of our sample households had learned what to do during the shaking (3% from radio and 4% from television).
- Only 4% of our sample reported that their households had been exposed to awareness program in schools or community; about 1/3 of these were provided by Nepal Red Cross. Those who participated in these programs were less likely to be injured or killed than those who did not.
- Public awareness programs and mass media campaigns need to be massively scaled up to reach a critical mass of people with risk reduction and preparedness education.

Discussion of findings and recommendations for public education and awareness are provided with the intention of having a robust conversation amongst national and global subject matter experts and disaster risk reduction educators, and to aid them in coming to a consensus about key evidence- and consensus-based, action-oriented messages for household risk reduction and resilience.

Recommendations for Public Awareness and Public Education: Key Messaging at the Household Level

Research Dissemination and Utilization

Following consultation with global and national expert reference groups to further examine, validate, and interpret these results, the creation of a 4-page public awareness report is recommended. This report should highlight the research approach, methods, and questions, the most significant findings, illustrated with charts and infographics, and the resulting recommendations for action. It should be produced in both Nepali and English, and distributed widely, especially back to the participating communities and to all stakeholders engaged in public health, earthquake safety, and public education.

A Scientific Roundtable is suggested for presentation and discussion of these results with interested stakeholders.

Duty-bearers and interested stakeholders in Nepal are encouraged to meet to incorporate these messages into a full set of evidence- and consensus-based and action-oriented messages for public education and public awareness, based on *Public Awareness and Public Education: Key Messages* (IFRC, 2012) – adapted and localized through a group process and engagement of nationally-based subject-matter experts in public health education, disaster risk reduction, and the full range of specific hazards faced in Nepal. The resulting reference document should be co-logoed and used by all relevant public agencies as well as INGOs and IGOs as they craft their social and behavior-change, information, education, and communication materials.

A special session to explain these results to the press is also recommended. Further, participatory mass media training programs (eg. with BBC Media) are recommended to be led by and with interested science writers and journalists, to prepare them to become leaders in communicating this subject matter to the public.

It is important to use "plain language" to convey a summary of epidemiological evidence about earthquake deaths and injuries, including factors related to: the shaking, the buildings, the objects, the injuries, and the individuals. Following is the "***What you can do before"*** guidance, focused on four areas, designed to be part of a wider, all-hazards Family Safety Plan.

It's important to remember that the advice that is given to the public is given for everyone who feels the shaking. It must be formulated to do the greatest good for the greatest number of people

Suggested Key Messages for Individuals & Households:

Assessment and Planning Actions

These include situational risk awareness as well as household and individual planning.

#1. Be aware that every earthquake is unique – the last one does not tell you exactly what to expect next time. The next could be different, and have worse impacts.

- The Gorkha earthquake shaking was apparently violent and did scare many people. However, it was not, in fact, very severe for many building types or for the people within them.
- Many buildings in Kathmandu as well as other towns close to the epicentre survived the earthquake not necessarily because they were strong enough, but due to the peculiar attributes of this earthquake. The same should not be expected in the next earthquake.
- More earthquakes that could have very different attributes are expected. Even smaller, more likely, earthquakes could cause much higher damage and destruction to a wide variety of the building stock in Nepal.

#2. Hold a family meeting every six months. Identify your risks and use your Family Safety and Resilience Plan Checklist to take the many small steps that can make you safer.

#3. Conduct school, workplace, and community surveys to identify hazards. Hold meetings to make plans for how you will reduce hazards, and how you will prepare to respond.

Risk Mitigation Actions

These include structural, non-structural, and infrastructural measures.

#4. When you build, construct in accordance with building codes and earthquake resistant construction guidelines. Learn and incorporate seismic resistant construction practices.

- Cement mortar and concrete are advanced and complex construction materials. When they are used without the inclusion of earthquake resistant design and construction techniques, buildings with these materials can be very dangerous.
- Buildings will be less damaged if they have:
    - a symmetrical layout
    - symmetrical windows and doors placed away from the edges of the building
    - earthquake bands for masonry buildings
    - a continuous and well connected frame for reinforced concrete structures.
- When reinforced concrete is used, deformed steel rods should be used. These rods should overlap each other. Columns and beams should have sufficient transverse ties (bent to 135° at the closure). The column size should always be bigger than the beam and slab combined depth. Concrete should be mixed in specified volumes and additional water should not be added. When concrete is added to the construction forms, it should be tapped down to remove air bubbles and ensure the concrete fully encases the deformed steel rods.

#5. Implement minimum retrofit measures to strengthen your building and prevent collapse. Strengthen walls with bracing and other means. Construct earthquake bands around the building, at the plinth, sill, and lintel levels. Replace heavy roofs with lighter weight materials (CGI, thatch, etc.). Ensure that floors and roofs are well connected with the walls.

#6. Fasten down non-structural items and building contents so that they move with the building and do not fall, swing, or slide to injure you or other people.

Response Preparedness Actions

These include learning skills and storing provisions.

#7. Practice 'situational awareness'. *Think* about the places where you spend your time, and notice the things that can break, fall, slide, or fly.

- Notice hazards, at ground level, from above, and below that you need to move away from.
- Notice safer spots nearby to avoid structural, non-structural, and building contents hazards that can fall, slide or fly.
- Discuss and solve problems to find the best solutions in different situations.
- Rehearse protective actions in your mind for different situations.
- Stay calm by taking slow deep breaths, or counting.
- Look around to assess the situation before moving.

#8. If you are outdoors, stay outdoors, find a clear spot, away from overhead, ground level, and underground hazards, and drop to your knees to prevent falling. DO NOT GO INSIDE.

- If you are near a building – move away from the building.
- If you are in a vehicle – move to a clear location and pull over. Stop in a safe place. Avoid bridges, trees, powerlines, poles, street signs, overpasses, underpasses, tunnels, and other hazards.
- If you are on a motorcycle or bicycle get off.
- If you are near or on a bridge – move off.
- If you are in a stadium – brace yourself against the seats in front of you.
- If you are in a mountainous area, be alert for falling rocks and other debris, unusual sounds or other early warning signs for landslides and avalanches, even weeks later.

#9. **If you are indoors, "Drop** to your knees to prevent falling, and make yourself small. Position yourself away from falling and sliding objects**. Protect** your head and neck and **Hold On** to your cover." Practice with everyone in the family, from youngest to oldest, until it becomes a well-mastered habit. There is one exception: If you are indoors, on the ground floor of a stone or mud house with a heavy roof, and if you can get outside to a clear space, then exit quickly and carefully as soon as you feel shaking, and move away from the building and any overhead hazards. Drop and cover away from the building and any overhead hazards. Extinguish any and all flames.

- Move away from windows, glass and exterior walls, and unstable and heavy objects.
- If you are near an exit door, open it a little so that if it becomes misshapen it will not be stuck closed.
- If you are in bed, stay there and protect your head with a pillow.
- If you are near a sturdy table, get under it. Hold on to the table leg strongly and close your eyes to protect them. Protect your eyes with the other hand.
- If you are near a low, sturdy piece of furniture, like a sofa, get down next to it and use a cushion to protect your head and neck.
- If you are sitting in a theatre or stadium seat, brace yourself while protecting your head and neck.
- If you are in a wheelchair, move into a safe position and lock your brakes. If you cannot get down low, brace yourself and protect your head with your arms.
- If you cannot drop to the floor, stay where you are, bracing yourself in place.
- If you are sitting at a desk – Get out of your seat and "Drop, Cover, and Hold on". Don't get yourself stuck in a tight space.
- If you are in a science lab – extinguish all flames, and cover any hazardous materials or place them in the sink. Drop, cover, and hold on.
- If you are in a library or a shop – move away from between the shelves to the end of a row. Drop, cover, and hold on.
- If you are in a multi-storey building, be careful both during and after the shaking. NEVER JUMP. Jumping can be deadly. DO NOT USE STAIRS DURING SHAKING. If you use stairs during

shaking, you may fall and be injured. Stairwells are often the weakest part of a building and may experience damage first. DO NOT USE ELEVATORS AT ALL. After the shaking stops, check for safety of stairs or fire escapes before using them.

#10. After the main shaking stops, move cautiously and expect aftershocks.

- Aftershocks will be frequent during the first hours and days after an earthquake and will gradually diminish in frequency and intensity. However, unusually large aftershocks may occur days or even weeks after the main earthquake, and can trigger additional building damage or collapse. Follow the same guidance for an aftershock as you would for any earthquake.
- If you are indoors, put on sturdy shoes before you move around.
- If it is dark, use a torch/flashlight. Move cautiously and evacuate the building. Follow standard building evacuation rules: "Don't run. Don't talk. Don't push. Don't go back in." .
- Help others to evacuate the building.

#11. Look for and prevent fire hazards.

- Extinguish all flames immediately.
- Do not light any match, candle, lighter, flame or cigarette until you are sure there is no danger of a gas leak.
- Check for gas leaks and turn off any gas connections.
- Do not use any electrical switch, appliance or phone if there is danger of a gas leak.
- Remember that liquefied propane gas, kerosene and carbon monoxide gases sink and can be trapped on lower floors. Natural gas rises and can become trapped on higher floors or escape through windows and doors.
- Stay away from downed power lines. Do not touch wires that are lying on the ground or hanging, or any objects touching them.
- Shut of power at the main electrical switch if you suspect damage to household wiring.'
- Do not refuel or operate generators indoors.
- Take care when handling flammable fuel.

#12. Store response provisions for communication, personal safety, first aid, fire suppression, and water, nutrition and sanitation.

#13. Learn response skills. These include: light search and rescue, first aid, small fire suppression, response-organization, and safe transport of injured.

The Takeaway Message for individuals and families

#14. Make a promise to your family and yourself, to take these steps:

1. Know your dangers, and plan ahead
2. Reduce your dangers
3. Prepare to respond

Suggested Take Away for Safety Advocates, Public Educators

Public awareness and public education campaigns to communicate specific action-oriented key messages for risk reduction and preparedness should be massively scaled up to reach the public – through schools, communities, radio and television.

- All disaster risk reduction and preparedness is a matter of small steps.
- It is important that disaster management, public health, public education, earthquake, and mass media experts and educators:
- Agree on the evidence-based and action-oriented messages for family and household safety and convey the value and effectiveness of these small steps.
- Develop the confidence of adults and children, both male and female, to plan and implement these steps.
- Create a groundswell of popular support to develop a culture of safety.

Project Background

Introduction

For the passionate public educators and advocates engaged with disaster risk reduction and resilience, this was not an unexpected event. The seismic risks of the Kathmandu Valley have been well known, studied, and discussed, and mitigation and public awareness projects had been underway for more than 20 years. However, this was *not* the expected Kathmandu Valley earthquake. This earthquake should be considered a "near miss." The ground accelerations were only about 1/3 of the design code accelerations (Avouac, 2016). This was *not* the still-awaited "big one." It was a foretaste, visited on 14 predominantly rural districts. The particular frequency of the motion coupled with the geology meant the types of buildings most highly impacted were high-rise building stock, which are uncommon in the impact area. All of those who experienced the impacts of these events feel the urgency of learning lessons from this earthquake, and hope that those who perished may leave a legacy of greater safety and less suffering for those who heed them. The challenge with all earthquake events is that the lessons are not entirely obvious. Major earthquakes occur years apart, in vastly different environments, so we have no choice but to learn from each one when it occurs, and examine their individual and collective lessons, as though constructing a full picture with the emerging pieces in a puzzle.

For the public, the question often asked is "What should we do *when*….." Having learned from the significant global earthquake events, this seems to be the wrong question. Many years ago, the American Red Cross made a public awareness video with a succinct message: *"It's too late when it shakes!"* The lesson of earthquakes is that human beings *can* mitigate the devastating losses of life, shelter, and livelihood caused by earthquake shaking through the careful application of knowledge applied to the construction of the built

environment, to structures, and to infrastructure. For people living in seismic zones, especially near active faults, an apt analogy is floating at sea. Living spaces and workspaces must be designed so that their contents move *with* the waves, and yet stay securely anchored to the structures themselves. And, these structures, in turn, must be securely anchored to the ground below.

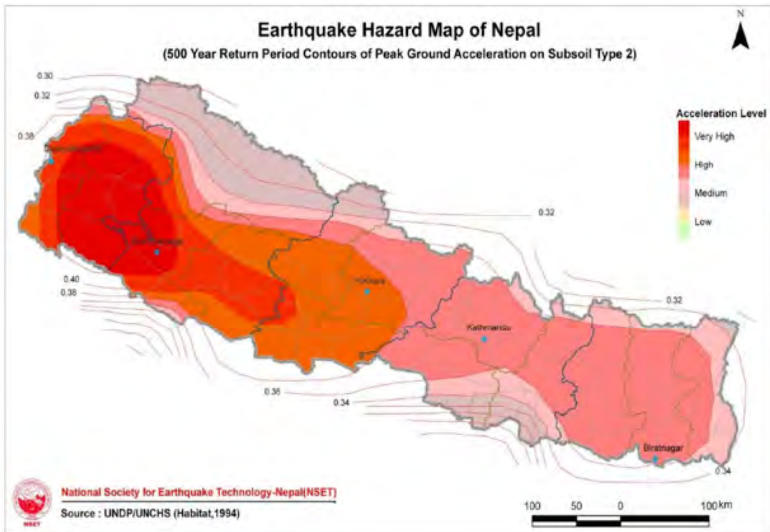
If there is a single, overarching lesson to be taken from this report, it is this: The suvivors of the Gorkha earthquake (and hopefully the rest of the Nepali public) are already deeply engaged in taking structural and non-structural safety measures to reduce their risks and support one another to prepare for future major earthquakes. They believe that these measures will be effective. Survivors report that the *major* reason that they had for not taking measures before the earthquake was "not knowing what to do." Poor understanding and use of implementation science, when it comes to *how* to apply the cumulative knowledge from previous earthquake events, seems to be our major problem. The corollary of this is that people may also have been taking measures that were ineffective. Earthquake safety practitioners, including public educators, subject-matter experts, and advocates can address these knowledge gaps by examining the evidence, providing the scaffolding for people to understand, think about, problem-solve, and act to reduce their risks in the domains where they have control, and by developing and consistently delivering the evidence-based, consensus-based, and action-oriented key messages that will save lives (IFRC, 2012). The researchers, and the wide and generous reference group that have participated in this study, hope that this will be a valuable contribution to that effort.

Seismicity in Nepal

Nepal is situated above the Indian tectonic plate which subducts under the Tibetan plates. The subduction process gives rise to the Himalyan Range, so that virtually the entire country is expected to have high to very high seismic shaking hazard. The national seismic map indicates the region could experience the highest possible levels of shaking intensities (MMI, IX, and X). This tectonic region produces regular, destructive earthquakes every 50 to 100 years. Earthquakes of various magnitudes are felt almost every year, with many resulting in some loss of life. Prior to 2015, the most recent major event was a magnitude 8.4 earthquake in 1934 in the Kathmandu Valley that killed over 8,000 people and destroyed more than 80,000 homes. Such events have occurred, on average, every 75 years in the densely populated Valley (GHI, 1999).

Historic records of seismic impacts in Nepal tell us that in 1255, one-fourth to one-third of the population of Kathmandu Valley died in an intensity X earthquake. Major earthquakes also took place in 1408 and 1681. In the 19th century there were three significant events, in 1810, 1833, and 1866. The 1934 Great Nepal-Bihar earthquake was the most devastating, causing 16,000 deaths in Nepal and India, and destroying one-fourth of all homes in the Kathmandu Valley. More than 80,000 buildings completely collapsed, and more than 126,0000 houses were severely damaged (EERI, 2016). In 1980, an M6.5 earthquake in the far west of Nepal killed 125 people, destroyed more than 11,600 buildings and severely damaged more than 13,400. In 1988, an M6.9 earthquake the Udaipur Earthquake in eastern Nepal resulted in 721 deaths and more than 6,500 serious injures and damage to more than 65,000 buildings. Most recently, in 2011 an M6.9 earthquake resulted in 3 fatalities, 164 injuries, collapse of more than 6,000 houses, and damage to 14,000 more (Ibid.).

From an examination of the areas and dates of past great earthquakes, and review of their past damage (Bilham et al. 2001), a great earthquake is expected to occur near Kathmandu, resulting in a catastrophe due to the combination of very high intensity shaking and significant exposure of vulnerable buildings and population.



Source: UNDP/UN-Habitat, 1994

Figure 1: Earthquake Hazard Map of Nepal

Due to the known seismicity of the region, in 1978 the National Seismological Network was launched. As a result, there is sufficient scientific data to be able generate earthquake hazard maps to guide disaster resistant construction. The National Society for Earthquake Technology-Nepal (NSET), a non-governmental organization, was launched in 1994 to support earthquake awareness, risk assessment, builder training, and technical support.

With a rapidly expanding population of over 1.5 million people, combined with poorly controlled development, poor construction quality and liquefiable soils, a large seismic event within or near the Valley is expected to cause extremely high loss of life. Estimates of a repeat of the 1934 Bihar-Nepal Earthquake suggest the event could destroy 20 percent of the Kathmandu Valley's building stock and cause heavy damage to another 40 percent. Causality and injury models for Nepal are based upon the expected poor performance of building infrastructure; thus, the timing of a seismic event — whether people are in their homes or outside, whether it is day or night— primarily dictate human loss estimates. Modeled loss estimates indicate deaths from a Kathmandu event may exceed 20,000, with similar numbers of injured people requiring hospitalization. Applications of casualty figures from similar cities struck by seismic events suggest losses could be double these figures (GHI, 1999). The country has been ranked as the 11th worst in relative vulnerability to earthquakes (UNDP, 2004), and Kathmandu as the city with the greatest potential for earthquake-induced loss of life anywhere in the world (GeoHazards International, 2001).

The 2015 Nepal Earthquakes

An earthquake of magnitude 7.8 struck Nepal on 25 April, 2015 at 11:56 NST. Two major aftershocks that occurred on the same day and the next day were greater than 6.0, and a major aftershock of 7.3 magnitude occurred on 12 May 2015 at 12:50 NST. These events resulted in more than 9,000 deaths and more than 22,000 reported injuries.

In addition to the huge number of lives lost and people injured, more than 458,000 buildings were heavily damaged or totally collapsed, and 3.5 million people were made homeless. There was widespread damage to public and private buildings, schools and health centers, roads, bridges, water supplies, hydropower plants, heritage sites, and trekking routes. More than 8 million people (1/3 of Nepal's population) were affected in 31 of 75 districts. Fourteen districts were declared as 'worst-hit'.[1] Beyond Nepal, there were 78 deaths in India, 27 in China, and four in Bangladesh attributed to this event.

In the 14 districts most affected by the Nepal earthquakes in 2015, the total population was 5.37 million at the time of the 2011 census. There were 8,775 deaths and 21,161 injuries (Nepal Risk Reduction Portal, Humanitarian Data Exchange, 2015). The seven most heavily impacted districts accounted for 91% of the deaths. These were: Sinhupalchok (3,531), Kathmandu (1,222), Nuwakot (1,125) Dhading (676), Rasuwa (656) Ghorka (449), and Bhaktapur (333).

Earthquake Epidemiology

Earthquake epidemiology is "the study of the distribution of death and injury in earthquakes and the causes of fatal or nonfatal injury (Jones et. al., 1994). In the short history of the field that has depended upon post-disaster research, conventional wisdom has yielded the simplistic conclusion that "earthquakes don't cause deaths, buildings do." Hoewever, both citizens and researchers recognize a more nuanced reality. There are major differences in construction type between wood, and other light-weight frame structures, heavy adobe and stone, and confined masonry, reinforced concrete, and steel-frame buildings, as well as the quality of their design and construction, all of which can have signficant implications for both causes and prevention of casualties.

It has only been three decades since researchers voiced concerns about the absence of empirical (Aroni and Durkin, 1985) and spurred a series of studies of earthquake epidemiology in just a few places. In this process, a wide variety of important variables have emerged related to individual, injury, built environment, hazard, mitigation, and response.

---

[1] 14 Worst Hit **Districts**: Kathmandu, Bhaktapur, Lalitpur, Kavrepalanchok, Dhading, Rasuwa, Nuwakot, Sindhupalchok, Gorkha, Dolakha, Sindhuli, Okhaldhunga, Ramechhap and Makwanpur.

Purpose and Research Questions

> "Disaster epidemiology provides the important evidence basis for identifying and prioritising effective structural and non-structural mitigation and environmental protection measures to be taken at all levels of society, as well as for planning for disaster response and for behavioural guidance during and after onset" (Petal, 2011).

Purpose

The purpose of this study is to identify the causes of injuries and deaths in the 2015 Gorkha Earthquake (and subsequently) in order to provide a scientific basis for education and training of the Nepali public in basic disaster preparedness and mitigation. Not long before the 2015 earthquakes, the Nepal Risk Reduction Consortium developed a set of ten common messages for disaster preparedness and ten key messages for earthquakes (See Appendix #7). This research seeks to offer evidence to validate, and, where needed, offer refinements and changes, to support a renewed process of consensus-building for public education for earthquake (and all-hazards) safety.

This research will also add to the global body of knowledge about earthquake epidemiology.

Research Questions

The questions posed during the design of this research were:

1. What specific risk factors are associated with injuries of different severity?
2. What hazards in the built environment and building typologies have specific risks for human casualties?
3. What specific risk mitigation efforts will decrease deaths and injuries?
4. What specific behavior during and after an earthquake may decrease deaths and injuries?
5. How important is rapid search and rescue and medical treatment to injury outcomes?
6. What disaster preparedness measures are identified by earthquake survivors as both feasible and effective?

In asking these questions the intention is to develop recommendations for protection from future earthquakes in Nepal and in other regions facing similar conditions. However, it was also incumbent upon the researchers to identify the limitations of the findings, and to seek out other examples from the global experience of earthquake casualties that are salient for the Himalayan Frontal Thrust Fault.

Whilst the general finding from studies of causes of deaths and injuries is that “earthquakes don't cause deaths, unsafe buildings do,” much less is known about the specific mechanisms and causes of deaths and injuries and how to avoid them.

Review of Literature

Earthquake Epidemiology Findings

Damage to buildings is considered the most important factor causing injury and death in earthquake events worldwide, and it was no different in the case of the 25 April 2015 Gorkha Earthquake. The potential for devastation is very serious in low-resource countries due to both lack of building codes, limited access or understanding of these, poor capacity for compliance, and lack of enforcement. All of these make structural collapse and resulting casualties more likley. Dramatically smaller numbers of earthquake casualties are seen in developed countries like Japan and New Zealand which have implemented strict seismic building codes and invested heavily in enhancing community preparedness. In comparison, other countries like China, Turkey, India, and Haiti have experienced devastating casualties particularly due to building collapse (Paton, 2010; Ellion, 2012). In the Christchurch, New Zealand earthquake in 2011, 115 of 185 total fatalities took place in one multi-storey office building, not built to code (Wikipedia, 2016).

To date, data on deaths and injuries have been published following these earthquakes:

Table 1: Sources of Data on Earthquake Deaths and Injuries

1970	Peru	1985	Mexico City
1971	Bingol, Turkey	1987	Whittier Narrows, US*
1971	Caldiran, Turkey	1988	Spitak, Armenia*
1976	Guatemala*	1989	Loma Prieta, US*
1976	NE Italy	1990	Luzon, Philippines
1977	Bucharest Romania	1994	Northridge, CA, US*
1978	Santa Barbara, US*	1995	Hanshin-Awaji, Japan*
1979	Imperial County, US*	1999	Kocaeli, Turkey*
1980	El Asnam, Algeria	1999	Chi-Chi, Taiwan*
1980	Southern Italy	2008	Sichuan, China
1983	Erzurum, Turkey	2010	Haiti
1983	Coalinga, US*	2011	Tohoku
1985	Chile	2015	Nepal

See Petal, 2012 for detailed references to these studies (* indicates epidemiological studies).

Variables Associated with Deaths and Injuries

Unfortunately, the collection of data about earthquake deaths and injuries data is inherently a challenging task. Whilst it would be ideal to collect this data as close as possible to the time of occurrence, this does not happen easily when the priorities are to deliver life-saving support, rather than to collect epidemiological data about presenting problems. Health providers are overwhelmed and people are treated and released rapidly to make room for more to come. As a result, the nature of data collected at a national level regarding injuries is notoriously unreliable. It is virtually impossible to assess from these

data what the distribution of injury severity is. This is further complicated by the fact that different demographic groups, and those with differential access to services, are more likely to present with and report injuries than other people (e.g. in Northridge CA, USA 1994, women, whites, and younger people were more likely to *report* injuries). Similarly, the specific mechanisms and causes of deaths is extremely difficult to identify without the observations of those in the immediate vicinity, to supplement medical examination and records. In general, there are no standardized data collection tools consistently used by first responders that shed light on the causes or mechanisms of injury and death (as opposed to the medical diagnosis). For example, responders may not note that a person appeared to have a head injury, let alone ask or record any data about what it was that struck the person, where, when, and how.

Nonetheless, this limitation is not reason to ignore the potential for learning as much as possible about earthquake casualties.

The basic variables of interest are the severity of injury, as well as the type and mechanisms of injury and death. Epidemiological research globally has revealed a broad set of potentially significant, sometimes independent, and oft-times interrelated variables (Petal, 2012). These include:

- ***Hazard level variables:*** earthquake source characteristics, local site hazard characteristics (including post-impact data as well as environmental factors such as temperature), time of year, time of day, shaking intensity, and duration.
- ***Individual and behavior level variables:*** age, gender, physical/mobility disabilities, injury characteristics, physical and social location, activity, occupant behaviour.
- ***Injury level variables:*** type of injury, injury severity, part of body affected, treatment sought.
- ***Built environment level variables:*** construction type, quality of construction, storey height, building damage, collapse pattern, volume loss, extrication difficulty, nonstructural risks, infrastructure risks, hazardous materials exposure.
- ***Mitigation level variables:*** household preparedness, fastening tall and heavy furniture, having fire suppression tools and knowledge, first response skills, and response provisions.
- ***Response level variables:*** time of arrival, availability of professional rescuers, length of time entrapped, response effectiveness, presence of trained community emergency response volunteers.

Below is a summary of findings for each category summarized primarily from four review sources: Tang et. al. 2017; Doocy et. al. 2013; Petal, 2012; Wood, 2014.

Hazard level variables:

- Energy and Depth: The public understands *magnitude* and depth as primary characterization and recognition of major earthquakes. However, beyond initial description, these and other micro-seismic characteristics are more significant for their impact on the building damage, and thus indirectly influence casualties (Sichuan, Haiti, Tohoku) (Iris, 2016).
- Location: To date the location of epicentre and hypocenter in known seismic risk zones is related to vulnerability, primarily related to population density and construction type. Levels of damage

are generally lower as they radiate away from the epicenter, and away from the fault. In Loma Prieta, for example, the radius for severe injuries was wider than for lethal injuries and the radius for minor and moderate injuries was wider still. However, there are now many examples from earthquake events where underground propagation along unseen faults results in high rates of injuries and deaths far from the source (Northridge CA, USA 1994; Kocaeli, Turkey 1999). As a result, casualties often extend far beyond the epicentre but may be not equally distributed around it.

- Acceleration and frequency of ground-shaking: Whilst these parameters are routinely noted in desciribing earthquakes, these have not been systematically studied in relation to casualties. In the Northridge earthquake both fatal and non-fatal injuries were abundant over a broad range of peak ground accelerations (PGAs). However, higher PGA was associated with mortality, and being hit by objects was associated with lower PGAs. Nevertheless, fatal and severe injuries were also reported in 9% of the zip codes with no damage. Building damage levels are affected by the frequency of earthquake waves.
- Ground amplification: As shaking propagates it may be amplified depending on the nature of the rock and surface soil type and depth. As far as specific locations and soil properties, it is now well-recognized that softer soils can be especially damaging to poorly-built and/or poorly-engineered taller structures, and harder soils and bedrock will impact poorly-built shorter structures (Iris, 2014). Buildings located at the tops of ridges, and unstable slopes can also be more vulnerable.
- Earthquake waves, soil, and building height interactions: In general, short buildings on hard bedrock and tall buildings on softer soils suffer more damage in earthquakes, whereas short buildings on softer soils and taller buidings on hard bedrock suffer less damage from earthquake shaking. This is because buildings themselves have their own 'natural resonance period', the rate at which they vibrate back and forth. Tall buildings naturally resonate at longer periods and therefore amplify these higher amplitude, low frequency earthquake waves, whereas shorter structures naturally resonate at shorter periods and therefore amplify lower amplitude, higher frequency earthquake waves. Similarly, softer soils have lower frequency resonance making the shaking larger and longer, whereas hard bed-rock has higher frequency resonance making the shaking smaller and shorter. If the frequency of earthquake waves matches those of the buidings, it will cause the largest oscillations in the building, and results in the most catastrophic damage (Iris, 2014)
- Intensity and velocity: Increased intensity and velocity of shaking are well-understood to have severe effects structures in the built environment. However, the impact of intensity and velocity on the human ability to move, and to move safely, are not well understood.
- Displacement: Horizontal and vertical ground displacement has not been well-studied in terms of comparative impacts on the vulnerability of built environment and people.
- Duration: The duration of shaking generally increases with the size of the earthquake. The longer the buildings shake, the greater the damage. However, the comparative impacts of duration of shaking on the vulnerability of built environment and people have not been well-studied. Moreover, the human ability to move, and to move safely, during various durations of different types of shaking, is barely understood at all.

- Time of day, day of week, season: The timing of impacts are related to occupancy of the built environment; activities are also associated with specific times and days. Being indoors vs. outdoors and near vs. far from dense urban environments are significant. Daylight hours and moderate temperatures are important for immediate search and rescue, as well as for access to health service. Inclement weather slows mutual aid and first response.

Individual age, gender, disability variables:

- Age: In some earthquakes the youngest children were the most vulnerable (Guatemala, Southern Italy, Chi-Chi), in some school-age children (Kocaeli) and in many older people were the most vulnerable (Guatemala, Coalinga, Loma Preita, Northridge, Hanshin-Awaji, Chi-Chi).
- Disability: In several earthquakes people with physical disabilities were found to be more vulnerable (Coalinga, Hanshin-Awaji) (Osaki, 2001). For example, in Northridge those over age 65 had 2.9 times the risk of hospitalized injury (Peek-Asa 2003). However, in the 1976 Friuli (NE Italy) earthquake, people who were agile were more likely to be injured because they rushed out and were crushed in the street by falling masonry (Hogg, 1980).
- Gender: Although in some earthquakes, women have been more vulnerable to casualties (e.g. Guatemala, Imperial County, Hanshin-Awaji), in others men have been more vulnerable, whereas in others there was no significant gender difference (e.g. Santa Barbara, Northridge). Overall women have been slightly more likely to be injured or killed (Wood, 2014).
- Combinations: In the Northridge earthquake injury rates were approximately equal by gender but increased significantly with increasing age. Gender, age, and disability combined may decreased resiliency due to a decreased ability to take protective action (Peek-Asa, 2003; Chou, 2004).

Injury level variables:

- Types of injuries: Fractures, soft tissue, and crush injuries were the three most common and most reported injury types. In high-magnitude earthquakes compared to those in low-magnitude earthquakes a lower percent of soft tissue injury and a higher percent of nerve injuries were observed (Tang et. al, 2017). Patients from countries with high levels of economic development suffered a higher percent of fracture and multiple injuries, but a lower percent of nerve and spine injury compared to those of patients from countries with low levels of economic development (Tang et. al, 2017).
- Part of body associated with fatal injuries**:** Head (Chile); Thorax, head, abdomen (Northridge); Neck, head, chest (Turkey).
- Part of body associated with survivable injuries: Extremities and the head/neck were the most common and mentioned injury locations (Tang et. al, 2017). Arms, hands, feet, legs (Santa Barbara, Imperial County, S. Italy, Northdridge, Kocaeli).
- Mechanisms of injury: Being struck by an object was the major cause of earthquake-associated morbidity (Tang et. al, 2017). The most common injuries reported from the predominantly wood-frame construction of California are lacerations, falls, contusions, fractures, and sprains (Imperial County, Coalinga, Loma Prieta, Northridge).

- Emotional injuries: The literature across cultures refers to these injuries very differently. Sometimes they are referred to in terms of 'mental health', 'psychosocial', or 'emotional' impacts. These have not been systematically reported in the literature, however, in the 1994 Northridge earthquake, 32-36% of those seeking care reported emotional injuries, though not clinical levels of distress (Bourque et. al. 1997). In Whittier Narrows it was 23%. In the 1999 Kocaeli event, 13% continued to seek mental health treatment after 20 months and 1% were identified having debilitating emotional injuries, including tension (40%), depression (26%), and fear (25%) (Petal, 2009).

Built environment level variables:

- Construction type: Until recently, most of the earthquake studies have had mostly rural impact and therefore early studies focused on the vernacular stone masonry and adobe construction that had been responsible for most of the deaths (Guatemala 100%; Chile 86.9%). The documented lethality rates for stone-rubble and stone-masonry buildings have varied (Spitak 2.8%-12%; Bingol 5.3%; Erzurum 8.3%; Caldiran 11.1%). With the shift to a greater urban than rural population globally, there have been more data recorded on both wood-frame and reinforced concrete buildings. In several earthquakes the overwhelming number of deaths were in poorly-constructed reinforced concrete buildings (Bucharest 70%; Mexico City 89%). Lighter weight construction and lighter weight roofs were associated with much lower lethality from building damage (Guatemala, Northridge). There are higher lethality rates due to fire risk associated with wooden buildings (Hanshin-Awaji).
- Building damage: Building damage is the single variable that correlates most frequently to deaths and injuries across earthquake locations. The use of standard building damage classification schemes (e.g. ATC-13) would enhance comparability of data. Recently, poorly-built reinforced concrete multi-family buildings have been studied. A lethality rate of 1.5% in heavily damaged reinforced concrete buildings, compared to 10.7% in totally collapsed RC buildings in Kocaeli, further demonstrated the great potential for incremental and minimum retrofit measures to prevent collapse and save lives.
- High occupancy buildings: A number of very high occupancy buildings of various construction types (confined masonry, frame panel, pre-cast concrete, reinforced concrete) have failed catastrophically and are associated with very high lethality rates (Spitak, Gorkha, El Asnam, Mexico City, Luzon); these include the more common multi-family reinforced concrete buildings (Kocaeli).
- Building height and floor: In several earthquakes, the odds of injury appeared to be greater the taller the building (Armenia, S. Italy, Spitak, Kocaeli, Chile). The relatively greater motion on higher floors may restrict people from taking protective action. The exception to this seems to be in low rise buildings where the upper floor may be safer (Hanshin-Awaji). Content related injuries seem to be higher in concrete and metal structures and lower in wood buildings (Loma Prieta), which is hypothesized to be an effect related to the height of these buildings.
- Structural hazards and death: In both California and Turkey, deaths were predominantly associated with structural hazards (98.5% in Loma Prieta, 75.8% in Northridge, and 61% in Kocaeli).
- Non-structural hazards and injuries: Building non-structural elements and building contents are also highly associated with injuries, especially slight and moderate, but also are associated with serious

and critical injuries (Northridge, Hanshin-Awaji, Kocaeli). In Loma Prieta and Northridge, 22% and 44% of hospitalized injuries, respectively, were attributed to non-structural hazards. In California, where buildings themselves contain more hazardous contents that can topple, slide, or break, the ratio of injuries to deaths is high, and non-structural building hazards are implicated in many moderate and less serious injuries. In earthquakes in areas with heavier construction types, more serious injuries have been associated with being struck, crushed, or pinned by heavier objects. In Kocaeli, Turkey, where reinforced concrete buildings in urban settings predominated, 69% of non-fatal injuries were associated with non-structural buiding components (including unreinforced infill walls) and building contents, 22% with structural components, and 11% with both. Tall and heavy furnishings, windows, and other glass objects, and other household equipment and objects were identified as having hurt people.

- In Turkey in 1999, 33% of injuries were attributed to being struck by a falling object, 24% to being under a falling object, 11% to being cut or pierced, 8% to falling, 20% to multiple, and 3% other (Petal, 2009). In Imperial County the ratio of building contents related injuries to other non-structural injuries was 3:1.
- <u>Time of death or injury</u>: For fatal injuries, virtually all of those in Kocaeli occurred during the shaking, whereas in two California earthquakes 15-18% of fatatilies occurred several minutes later. As far as non-fatal injuries, 8-39% have been found to occur after the main shock. In Kocaeli 13% occurred just after, 2% during search and rescue, and 1% each during aftershock and clean-up. These post-shaking injuries are considered to be largely avoidable.
- <u>Inside buildings vs. outside buildings</u>: In the absence of a major day-time urban earthquake, there are few data to indicate the potential dangers of external falling debris from tall buildings in densely populated areas. It is known that debris falls away from buildings in a radius up to ½ of the building's height, and thus this must be considered a danger zone.
- <u>Collapse patterns,</u> as well as the size and number of void spaces or the void-to-volume ratio, are key factors in survivability, including time to extrication. However, high rates of entrapment limit the success of rapid extrication efforts (Taiwan 1999). Life-saving first aid, in-situ, has been suggested as a way to increase survival until extrication.

Mitigation level variables:

- <u>Structural and non-structural risk reduction measures</u>: It is now clear from the enormous differential impacts of similar-sized earthquakes in the U.S., Japan, and New Zealand vs. similar events in Iran, Pakistan, Turkey, and elsewhere, that measures taken to prevent structural and infrastructural collapse have been successful in mitigating the enormous potential for serious injuries and deaths. It has been notoriously challenging to measure the deaths and injuries that have *not* happened. The efficacy and potential-efficacy of securing non-structural hazards and building contents have been demonstrated through shake table research in Japan and California, and noted in photographic and video evidence (YouTube, 2016), but in the absence of widespread adoption of non-structural mitigation measures, these have not yet been systematically studied in situ.

Response level variables:

- Until large numbers of people systematically adopt specific protective actions, the efficacy of these for reducing casualties is extremely difficult to measure. In the meantime, other data has been used to infer recommended protective actions (see separate section below).
- A study in Iceland confirmed that whilst taking protective action worked well for some people in areas with lower intensity shaking, residents who experienced strong shaking reported being unable to move to safer places within their homes, and that poorly fastenend household contents posed a significant threat (Akason. Et. al. 2006).

- <u>Behavior of Occupants / Protective Actions</u>: Movement, and in particular exiting, during shaking has been found to be dangerous. In the 1994 Northridge earthquake those who reported moving during the earthquake were twice as likely to have been injured as those who remained in place (Shoaf, et. al., 1998). Similarly, in the February 2011 Christchurch earthquake, movement significantly increased injury risk with 70% of injuries caused by 'trip' and/ or 'fall' during the shaking (Johnston et al., 2014). In the Kocaeli earthquake those who stayed in bed were safer than those who did anything else (Petal, 2009). Evacuation of unreinforced masonry buildings during shaking increased the risk of injury by a factor of three (Aroni and Durkin, 1985). Gender, age distribution, physical disability, and education levels have been found to be related to choice of protective action. (Shapira et. al 2015). In the 1970 Peru earthquake (Shoaf, 2002a), people who ran instinctively out in the wide streets at the first instance escaped any injuries and casualties; and those who stayed inside where trapped by the collapsed houses. In the Friuli earthquake of 1976, those who were more mobile suffered more from this earthquake than the elderly and/or very young people, as they were the ones who ran outside at the first tremors and were crushed by the falling masonry.
- <u>Entrapment and extrication</u>: The severity of injuries, the time taken to rescue, and the length of time until medical treatment are among the factors in building collapse survival. In virtually all earthquakes the vast majority of live rescues are performed by household members and neighbors, during the first 24 hours, which is considered the "Golden Day." Thus, beyond a few outliers, the efforts of international search and rescue response are known to be largely ineffective. In spite of the dramatic drop off rate in live rescues, the moral imperative is to continue search and rescue until all survival void spaces have been uncovered. One study that directly assessed health sector preparedness found that low-prepared regions had five times more fatalities than high-prepared regions (Bissell et. al. 2004)
- <u>Access to health services</u>: There are three key factors in timely access to health services. One is the scale of casualties, as mass casualty events will require more effective triage. The second is the length of time to receiving medical aid, whether because of lack of physical access (e.g. transportation from remote locations), and the third is the lack of sufficient trained care providers.

Protective Actions

Protective action recommendations are of great interest to the public. People would like to know if there is anything they can do for safety, and if so, what they can do during and immediately after earthquake shaking. Several studies on this subject guide this discussion (Goltz & Bourque, 2017; FEMA, 2015; GHI, 2015; Wood, 2014; Spence et. al. 2011; Goltz, 2006).

The GeoHazards International (GHI) publication is informed by valuable literature reviews. It isolates the question of "what to do during shaking" from the surrounding comunications on what to do before and after earthquake shaking. The study notes that considerations for developing messaging includes a variety of scientific and evidence-based vulnerability factors (e.g. geographic areas, earthquake hazard, construction, causes of deaths and injuries in past earthquakes), social factors such as gender, functional and access needs, and cultural factors such as beliefs, traditions, and customs. The study recommendations are based on two findings:

1. No single action is appropriate in all locations, and
2. With information from trusted local experts, individuals should, in advance of the occurrence of an earthquake, evaluate and understand the hazards posed by location and surroundings.

The evidence-based focus is on the threats posed by: building collapse or damage, objects falling, sliding or toppling, and objects falling from the building exterior. The study goes on to suggest that "local teams" assemble representatives from technical disciplines and stakeholder groups to undertake a process to consider message content and develop effective messages and communication strategies. These messages and strategies would help people to develop *situational awareness,* and should be divided into "slogan", a "60-second message," and a "60-minute" message with detailed guidance. Unfortunately, the resources and wherewithal for such "local teams" seems highly unrealistic. The bottom line message refers to "*wherever you go, look for the safest place you could reach within five seconds after the shaking starts*" (p6). The appraisal of 'safest place' refers to the things that are known about hazard avoidance. However, this '5-second rule' seems quite fanciful, and is not based on any evidence of recognition, processing, or action time, nor on the feasibility of moving safely.

Some studies suggest that up to half of people in an office building may have hurt themselves (bumping themselves) while engaging in unnecessary evasive behavior (Mahue-Giangreco et. al. 2001). Petal cautions against the treatment of "exiting the building" as an independent variable, pointing out that it is incorrect to equate exit without injury as "protective" and staying in place or exiting with injury as non-protective, because: a) the already-injured in damaged buildings may not be able to exit to be counted (Armenian, 1992), b) those killed while attempting to exit may not be counted, and c) the ability to exit is constrained by the severity of ground-shaking, displacement, number of floors, building height, individual mobility, and hazards inside and out (Petal, 2012 p.39). Therefore, the question for public education is whether being able to exit (with or without injury) is less, or more harmful, than remaining inside. Peek-Asa et al. (2001) note that the disparate findings between Armenia and California are "not necessarily contradictory because exiting from a poorly-built collapsing structure may protect against death while attempts to exit buildings that do not collapse may increase risk for injury" (Peak-Asa et. al. 2001). To complicate matters, if someone sustains a minor injury, for example, by diving under a desk, or standing under a strong doorway, and being hit by a door – that may be acceptable, compared with being exposed to greater injury from alternate behavior.

Goltz's research has examined two dramatically contrasting views of human behavior: the preponderance of social science literature that suggests that people's immediate response to emergency are rational and

adaptive (Tierney, Lindell, and Perry, 2001) vs. Charles Richter's description of the universal impulse to run, which is built into the Modified Mercalli earthquake intensity scale (Richter, 1958), and the popular media references to panic and flight (Dynes, 2006). It examines data from three quite different California earthquakes to see the extent to which characteristic ground motion itself may impact human behavior. The variations in actions taken at the time of the shaking were: taking cover, remaining in place, going to others, or running outside. The study is consistent with other studies, finding that fear was associated particularly with the gender, ethnicity, the presence of dependent children, lower levels of educational attainment, lack of adequate preparedness, length of residence, and the strength or intensity of shaking. Higher levels of fear are associated with people moving (taking cover or running) vs. staying in place. The presence of others – dependent children in the home and those in the company of others at work or home – contributed to taking cover in Whittier Narrows and Loma Prieta. "The lack of discernable effect of shaking intensity on the type of behaviour calls into question the linkage of different levels of earthquake shaking and specific behavioural response" (Goltz, 2006; Goltz & Bourke, 2017).

Running during earthquake shaking is highly discouraged in California. Goltz's research found that running outside was more likely by men, non-Mexican Hispanics, persons with fewer years of California residence, and those who described themselves as totally unprepared for an earthquake. Other factors noted included lower education, lower income, and number of earthquakes experienced.

Fear has demographic, situational, and cultural dimensions (e.g. higher levels of fear among women, Hispanics, lower levels of education, higher intensity shaking, and lived in California for fewer years). Goltz & Bourke conclude that:

> "… fear, contrary to conventional wisdom, is not a sole or even major determinant of maladaptive behavior…. High levels of fear were linked to running outside and going to others but it was also linked to taking cover and avoiding hazards. Thus, fear seems to be a causal factor in physical movement, but other variables are involved in translating the impetus to move into specific response actions. That fear is associated with physical movement was also highlighted by the finding that those who chose to remain in place tended to be the least frightened" (Goltz & Bourke, 2017).

Further, the authors found that "Higher levels of fear were linked to both running outside and going to others, but also to taking cover and avoiding hazards" (Goltz & Bourke, 2017). Ironically, whilst women were more likely to express fear, they were also more likely to take cover, and less likely than men to run outside.

The conclusions include optimistic observations of the success of a couple of decades of consistent public awareness messaging:

> "Can we say in concert with most social scientists that behavior in response to a sudden onset disaster is rational, goal oriented, and consistent with prior social roles? Indeed, we can. The large majority of people in all three earthquakes chose responses that were generally consistent with the advice of disaster response agencies that emphasize minimal movement during a strong earthquake or taking cover in a safe location" (Goltz & Bourke, 2017).

Research Design and Methodology

Epidemiological Research Design

The primary research methodology used in this study was an epidemiological survey, for the following reasons:

- Epidemiological research using standardized surveys across a wide number of disaster events, allows the development of a body of knowledge, and the potential for comparing results across a range of variables. This comparison facilitates both validation of results and the crystallization of salient questions. There is an emerging standard template through which the differential impacts of particular earthquakes can be fruitfully compared (Shoaf et. al. 2002b; Petal, 2009; Petal, 2012).
- Researchers often bemoan the need to collect standardized data across a range of events even though real benefit to humankind lies in sharing our experiences. At this point all such research is unique, as each event highlights some important variables.
- Survey research is an efficient way to reach a sizeable number of respondents – enough to form a reliable sample of the impacted population. Surveys can be administered quickly, efficiently, and for less money than open-ended interview.
- Face-to-face survey research, where the interviewer and interviewee are present together, is an effective means of rapidly establishing a relationship in order to sensitively acquire information in a post-disaster setting.
- Both closed and open-ended questions can be included.
- Survey interview skills can be taught and employed by a team of native-speaking interviewers who can collect data rapidly and accurately even when the primary researcher is not fluent in the target language.
- The results permit us to further refine our knowledge of the specific causes of morbidity and mortality.
- The results should provide information that can be communicated to and understood by a diverse population.
- The number of variables measured and questions answered can be increased by increasing the sample size, thus the survey research can theoretically be expanded with additional resources.
- The methods and tools can be used in the future to study the impact of similar future earthquakes.

The major drawback of structured surveys is that they limit access to spontaneous responses and information. Ideally, a combination of structured and unstructured methods provides an opportunity to pick up on important inputs that enter from off the researcher's radar screen.

This study follows a descriptive cross-sectional study design. It was implemented in five districts identified as highly affected due to the earthquake which occurred on 25 April, 2015 – Bhatapur, Kavrepalanchok, Kathmandu, Nuwakot, and Sindhupalchok. A quantitative research technique using a structured interview questionnaire was implemented for the data collection.

Variables

Variables to be examined were selected based on key demographics associated with vulnerability, differential findings in other earthquakes, major features observations from earthquake reconnaissance, and recommended mitigation and preparedness activities, with a view to generating advice for greater safety and survival. In addition, survivors' experiences were tapped to learn of their perceptions of feasible and protective actions.

The variables selected were as follows:

- ***Hazard Level Variables:*** earthquake characteristics and location
- ***Individual Level Variables:*** age, gender, marital status, occupation, caste/ethnicity, disability, family income, education
- ***Injury Level Variables:*** parts of body injured, injury severity, time to treatment, time of injury, location at time of injury, cause of injury, position/behavior/movement during shaking, medical care sought
- ***Built Environment Level Variables:*** type of area, building function slope, relation to other buildings, position, building type, building features, structural and non-structural causes of injuries and deaths, building damage level
- ***Mitigation and Preparedness Level Variables:*** risk assessment measures, structural measures taken for safety, non-structural measures taken for safety, preparedness measures, response skills, response provisions
- ***Response Level Variables****:* perceptions of efficacy and safety of recommended actions, entrapment and search and rescue, medical response
- ***Community Awareness Program Variables:*** availability and participation in school or community programs.

(For more in-depth details please see the questionnaire in Appendix #8).

Study Tools and Techniques

The household survey questionnaire was based on findings of studies done over the last 20 years in U.S., China, and Turkey (Shoaf, 1996; Petal, 2009), and adapted and localized with support from a global expert reference group, including Nepali public health and earthquake engineering specialists, prior to and after translation (see Acknowledgements). The questions were programmed into a tablet-based application for data collection using *Open Data Kit*. Pre-testing of the data collection tool was done prior to the field supervisors'/researchers' training. Paper-based data collection forms, too, were provided to the field researchers/supervisors for back-up in case the tablet was not functional. Portable flipcharts were produced for use by each field researcher to identify the damage levels of the building and injury severity) (See flipchart in Appendix #9). Household visits were timed to maximize when most family members could be expected to be home.

Localization and translation of the survey

The survey was translated and "localized" for the Nepali context in consultation with an expert reference group that included Nepalese engineers, social scientists, and health providers as well as other experts in language, public education, and social work. Adjustments were made to describe construction types, use standard demographic categories, describe ranges of likely choices, and use standard terminology to be understood by the target population, and explained as needed, by enuperators. In particular, in order to minimize under-reporting of emotional suffering through the use of potentially stigmatizing terms, terminology to identify 'heart-mind distress' vs. 'brain-mind disfunction" (Kohrt, 2010) were selected, and "local (spiritual) healers" were listed among treatment options sought (and answers such as "jhankri", "jharphuk", "lama", "phukphak" would all have been coded as such. The survey questionnaire was pretested, reframed, and re-translated.

Sampling Design

Sample Frame

Cluster sampling using purposive method was adopted to select the study sample. Five of the seven hardest-hit districts with the highest number of fatalities, and highest numbers of damaged buildings were selected in order to cover a range of urban, peri-urban, and rural settings. Appendix #3 provides a graphic illustration of the overall sampling procedure.

The selected districts were: Bhaktapur, Kathmandu, Kavrepalanchok Nuwakot, and Sindhupalachok. In each of these five districts, the 10 VDCs/Municipalities/Metropolitan Cities identified as hardest hit, based on number of fatailities, were identified and one ward was purposively selected. Outliers caused by very high fatalities in 1-2 buildings were eliminated. The criteria for selection of wards were: accessibility (by road), and sufficient density for efficient data collection from at least three households per day per field researcher. Social mapping with key informants was used to generate a full list of accessible households with a sampling frame of at least 100 households.2 From this list every second household was selected until 50 households were identified. Substitutions of 'next building' were made where building was uninhabited, or when no inhabitants could be found after a third visit.3 In multi-family buildings units were counted from top down, clockwise on each floor. The target was to interview or obtain survey responses for all members of the household who were in the VDC at the time of the 25 April earthquake. Each home was visited up to three times. Proxy reporters were requested for children under 18, and other unavailable or deceased persons.

---

[2] The following methodology, adopted from: http://un.org.np/sites/default/files/report/tid_188/Internal-Migration-March2005.pdf was used. "They are selected along a transect line from the center to the periphery of the cluster identified by spinning a bottle at its center point. First, the total number of households – defined as people sharing a meal – along the transect line is established by visiting each building along the line. Secondly, that number is divided by the required sample to reach at the sampling interval with which households along the line are selected for interview. If necessary, the exercise is repeated till the sample size requirement is met."

Sample Size

A sample size of 500 households was purposively selected considering the time and resources. A total of 1,855 household members from sampled households were present in the VDC on 25 April 2015 Nepal Earthquake and were eligible respondents for the study. Individual surveys were obtained for 1,403 members (815 self-interview and 588 proxy interview). Surveys were not completed for the remaining 25% (469) household members who were present in the VDC at the time of the earthquake, because they were not available, and none were present who felt they had sufficient knowledge to respond on their behalf. (This included 23 dead and 16 injured individuals.)

Data Collection, Quality Assurance, Management and Analysis

Data collection was conducted by 5 field supervisors and 22 data enumerators, over the course of two weeks. The team was intensively-trained and participated in a one-day field trial prior. Overall data management was carried out by an experienced Data Management Officer and a Data Analyst. Real time data monitoring from timely data uploads took place. Data coding, editing, and cleaning took place centrally with multiple measures taken to assure security and confidentaility. Descriptive and bivariate analysis was conducted to assess association between deaths and injuries and groups of variables.

Human Subjects Protections

Human subject protection was implemented in several ways:

- Approval of proposal by National Health Research Council ethics review panel was received prior to study.
- Approval was obtained from district authorities prior to data collection.
- Data collection design and enumerator training was sensitive of the needs and concerns of survivors.
- Psychosocial support training was provided by Dr. Petal for the research and field data collection
- Children under the age of 18 were not interviewed as primary informants, but because they may be present during interviews, Save the Children provided child-safeguarding training of research and field data collection teams.
- Children over the age of 14 were present during the interview at the discretion of a parent or guardian who had already participated in the survey.
- Informed consent was explained and obtained at the begining of each interview. This included an explanation of survey objectives, privacy and confidentiality protection, possible harm of the study and utility of the study, ability to skip questions or to stop at any time.

Human subject protection was considered in program design. In post-disaster research, multiple research teams collecting data from survivors raises concerns about:

- the possibility of exacerbating distress,
- raising expectations about availability of material aid or provoking concerns at lack thereof, and
- the extractive nature of researchers coming in for one-way transmission of knowledge and experience.

Field data collection design incorporated several measures to accommodate these concern: Interviewers were selected from the region and empowered by their role as representatives of a well-respected research partner. They brought with them earthquake safety information, provided by NSET, to share. Enumerators clearly explained that their goal was to learn in order to prevent others from suffering similar tragedies in the future. Respondents were made aware that the results of the research would be reported back to local community leaders. Thus, a sincere effort was made to bring respondents into a reciprocal support endeavor.

Based on a general review of the literature on mental health and disasters, and consultation with disaster mental health providers in eastern and western contexts, the consistent observation is that people want, and perhaps need to talk about their experiences, as a healing and coping mechanism. Mental health professionals advise that in post-natural hazards impact, memories of losses are constantly being stimulated by many sources, other than our survey, and that these memories are not buried and forgotten traumas that the research would unearth (Petal, 2009). On the contrary, survivors of natural disasters, given the choice, will almost always choose to tell their stories, hoping to benefit from recounting this to empathetic listeners. The team demonstrated respect for respondents by carefully obtaining informed consent and allowing them to set the limits of sharing. The interviewers were trained to express empathy freely, and to listen and record diligently, thus validating the survivor's experience. Interviewers learned to always make people the priority rather than the survey.

Potential Biases and Limitations

Whilst recall bias might have occurred as this study captured the earthquake related experiences of people after a period of almost one year, other studies have reported little degradation of memory over time. Proxy interviews were also carried out for the unavailable/deceased person, which may lower the accuracy of the data. The study was limited to only 5 districts based on the high impact of the earthquake, and only 500 households (1403 completed interviews/surveys out of 1855 household members) were purposively selected. As such, findings may not represent all of the districts. Particularly unrepresented in this survey are people in larger and taller urban buildings and people who were in the most lethal buildings, as households with fewer survivors would be less likely to stay in the same households, or there may be no survivors to report at all.

Research Findings

Please note that particularly salient findings are highlighted with a box, like this.

National Data on Deaths, Injuries, Building Damage, Lethality, and Gender

Looking at deaths and injuries, some basic statistics gathered by the Government of Nepal provide a starting point (See Table 2):

- **DEATHS:** The Government of Nepal recorded 8,790 deaths in this earthquake, as of June, 2015 (GoN, 2015b). Fifty-five percent of those who died were females (49% to 64% depending on district), and forty-five percent were males (36% to 51% depending on district), indicating that significantly more women than men died in this earthquake.
- **DEATH RATE**: This statistic is used in relation to the total impacted population. Overall in the 14 worst-hit districts, ***the death rate was 16 per 10,000 population***. Rates were as high as 152 per 10,000 in Rasuwa, and as low as 1 per 10,000 in Makwanpur.
- **GENDER DIFFERENCES IN DEATH RATE**: The final official death toll was 8,838, comprised of 3,944 men and 4,894 women (GoN 2015b). Due to the potential that internal displacement in search of employment might mean that the distribution of men and women in the hardest hit districts may not be equal, we compared the gender distribution in the 14 most-highly impacted districts according to the 2011 Nepal Census. The overall distribution varied between 46-54% with a 50/50 distribution overall. In the 5 districts where our survey was conducted, in the 2011 Census, Kathmandu had a 52:48, male:female split in 2011, Bakhtapur 51:49, and the other three districts 48:52 (GoN, 2011).
    - Indeed women did experience a higher rate of death compared with men. The gendered division of labor, with more women indoors cooking and caring for young children may have contributed to some of this inbalance.
- **INJURIES:** The Government of Nepal recorded 22,307 injuries for this earthquake. Injury reports are notoriously varied (Shoaf, 2002). In all likelihood government records of injuries do not include minor injuries that were self-treated, or not presented to regular medical facilities. Government gathered data may only capture those with access to services and ability to report.
- **INJURY RATE:** This statistic is used for reported injuries in relation to the total impacted population. In the 14 worse-hit districts, ***the injury rate was 32 per 10,000 population***. It ranged as high as 405 per 10,000 population in Nuwakot to < 5 in Makwanpur
- **RATIO OF DEATHS TO INJURIES**: The overall ratio of deaths to injuries was 0.41.
- **LETHALITY RATE:** This statistic is used in relation to buildings. **The lethality rate was 0.19 per heavily damaged or collapse building**, lower than expected, perhaps due to time of day and many rural residents being outdoors.

Table 2: Deaths, Injuries, and Building Damage in Nepal Earthquakes 2015 by District

(14 most highly impacted districts)

Most highly impacted by number and proportion of deaths and injuries and building damage are indicted in ***bold***

Districts represented in research sample are <u>underlined</u>.

District	Population* (2011)	Deaths	Injuries	D:I	Death Rate per 10,000 pop.	Injury Rate per 10,000 pop.**	Census Pop. Density /sq.km	Heavily Damaged or Collapsed Bldgs.	Lethality Rate per Heavily Damaged or Collapsed Bldg.
<u>Kathmandu</u>	1,744,240	***1,222***	***7,949***	0.15	7	***46***	4,416	***36,973***	0.033
<u>Bhaktap</u>	304,651	333	***2,101***	0.16	11	***69***	2,560	***18,900***	0.018
Lalitpur	468,132	180	***3,015***	0.06	4	***64***	1,216	***16,512***	0.011
<u>Kavrepalanchok</u>	381,937	318	***1,179***	0.27	8	31	274	***49,647***	0.006
Dhading	336,067	676	***1,218***	0.56	20	36	174	***43,834***	0.017
Rasuwa	43,300	656	771	0.85	***152***	***178***	28	7,040	0.085
<u>Nuwakot</u>	277,471	***1,215***	***1,125***	1.08	***44***	***405***	248	***57,957***	0.018
<u>Sindhupalchok</u>	287,798	***3,531***	***1,573***	2.24	***123***	***55***	113	***63,636***	0.054
Gorkha	271,061	449	952	0.47	17	35	75	***44,695***	0.01
Dolakha	186,557	176	662	0.27	9	35	85	***48,880***	0.003
Sindhuli	296,192	15	230	0.07	<1	8	119	***18,257***	0.001
Okhaldhunga	147,984	20	61	0.33	1	4	138	***10,032***	0.002
Ramechhap	202,646	41	134	0.31	2	7	131	***26,797***	0.001
Makwanpur	420,477	33	229	0.14	<1	5	173	***15,058***	0.002
14 District Total	5,368,513	8,775	21,161	0.41	16	32		458,218	0.019
Nepal 75 District Total	26,620,809	8,888	22,307						

*Sources: * Population (GoN, 2011); ** (GoN 2015)* N.B. These numbers are considered final and are slightly higher than those related to humanitarian agencies in June, 2015.; The May 12th aftershock contributed 2,000 deaths and more than 2,500 of these injuries. Other statistics are calculated.

Table 3: Deaths and Injuries and Gender in Nepal Earthquakes 2015 by District
(14 most highly impacted districts)
Most highly impacted by number and proportion of deaths and injuries, and building damage are indicted in ***bold***
Districts represented in research sample are underlined.

District	Deaths Males N	Deaths Males %	Deaths Females N	Deaths Females %	Deaths Total N	Deaths Total %	Injuries Total N	Injuries Total %	Death & Injuries Total
Kathmandu	621	51%	601	49%	1,222	13%	7,949	87%	9,171
Bhaktap	119	36%	214	64%	333	14%	2,101	86%	2,434
Lalitpur	71	39%	109	61%	180	6%	3,051	94%	3,231
Kavrepalanchok	129	41%	189	59%	318	21%	1,179	79%	1,497
Dhading	291	43%	385	57%	676	36%	1,218	64%	1,894
Rasuwa	312	48%	344	52%	656	46%	771	54%	1,427
Nuwakot	483	43%	642	57%	1,125	52%	1,051	48%	2,176
Sindhupalchok	1544	44%	1,987	56%	3,531	69%	1,573	31%	5,104
Gorkha	215	48%	234	52%	449	32%	952	68%	1,401
Dolakha	90	51%	86	49%	176	21%	662	79%	838
Sindhuli	5	33%	10	67%	15	6%	230	94%	245
Okhaldhunga	10	50%	10	50%	20	25%	61	75%	81
Ramechhap	17	41%	24	59%	41	23%	134	77%	175
Makwanpur	16	48%	17	52%	33	13%	229	87%	262
14 Districts Totals	3,923	45%	4,852	55%	8,775	29%	21,161	71%	29,936
Nationwide Totals	3,994	45%	4,894	55%	8,888	28%	22,307	72%	31,195

Those districts hardest hit are indicated in bold. The districts in our study are italicized above.

Hazard Level Variables

Location, energy, and depth

- The 25 April 2015 M7.8 Gorkha mega-thrust earthquake occurred in a region of high seismicity, 80 km NW of Kathmandu at a depth of 15 km. Ground motion characteristics of the event, however, defied expectations.
- The Modified Mercalli Intensity of the earthquake in the districts studied was 7 in Bhaktapur, Kathmandu, Nuwakot, and Sinhupalchok, and 6 in Khavrepalanchok.

Acceleration

- The peak ground acceleration (PGA) of the earthquake was very low, compared to earthquakes of similar magnitude and depth. The exception was in some hilly areas of Kathmandu where peak ground accelerations were much higher. Generally, acceleration measured was only 0.16 g, low when compared to similar magnitude earthquake in 1995 in Kobe (0.8g) in Bhuj (0.55g), and 1999 in Kocaeli (0.3-.4g). As a result, many poorly-constructed buildings did not sustain much

damage. However, adobe buildings begin cracking with just 0.10 g and were, therefore, heavily damaged in this event.

- The acceleration experienced was only about 1/3 of that acceleration associated with prescribed as design load in Nepal's National Building Code. Because of this, damage to well-constructed buildings should not be expected. Due to this low level of acceleration, it can be inferred that many of the un-damaged building may have been poorly constructed and could be damaged in future earthquakes with more typical, higher, acceleration. Conversely, some high rise buildings believed to be well-constructed were heavily damaged which was not unexpected. Due to their height and load, the acceleration likely matched the value associated with the natural sway of the building, causing an amplification of the movement and corresponding heavy damage. This does not mean that undamaged buildings are safe in future earthquakes.
- The ground motion from more typical earthquakes have had, and will likely have, higher accelerations that will cause much more widespread building damage.

Frequency of ground shaking

- The shaking intensity could be described as slow and gentle, taking 4-5 seconds to complete a cycle of back and forth motion. This type of shaking affects taller buildings, and tends not to damage well-built, low-rise reinforced concrete buildings. Most 3-6 storey buildings sway back and forth every 0.3-0.6 seconds. Had the shaking been faster, it would have matched the natural sway of many of these low-rise, reinforced concrete buildings and caused significantly more damage.

Displacement

- The displacement of the ground was as much as 95cm -- sufficient to cause damage to flexible structures like older buildings with mud brick walls and wooden floors, as well as tall slender temples. It also caused people indoors on higher floors to feel the substantial swaying.

Duration

- The duration of intense shaking was about 56 seconds.

Intensity and velocity

- People described the earthquake as violent and intense because they experienced the huge, swaying displacement. While this displacement was perceived as scary, overall people were not facing as much risk from building collapse as they would with higher peak ground acceleration, and less swinging. However, one has no way to know this when the shaking starts, and few people would be able to process these distinctions while experiencing the event.
- The observed damage to traditional adobe and stone construction in rural areas was very bad, but also expected. This type of construction needs many specific anti-seismic mitigation measures to ensure that the building's walls, floors, and foundation move together with the motion of the ground, rather than shake apart.

The Sample Population Surveyed

Our sample population included 500 households. Of these, 496 provided at least one complete individual survey.

- The total number of individuals living in these 500 households was 2,599 – with a mean household size of 5.2. However, 39% (744) of household members were outside the VDC at the time of the earthquake, and only 71% (1,855) of individuals were in the selected VDC at the time of the April 25 earthquake.
- The response rate was 76% (1,403 completed surveys). Of these, 58% (815) responded for themselves, 16% (218) responded for other adults, and 26% (370) responded for children under 18. Proxy responders were 59% parents or parents in-law, 18% spouses, 7% grandparents.
- The rate of refusals was 24% (452) – ten individuals declined and 442 individuals were not available, and no proxy was available. This included 22 dead, 16 injured, 436 not injured or dead.
- Respondents were 42% (583) male and 58% (820) female. The gender distribution of household members in the VDC at the time of the earthquake was 44% male and 56% female. The reason for this unexpected inequality is likely that in these rural locations, male members of the family may either work, live, or attend school outside the VDC.
- Age distribution of the 1,403 completed responses was 0-3 years 3% (48), 4-6 years 4% (57); 7-14 years 14% (184); 15-19 years 10% (139); 20-29 years 19% (250); 30-39 years 14% (193); 40-49 years 15% (197); 50-59 years 11% (143); 60-69 years 7% (99); and 70+% 7% (98).
- Rates of illiteracy were progressively and significantly lower, and educational attainment higher, in the younger age groups, indicative of Nepal's progress towards universal basic education over the past several decades.
- Education level, main source of income, caste and ethnicity, and employment staus all mirror the population in the districts studied.

For a full description of demographics of the surveyed population, see Appendix #3 and #6.

Deaths and Injuries in the sample population

- In the full sample of the 1,855 individuals present in the VDC during the earthquake: 88% (1,627) were uninjured, 10% (190) were injured, and 2% (38) people died.
- The rate of injuries in the sample population is significantly higher rate than government statistics suggest. This is expected because our survey captures the impacts of many more of the minor and self- or locally-treated injuries which government data does not. Of the 187 people injured in our sample, 63% (118) sustained minor injuries and 37% (69) were seriously or critically injured.
- The rate of deaths in the sample population is also higher than government statistics suggest. This oversampling is likely a direct reflection of our effort to sample the hardest-hit VDCs.
- Of the 1,403 for whom full survey responses were completed: 87% (1,213) not injured or dead, 13% (175) were injured, and 1% (15) died.

As anticipated in a study of this kind, the sample size of deaths is insufficient to disaggregate data about the fatalities for many variables, but is nevertheless valuable as part of understanding the total picture of casualties.

Individual Level Variables

Sample Population: Deaths & Injuries by Gender

- The rate of deaths and injuries in the sample population was not significantly different for men and women. Whilst females in our sample reported more minor and critical injuries than men, men reported more serious injuries. However, there was no statistically significant difference in injury severity between males and females.

Sample Population: Deaths & Injuries by Education Level Groups

- Deaths and injuries were not significantly different for people of different education levels.

Sample Population: Deaths & Injuries by Age

- The likelihood of death was higher for preschool children and those over the age of 70. It was lower for those between the age of 15 and 59.
- Children under the age of 15 were less likely to be injured whereas those 50 years and older were more likely to be injured.
- Youngest, pre-school children more likely to sustain more serious injuries, wheras people in their 20s-30s were less likely to sustain serious injuries.

Sample Population: Deaths & Injuries by Disability

Table 4: Injury/Death of People with Disabilities

Disability		Not injured	Injured / Dead	Total
Did not have a disability before	N (Row %)	1463 (88%)	197 (12%)	**1660 (100%)**
	Column %	90%	86%	**89%**
Did have one or more disabilities before	N (Row %)	164 (84%)	31(16%)	**195 (100%)**
	Column %	10%	14%	**11%**
Total	N (Row %)	**1627 (88%)**	**228 (12%)**	**1855 (100%)**
	Column %	**100%**	**100%**	**100%**

Pearson's Chi-squared value 2.629 1 df. This was significant at the 0.069 level (Exact 1-sided)

- In our sample, 11% of respondents had pre-exisiting health, sensory, or cognitive challenges, about what is expected in a normal population. These respondents were more likely to be injured or killed. Additionally, they represent 14% of the injured/dead. Whilst this does not rise to the standard of significant at the 0.05 level it is at least suggestive of a greater likelihood of injury and death.

- Comparing disabilities and health problems before and after the earthquake, the incidence of physical or sensory disabilities more than doubled in our sample population from 1.6% to 3.3 %, as did the incidence of mental health problems from .6% to 1.6. However, the incidence of these challenges in the sample population is much lower than expected in a normal population sample.

Built Environment Level Variables

Construction types

Experts in engineering and construction identified three major types of construction in the hardest-hit areas of Nepal: Gārowālā, Pillarwālā, and Kath/Katch.

Gārowālā Buildings: rubble stone with mud mortar

Pillarwālā Buildings: confined masonry or reinforced concrete with infill walls

Figure 2: Predominant Construction Types in 14 Hardest-hit Districts in Gorkha Earthquake

(Source: NSET)

Structures, height, era of construction and injuries and deaths

- Of our sample population, 58% (809) were indoors during the April 25th earthquake, 18% (249) were outdoors near a building or other structure, and 25% (345) were outdoors not nearby a

building or another structure. Of those who were in or near a building, 82% (830) were near single family houses and 13% (135) were in or near a multiple family building, 2% (18) were in or near shops and the remainder 3% (33) were in or near a variety of other structures.

- Of those in or near a building, 80% (793) were in or near *gārowālā* (stone or brick masonry) buildings, 19% (191) were in or near *pillarwālā* (reinforced concrete frame or confined masonry) buildings, 1% (6) were in or near k*ath/kachcha* (wood/bamboo) buildings, and 1% (7) "don't know" (They may have been multiple response for those near buildings). Of those injured, similarly 79% (131) were in or near *gārowālā* (stone or brick masonry), 8% (13) in or near *pillarwālā* (reinforced concrete frame), and 2% (3) near *kath/kachcha* (wood/bamboo) buildings. Of the dead, 92% (11) were in or near *gārowālā* (stone or brick masonry) buildings and 8% (1) not in or near any structure.
- Of those 190 people who were injured or killed 78% (148) were in a building, 11% (20) were outdoors near a building, 3% (6) were outdoors near another structure, and 8% (16) were not near any structure.
- As expected, deaths and injuries are significantly associated with being in or near a building. Deaths are more significantly associated with being in or near *gārowālā* (stone or brick masonry) buildings.
- In our sample population 1,000 people reported the number of floors in the buildings they were in, or near, at the time of the earthquake: 1-story buildings 8% (80), 2-story 39% (389), 3-story 39% (391), 4-stories and more 14% (140).
- In our sample *gārowālā* (stone or brick masonry) buildings had a range of 1-5 floors and a mean of 2.5. *Pillarwālā* (reinforced concrete frame) buildings had a range of 1-7 floors and a mean of 3.3. *Kath/kachcha* (wood/bamboo) had a range of 1-3 floors and a mean of 2. Those unknown had range of 2-4 floors and a mean of 3.4.
- There was no significant difference between the number of floors and whether or not deaths and injuries were sustained in *gārowālā* (stone or brick masonry) buildings.
- Of those who were injured or died, 8% (11) were in structures built before 1934, 39% (55) in buildings constructed between 1934 and 1988, 48% (67) in buildings constructed between 1988 and 2010, and 3% (4) in buildings constructed since 2011 (2%). Two percent (3) did not know the era of construction.*[4]

[4] N.B. The year 1934 corresponds to the last 'great' earthquake in the Kathmandu Valley. The year 1988 is when the Bihar earthquake in eastern Nepal spurred the adoption of earthquake resistant building codes. The year 2011 corresponds to the most recent earthquake in Nepal. (Whilst the Nepal National Building Code was adpted in 2003 and was first legally enforced in 2005 it was felt that these dates in history may have had more impact on structural awareness.

Structural and Nonstructural Elements and Building Contents

- Where respondents reported "lots of damage" to contents of the building, as opposed to "none/little" or "some," this turned out to be strongly correlated with deaths and injuries. This may of course be due to the fact that more structural damage leads to more damage to building contents. However, it is extremely important to note that as structural safety improves, non-structural hazards take on a much greater role in casualties. Moreover, as incomes levels rise, so too building contents increase, posing new hazards.
- In comparing severity of injuries by building structural or non-structural elements, there was no significant difference in injury severity. However, the severity of injuries caused by building contents was worse than both of these.
- Death was more clearly related to higher levels of building damage.

Table 5: Struck by Structural and/or Non-Structural Building Elements and Severity of Injury

Struck by	Minor N (row %) (col %)	Serious / Critical N (row %) (col %)	Total N (row %) (col %)
Structural building elements	72 (60%) (65%)	48 (40%) (55%)	121 (100%) (37%)
Non-structural building elements	24 (53%) (21%)	21 (47%) (24%)	45 (100%) (14%)
Both structural and non-structural building elements	16 (47%) (14%)	18 (53%) (21%)	34 (100%) (50%)
Total	**113** (57%) (100%)	**87** (43%) (100%)	**200** (100%) (100%)

Table 6: Struck by the Building and/or Contents and Severity of Injury

Struck by	Minor N (row %) (col %)	Serious / Critical N (row %) (col %)	Total N (row %) (col %)
Structural and non-structural building elements	81 (61%) (76%)	51 (39%) (64%)	132 (100%) (71%)
Building contents	13 (45%) (12%)	16 (55%) (20%)	29 (100%) (16%)
Both building and building contents	12 (48%) (11%)	13 (52%) (16%)	25 (100%) (13%)
Total	**106** (57%) (100%)	**80** (43%) (100%)	**186** (100%) (100%)

Injuries and Deaths by Type of Construction and Damage Level

- In this earthquake most of the affected buildings were *gārowālā* (stone and brick masonry) buildings.
- The majority of those who died 73% (12) were in or near *gārowālā* buildings at the time of deaths. Only 8% (1) was not in or near any structure.
- Of those who were injured in or near a structure 89% (131) were in or near a *gārowālā* building, 9% (13) were inor near a *pillarwālā* building, 2% (3) were in or near a *kath/kachcha* building.
- Rates of deaths and injuries increase with building damage level. The rate of injuries in buildings that sustained slight, light, and moderate damage is relatively stable at <10%, wheras the rate of deaths and injuries in very heavily damaged buildings is at least 18%, and in totally collapsed buildings it can be 27% and more.
- Severity of injuries increases with building damage level: Of the people who were in less damaged buildings, about 8% suffered injuries. Of the people who were in very heavily damaged and totally collapsed building 22% suffered injuries and 3% died. This is clear indication that the prevention of the worst levels of building damage is a priority for reduction of casualties.
- Collapse avoidance is the most obvious remedy to reduce the majority of deaths and injuries.
- As expected, the rates of injury and death are highly correlated with the damage level of the building. By far the most hazardous building are those uninhabitable and irreparably damaged (every heavily damaged or totally collapsed).

Table 7: Type of Construction Associated with Deaths and Injuries

Type of Construction	Not Injured	Injured	Dead	Injured + Dead	Total
(indoors or outdoors)	**N** (row %) (col %)	**N** (row %) (col %)	**N** (row %) (col %)	**N** (row %) (col %)	**N** (row %) (col %)
Gārowālā (stone or brick masonry)	669 (81%) (79%)	139 (17%) (89%)	14 (2%) (9%)	153 (19%) (90%)	**822** (100%) **(81%)**
Pillarwālā (reinforced concrete frame)	178 (93%) (21%)	14 (7%) (9%)	0 (0%) (0%)	14 (7%) (8%)	**192** (100%) **(19%)**
Kath/Kachcha (wood/bamboo)	4 (57%) (<1%)	3 (43%) (2%)	0 (0%) (0%)	3 (43%) (2%)	**7** (100%) **(<1%)**
Total	**849** (83%) (100%)	**156** (15%) (100%)	**14** (2%) (100%)	**170** **(17%)** (100%)	**1019** (100%) (100%)

(Seven people who did not know construction type and were not injured were excluded).

Table 8: Injury Rates by Level of Building Damage

Level of Building Damage		Not injured	Injured	Dead	Total
None-slight	N	**129**	**12**	**0**	**141**
	Row %	**91%**	**9%**	**0%**	**100%**
	Column %	**16%**	**8%**	**0%**	**14%**
Light/moderate (repairable)	N	**169**	**12**	**0**	**181**
	Row %	**93%**	**7%**	**0%**	**100%**
	Column %	**20%**	**8%**	**0%**	**18%**
Moderate / Heavy (not repairable)	N	**125**	**13**	**0**	**138**
	Row %	**91%**	**9%**	**0%**	**100%**
	Column %	**15%**	**9%**	**0%**	**14%**
Very heavy	N	**122**	**26**	**0**	**148**
	Row %	**82%**	**18%**	**0%**	**100%**
	Column %	**15%**	**17%**	**0%**	**15%**
Total collapse	N	**280**	**88**	**14**	**382**
	Row %	**73%**	**23%**	**4%**	**100%**
	Column %	**34%**	**58%**	**100%**	**39%**
Total	N	**825**	**151**	**14**	**990**
	Row %	**83%**	**15%**	**1%**	**100%**
	Column %	**100%**	**100%**	**100%**	**100%**

Pearson's Chi-squared value: 62.894 8 df. This is significant at the .001 level
(5 cells will less than expected minimum count) (Those who could not identify building damage level were excluded)

Location at the Time of Injury or Death

- Of the survey respondents, 58% were indoors at the time of the shaking, 15% were outdoors, but near a building, 3% were outdoors near another structure and 25% were not in or near any structure.
- Of those who were indoors, 18% were injured or killed, of those outdoors near a building 10% percent were injured or killed, of those outdoors near a structure 14% were injured or killed, and 5% were not in or near any structure.
- The indoor vs. outdoor-near-a-building location at the time of the earthquake was not a significant factor in whether people were injured or not. This is an important finding that tells us that building damage can impact the people nearby the building, as much as those inside. (Importantly, the impact of buildings on people outside the building is not typically an engineering concern).

Specific Causes & Mechanisms of Deaths and Injuries

- Structural elements of buildings were implicated in 71% of casualties, non-structural building elements with 26% of casualities, building contents with 16% of casualities and outdoor objects with 27%.
- Structural elements were implicated in 100% of deaths, non-structural building elements in 67%, building contents in 25% and outdoor objects (such as stones, wood pile and other agricultural equipment) in 8%. Whether the striking object was structural or non-structural did not make a significant difference to the severity of injury.
- Deaths were caused by begin trapped and crushed under a falling object 92% (11), struck by a falling object 58% (7) or by a cutting or piercing object 33% (4). These may have been building structural or non-structural elements or guilding contents
- Injuries were caused by being struck by a falling object 59% (85), falling 26% (46), trapped and crushed under a falling object 19% (33), by a cutting or piercing object 17% (30), and by jumping from a window or balcony 4% (7). Less frequent causes of injury were being struck or scratched by the wall/door/floor, stampede, transportation accident, and colliding with livestock.
- For the 175 people injured and 12 deceased, 346 structural and non-structural elements and outdoor objects were associated with their injuries; 56% of these were structural elements of buildings, 19% non-structural elements of buildings, 10% building contents and 15% outdoor objects (such as stones, wood pile and other agricultural equipment).
- The most hazardous ojects of each type are: structural elements – **walls and roofs**; non-structural building elements – **doors, windows, tiles, sinks and tubs;** building contents – **tall furniture**; outdoor objects – ground, stones, and wood piles.
- Being struck by building structural or non-structural elements was not associated with severity of injury.

- The building components most clearly associated with serious and critical injury were walls and roofs, and, to a lesser extent, columns, staircases, doors, and tall furniture.
- For 92% of all injuries, structural elements were involved, for 34% non-structural building elements (not including building contents) were involved.
- Structural elements were associated with 90% of minor injuries and 94% of serious and critical injuries, whereas non-structural building element were associated with 30% of minor injuries and 41% of serious and critical injuries.

Table 9: Specific Indoor Objects Causing Injury and Death

(all items = or > 25% of category are highlighted in red; >50% are shown in bold)

Type	Object	Minor		Serious / Critical		Total Objects causing injuries* (N=322)		% of injured (N=187)
		N	(row %) (col %)	N	(row %) (col %)	N	(row %) (col %)	Col%
Structural elements of the building	Wall	46	**58 %** 39%	33	42% 27%	79	100% 25%	**42%**
	Roof	24	48% 20%	26	**52%** 17%	50	100% 16%	27%
	Column	10	45% 8%	12	**55%** 8%	22	100% 7%	12%
	Staircase	16	**76%** 14%	5	24% 7%	21	100% 7%	11%
	Floor	*8*	**67%** 7%	4	33% 4%	*12*	100% 4%	*6%*
	Ceiling	6	**60%** 5%	4	40% 3%	10	100% 3%	5%
	Balcony	3	50% 3%	3	50% 2%	6	100% 2%	3%
	Beam	4	**80%** 3%	1	20% 2%	5	100% 2%	3%
	Sub-total objects	***109***	***56%*** ***60%***	***84***	*44%* ***66%***	***193***	100% ***60%***	***103%***
Non-structural elements of the building	Door	11	**58%** 9%	8	42% 6%	19	100% 6%	10%
	Window	5	42% 4%	7	**58%** 4%	12	100% 4%	6%
	Tiles, sinks, tubs	5	45% 4%	6	**55%** 4%	11	100% 4%	6%
	Porch roof	4	50% 3%	4	50% 3%	8	100% 2%	4%
	Ladder	5	**71%** 4%	2	29% 2%	7	100% 2%	4%
	Lighting fixtures	2	50% 2%	2	50% 0%	4	100% 1%	2%

	Partition wall (light)	3	100% 3%	0	100% 0%	3	100% <1%	2%
	Pipes	0	0% 0%	1	100% 0%	1	100% <1%	0%
	Sub-total objects	***35***	*54%* ***19%***	***30***	*46%* ***22%***	***65***	100% ***20%***	*35%*
Building contents	Low furniture	10	63% 8%	6	38% 5%	16	100% 5%	9%
	High furniture	3	21% 3%	11	79% 5%	14	100% 4%	7%
	Hanging light	2	50% 2%	2	50% 0%	4	100% 1%	2%
	Sub-total objects	***15***	*44%* ***8%***	***19***	***56%*** ***12%***	***34***	100% ***10%***	*19%*

Outdoor objects	Wood pile	8	7%	3	2%	11	100% 4%	6%
	Stone	11	9%	1	0%	12	100% 4%	6%
	Other	5	73% 4%	2	27% 0%	7	100% 2%	4%
	Sub-total injury category	**24** **183**	**80%** 3%	**6** **139**	20% 9%	**30** **322**	100% **9%**	16%
Total	OBJECTS	**183**	57% 100%	**139**	43% 100%	**322**	100% 100%	100%
Total	INJURIES	**118**	63% 100%	**69**	37% 100%	**187**	100% 100%	100%

* Multiple objects were involved in some injuries. ** *(GoN, 2015)*

Table 10: Specific Causes of Injury and Death

Causes of Injuries and Deaths	Injured N	Injured %	Dead N	Dead %	Total N	Total %
Struck by falling object	85	**49%**	7	**58%**	92	49%
Falling	46	**26%**	0	0%	46	25%
Stuck under a falling object	33	**19%**	11	**92%**	44	24%
Cutting or piercing object	30	**17%**	4	**33%**	34	18%
Jumping from window or balcony	7	4%	0	0%	7	4%
Got hit on the wall/door	3	3%	0	0%	3	2%
Stampede (people)	2	1%	0	0%	2	1%
Self-inflicted	2	1%	0	0%	2	1%
Transportation accident	1	1%	0	0%	1	1%
Livestock	1	1%	0	0%	1	1%
Don't know	1	1%	0	0%	1	1%
Total	**175**	**100%**	**12**	**100%**	187	100%

Response Level Variables

Action at the time of injury/ death:

- Ninety-six percent of injuries and 100% of deaths took place during the main shaking rather than afterwards or while awaiting or during search and rescue.
- The odds of being injured or killed were lowest for those taking cover, highest for those moving, and in between for those staying in place. Those moving were twice as likely to be injured or killed compared to those taking cover.
- The safest action was taking cover: Of those who took cover, 91% (80) were not injured, 9% (8) were injured, and none died. Staying in place was the second safest action: Of those who stayed in place 87% (550) were not injured, 12% (73) were injured, 1% (8) died. The least safe action was moving: Of those who moved 84% (671) were not injured, 15% (122) were injured, and 1% (9) died.
- The activity most associated with injury and death was exiting the building 47% (76).
- For those who were injured or killed the most frequent activities were exiting or running outside (41%), staying where they were (27%), going down stairs (7%), waiting for search and rescue (7%), going inside (5% each), caring for animals (4%), and other (5%).

- At the time of the earthquake shaking 53% (802) of people in our sample moved, and 41% (631) remained in the same place (although some sat down, stood up, fell down or lied down). The remaining 6% (88) took some kind of protective cover, such as in an open space, under furniture, in a doorway, or next to a wall. Of those who moved, 81% were moving towards the outside, 13% towards other people, and 6% other.
- Of the people who moved, those who jumped or crawled were more likely to be injured than those who walked or ran.
- People were more likely to be injured while lying down, sitting, standing, rather than cooking, walking, or anything else. Thus, it appears that people who are on their feet and moving may be more ready to take protective action or more situationally aware, and therefore less likely to be injured than those in other postures.
- Most of the people who remained in place, 86% (1056), did not consciously adopt a particular position during the shaking. The other 14% (185) took a variety of different positions, none consistently enough to discern any position being more protective than another.
- Of the 13 people who reported taking the "Drop, Cover, Hold On" position, 8 of these described being on their knees, three squatting, one under the bed, and one on the bed.

Note that in the table below, the three conceptual categories of "remaining in place", "taking cover", and "moving" were determined during analysis, based on the recent work of Goltz & Bourke (2016). It will be advisable in future to design this classification during survey design for more direct comparability.

Table 11: Type of First Action During Earthquake (N=1521)

Activity	Not Injured			Injured			Dead			Total	
	N	Row %	Col %	N	Row %	Col %	N	Row %	Col %	N	Col %
REMAIN IN PLACE	550	87%	42%	73	12%	36%	8	1%	47%	631	41%
TAKE COVER	80	91%	6%	8	9%	4%	0	0%	0%	88	6%
MOVED	671	84%	52%	122	15%	60%	9	1%	53%	802	53%
Grand Total	1,301	86%	100%	203	13%	100 %	17	1%	100%	1,521	100%

Table 12: Specific First Action During Earthquake (N=1521)

Activity	Not Injured			Injured			Dead			Total	
	N	Row %	Col %	N	Row %	Col %	N	Row %	Col %	N	Col %
REMAIN IN PLACE											
Stayed in same place	285	88%	52%	33	20%	45%	6	2%	75%	324	51%
Stood up	127	85%	23%	21	14%	29%	1	1%	13%	149	24%
Sat down	96	96%	18%	4	4%	5%	0	0%	0%	100	16%
Tried to move but could not	37	70%	7%	15	28%	21%	1	2%	13%	53	8%
Lied down	3	100%	<%	0	0%	0%	0	0%	0%	2	0%
Fell down	2	100%	<1%	0	0%	0%	0	0%	0%	3	0%
REMAINING IN PLACE TOTAL	550	87%	42%	73	12%	36%	8	1%	47%	631	41%
TAKE COVER											
Open space	44	90%	6%	5	10%	63%	0	0%	0%	49	6%
Under furniture	14	93%	2%	1	7%	12.5%	0	0%	0%	15	17%
Doorway	11	92%	2%	1	8%	12.5%	0	0%	0%	12	14%
Against wall	5	100%	1%	0	0%	0%	0	0%	0%	5	6%
Next to furniture	3	100%	0%	0	0%	0%	0	0%	0%	3	4%
Safe area	3	75%	0%	1	25%	12.5%	0	0%	0%	4	5%
TAKING COVER TOTAL	80	91%	6%	8	9%	4%	0	0%	0%	88	6%
MOVE											
TO OTHERS	**92**	**88%**	14%	12	11%	10%	1	1%	11%	105	13%

Own house to children / others inside	72	92%	10%	6	8%	5%	0	0%	0%	78	9%
Other people in the different room	14	93%	2%	1	7%	1%	0	0%	0%	15	2%
Other people in the same room	6	50%	1%	5	42%	4%	1	8%	11%	12	1%
TO OUTSIDE	**545**	**84%**	81%	99	15%	81%	8	1%	89%	652	81%
Outside	516	84%	69%	89	15%	69%	7	1%	78%	612	69%
Downstairs	16	64%	2%	8	32%	6%	1	4%	11%	25	3%
Towards the field	10	91%	1%	1	9%	1%	0	0%	0%	11	1%
Towards Patio	1	100%	0%	0	0%	0%	0	0%	0%	1	0%
Front yard	2	67%	0%	1	33%	1%	0	0%	0%	3	0%
OTHER	**34**	76%	5%	11	24%	9%	0	0%	0%	45	6%
Inside	17	81.0%	2%	4	19%	3%	0	0%	0%	21	2%
Towards other room	1	100%	0%	0	0%	0%	0	0%	0%	1	0%
Balcony	7	88%	1%	1	13%	1%	0	0%	0%	8	1%
Terrace	1	100%	0%	0	0%	0%	0	0%	0%	1	0%
Upstairs	0	0%	0%	2	100%	2%	0	0%	0%	2	0%
Animals	1	25%	0%	3	75%	2%	0	0%	0%	4	0%
Jumped from tree	0	0%	0%	1	100%	1%	0	0%	0%	1	0%
Under tree	1	100%	0%	0	0%	0%	0	0%	0%	1	0%
Road	5	100%	1%	0	0%	0%	0	0%	0%	5	1%
Nowhere, just moved in fear	1	100%	0%	0	0%	0%	0	0%	0%	1	0%
MOVED TOTAL	671	84%	52%	122	15%	60%	9	1%	53%	802	53%
Grand Total	1,301	86%	100%	203	13%	100%	17	1%	100%	1,521	100%

Table 13: Type of Movement During Earthquake

Activity	Not Injured			Injured			Dead			Total	
	N	Row %	Col %	N	Row %	Col %	N	Row %	Col %	N	Col %
Walked	100	82%	13%	21	17%	16%	1	1%	11%	**122**	**14%**
Ran	575	86%	77%	88	13%	68%	7	1%	78%	**670**	**75%**
Crawled	40	77%	5%	11	21%	9%	1	2%	11%	**52**	**6%**
Jumped	23	74%	3%	8	26%	6%	0	0%	0%	**31**	**3%**
Outside with help	12	92%	2%	1	8%	1%	0	0%	0%	**13**	**1%**
Wheelchair	1	100%	0%	0	0%	0%	0	0%	0%	**1**	**<1%**
Total	**751**	**84%**	**100%**	129	15%	100%	9	1%	100%	**889**	**100%**

Table 14: **Position During Shaking**

Position	Not Injured			Injured / Dead			Total	
	N	Row %	Col %	N	Row %	Col %	N	Col %
Did nothing	1056	86%	87%	169	14%	89%	**1225**	**87%**
Doorway	23	85%	2%	4	15%	2%	**27**	**2%**
Lie on the floor	23	92%	2%	2	8%	1%	**25**	**2%**
Under bed	21	91%	2%	2	9%	1%	**23**	**2%**
Against wall	12	86%	<1%	2	14%	1%	**14**	**1%**
Drop, Cover, Hold on	11	85%	<1%	2	15%	1%	**13**	<1%
Holding pillar	8	89%	<1%	1	11%	<1%	**9**	<1%
Press floor with thumbs	6	86%	<1%	1	14%	<1%	**7**	<1%
Holding tree	7	100%	<1%	0	0%	0%	**7**	<1%
Other	6	86%	<1%	1	14%	<1%	**7**	<1%
Holding on to seat / staircase rail / window	4	80%	<1%	1	20%	1%	**5**	<1%
Total	**1182**	**87%**	**100%**	**185**	**14%**	**100%**	**1367**	**100%**

Table 15: **Distance Moved During Earthquake**

Distance	Not Injured			Injured			Dead			Total	
	N	Row %	Col %	N	Row %	Col %	N	Row %	Col %	N	Col %
< 1m	30	75%	4%	7	18%	5%	3	8%	33%	**40**	**4%**
1-3m	114	75%	15%	32	21%	25%	5	3%	56%	**151**	**17%**
4-10m	314	87%	42%	44	12%	34%	1	0%	11%	**359**	**40%**
10-20m	160	85%	21%	29	15%	22%	0	0%	0%	**189**	**21%**
> 20m	133	88%	18%	18	12%	14%	0	0%	0%	**151**	**17%**
Total	**751**	**84%**	**100%**	130	15%	100%	9	1%	100%	**890**	**100%**

Table 16: **When People Were Injured or Killed**

When injury or death occured?	N Injuries	% Injuries	N Deaths	% Deaths
During the first earthquake	168	96%	12	100%
During an aftershock (including May 12th EQ)	4	2%	0	0%
During search and rescue	3	2%	0	0%
Total	175	100%	12	100%

Table 17: Activity at the Time of April 25th Earthquake Injury and Death

Activity	Injured / Dead N	Injured / Dead Col %
Exiting building	76	41%
Staying where I was	51	27%
Running down stairs	14	7%
Waiting for search and rescue	14	7%
Going inside a building	9	5%
Caring for animals	8	4%
Running outside from the house	6	3%
Jumping from window or balcony	2	1%
Waiting for medical aid	1	1%
While searching for things under rubble	1	1%
While walking	1	1%
Jumping from the tree	1	1%
While rescuing others	1	1%
Don't know (proxy)	2	1%
Drop, Cover and Hold	0	0%
Total	**187**	**100%**

Injury Level Variables

Types of Injuries Associated with Non-fatal and Fatal Injuries

- About 35% of all (273) non-fatal injuries were superficial bruises and abrasions. Of the remaining injuries 12% were sprains, 11% deep wounds, 11% crushing, 9% head injury, 7% spinal cord injury, 5% fractures, and 9% all others.
- The majority of the dead, 75%, had multiple injuries, compared with only 25% of those with non-fatal injuries.
- The predominant parts of body associated with 27 (82%) of 33 deaths were head, neck, and chest injuries.
- The most frequent types of injuries associated with deaths were crushing (24%), head injury (18%), and chest injury (15%).
- The predominant parts of the body associated with deaths were head (75%), chest (58%), back (42%), and legs (41%).
- The predominant parts of body associated with 256 non-fatal injuries were legs, knee, feet, and toes 33% (89).

Entrapment:

- Of our sample, 7% (101) experienced being trapped. Of those trapped, 78% were injured or killed, and 22% were not.
- Of those who were injured or died, 42% (79) experienced entrapment, and 57% (109) did not.
- Of the 101 people who were entrapped, the mean was 103 minutes and the median was 20 minutes. For those who were not injured, the mean was 15 minutes and the median was 10 minutes, whereas for those who were injured or killed, the mean was 128 minutes and the median 30 minutes.
- Of the 101 people who were entrapped 84% (85) were rescued with help from people nearby and 16% (16) got out themselves. None were rescued by professional teams.

Medical Treatment Sought and Received:

- Of the 187 injured people 66% (123) sought medical treatment, 28% (52) did not, and 6% (12) died immediately.
- Of those seeking medical treatment 46% went to a public hospital, 20% to a community response team, 19% to a private hospital, 14% to a health clinic, and the remaining 7% to other medical services.
- The range of time from injury to treatment was less than a minute to 1.5 days
- Of the injured respondents, 44% walked to receive treatment, 27% were carried on foot by others, 21% traveled by bus, 10% by motorcycle, 7% by ambulance, 9% by car, truck, or taxi, and 2% by helicopter.
- Mean transport time to receive medical treatment was 4.7 hours.
- Of the injured respondents, 80% were treated and released, 10% were hospitalized for less than a week, 6% for 1-4 weeks, and 4% for more than four weeks.

Emotional Injuries:

- Emotional injuries were reported by 35% (470) of our sample. About 11% (53) of these described severe impact, 22% (105) moderate impact, 53% (248) some impact, and 14% (64) none. These results did not differ significantly with age.
- Of the people who experienced emotional injuries for more than a month, 53% expressed being worried/anxious, 35% afraid, 21% sadness and loss, 9% depression/apathy, 6% phantom quake (imagined experience of earthquake, when there was none), and 5% other health problems.
- Males and females were significantly different in the emotional injuries reported. Females reported experiencing more emotional injuries, with lower impacts and males reported experiencing fewer emotional injuries, but more severe impacts.
- Of the emotional injuries described, 12% of the 474 were severe, 22% moderate 53% some, and 14% none.

- In terms of persistence of emotional injuries, more than 12 months after the earthquake 50% described the emotional impact as already better, 41% slowly getting better, 7% the same and 2% getting worse.

Table 18: Causes of Injuries and Deaths

	Injured			Dead			Total	
	N	Row %	Col %	N	Row %	Col %	N	Col %
Fracture	10	100%	6%	0	0%	0%	10	5%
Dislocation	7	100%	4%	0	0%	0%	7	4%
Sprain	28	100%	16%	0	0%	0%	28	15%
Superficial injury (bruises and abrasions)	86	99%	49%	1	1%	8%	87	47%
Deep wounds (Open cuts/wounds)	27	93%	15%	2	7%	17%	29	16%
Head injury (blunt force trauma)	22	79%	13%	6	21%	50%	28	15%
Crushing injury	27	77%	15%	8	23%	67%	35	19%
Injury to spinal cord/nerves	17	89%	10%	2	11%	17%	19	10%
Facial injuries (cuts, broken nose…)	5	83%	3%	1	17%	8%	6	3%
Foreign body in eye, ear, nose, throat	1	50%	1%	1	50%	8%	2	1%
Dental injuries (teeth, jaw)	1	50%	1%	1	50%	8%	2	1%
Chest injury (lungs, heart, ribs, sternum, collar bone…)	4	44%	2%	5	56%	42%	9	5%
Amputation	4	100%	2%	0	0%	0%	4	2%
Hearing Problem	1	100%	1%	0	0%	0%	1	1%
Don't know (proxy)	0	0%	0%	1	100%	8%	1	1%
Total	175	94%	100%	12	6%	100%	187	100%

Mitigation and Preparedness Level Variables

When it comes to planning measures:

- An encouraging increase of 39% have a family safety plan and 52% more plan to have one, compared to 3% before the earthquakes.
- More now have plans at work, 13%, and school, 14%, compared to 1% and 2%, respectively, before the earthquakes.

When it comes to structural measures:

- Only 3% (13) of households reported taking measures before the earthquake to strengthen their building. Just over half of these, or 54% (7), had damage in the uninhabitable range. For the other 97% (451) of households, 71% (318) suffered damage in the uninhabitable range. However, these

results were not significant. Without knowing the quality of measures taken, it's impossible to gauge the effectiveness of the measures taken.

- When the survey was completed, 24% had already moved to what they believed to be a safer home and 52% more planned to do so, 9% reported that they had newly constructed more safely, and 56% planned to do so, while 36% planned to retrofit (though only 3% had done so, thus far).
- In addition, 8% (43) of households surveyed mentioned additional measures taken or planned, to build or repair their houses to be safer.

When it comes to non-structural measures:

- At the time of the survey, 16% of households had secured tall furniture and equipment and 57% more planned to, compared to 3% before the earthquakes.

When it comes to response preparedness skills and supplies:
There were a few measures that households had clearly taken without having had any training.

- At the time of the survey, 23% had purchased battery-operated radio and 55% planned to get one, compared to 18% before the earthquakes.
- A fifth of the respondents (20%) newly learned how to put out a small fire and 56% planned to learn how, compared to 19% before the earthquakes – thus doubling skills for suppression of small fires.
- At the time of the earthquakes, 7% had learned first aid and 5% had a first aid kit. By the time of the survey, 5% more had learned first aid and 8% more had a first aid kit. Those who had taken these measures found them effective (83-85%), and those who had not, believed that they would have been effective (90%). 63% intend to take first aid in the future and 23% intend to get a first aid kit.
- Remarkably, those who had not done any of these things, overwhelmingly felt that these preparedness skills and supplies would be effective, with 90-94% reporting that most of the measures would have been effective if they had them at the time of the earthquake. Those who had done those things found them slightly less effective, but still overwhelmingly endorsed the planning activities.
- As far as reasons for not taking measures, the most frequently listed was "not knowing what to do" (53%), and being "too busy" (15%). Other reasons like being too old/too young/not capable, not caring, can't affort it, too late, not making a difference, or not wanting were 7-9% of the reasons for not obtaining preparedness skills or supplies.
- Sources of information for our household informants were: radio (60%), friends/family (59%), TV (52%), NGO/CBO (17%), newspaper (16%), at work/from colleagues (9%), through own experience (7%). Other sources were school/college (5%), government and and internet/social media (4%) each, and the Red Cross (3%).

Table 19: **Household Risk Reduction & Preparedness Measures Taken Before**
N = 496 households

Measures	Measures taken before		Effectiveness (Out of 'Yes')		Would have been effective (Out of 'No')	
	N	%	N	%	N	%
Family safety plan at home	16	3%	11	69%	425	89%
Emergency/disaster plan at work	6	1%	4	67%	381	78%
Emergency/disaster plan at school	9	2%	1	11%	328	67%
Building strengthening measures [reftrofit] at home	5	1%	4	80%	285	58%
New construction for hazard resistance at home	13	3%	5	38%	354	73%
Secured tall furniture or equipment	16	3%	11	69%	385	80%
Learned first aid	36	7%	30	83%	412	90%
Learned how to put out small fire	95	19%	78	82%	312	78%
Learned how to organize post-disaster response	12	2%	10	83%	429	89%
Flashlights	125	25%	116	93%	329	89%
First aid kit	27	5%	23	85%	423	90%
Store extra batteries	20	4%	16	80%	413	87%
Store water	26	5%	22	85%	406	84%
Stored food	15	3%	15	100%	420	87%
Battery-operated radio	89	18%	71	80%	346	85%
Emergency kits and tools	2	<1%	1	50%	434	88%
Community or school level Hazard, Vulnerability and Capacity Assessment	12	2%	5	42%	371	77%
Moved to safer home	29	6%	16	55%	322	69%

Table 20: Household Risk Reduction & Preparedness Measures Taken After
N=480 Households

Measures	Measures taken after		Measures intended		Measures not intended	
	N	%	N	%	N	%
Family safety plan at home	187	39%	249	52%	44	9%
Emergency/disaster plan at work	60	13%	282	59%	97	20%
Emergency/disaster plan at school	69	14%	225	47%	95	20%
Building strengthening measures [reftrofit] at home	18	4%	170	35%	137	29%
New construction for hazard resistance at home	41	9%	267	56%	119	25%
Secure tall furniture or equipment	78	16%	271	57%	113	24%
Learn first aid	39	8%	302	63%	134	28%
Learn how to put out small fire	94	20%	269	56%	113	24%
Learn how to organize post-disaster response	33	7%	332	69%	112	23%
Flashlights	241	50%	204	43%	34	7%
First aid kit	67	5%	323	23%	89	6%
Store extra batteries	89	19%	306	64%	83	17%
Store water	87	18%	275	57%	118	25%
Stored food	57	12%	302	63%	119	25%
Battery-operated radio	109	23%	266	55%	98	20%
Emergency kits and tools	10	2%	309	64%	156	33%
Community or school level Hazard, Vulnerability and Capacity Assessment	22	5%	302	63%	136	28%
Move to safer home	116	24%	236	49%	92	19%

Perceptions of possible and safe behavior during earthquake

- It is not known how accurate survivors' perceptions are, but they are mixed as to whether movement would have been possible and safe in this particular (and unusual) shaking. Since most did try to move, it seems that their perceptions of 'the possible' were likely quite accurate, regardless of how subjective and site and individual-specific. As to the safety of these measures, the combination of our 'hard' evidence and survivors' perceptions are both instructive
- A large majority of respondents, 83%, said running out in the first 5 seconds was not possible, and similarly, 70% of respondents said running out within the first 10 seconds was also impossible.
- As to being able to run out within the first 15 seconds, 53% of respondents think that that it would have been possible and 47% do not. Had it been possible to exit within 15 seconds, 61% think that it would have been safe and 39% think it would not. The public does not perceive any other measure as having more than a 50% chance of being both possible and being safe.
- Since movement has been associated with higher rates of injury and death, the recommendation to "move" outside does not meet the criteria of 'doing no harm'.

Table 21: Perceptions of Possible and Safe Behaviors During Earthquake

Behavior During	Possible		Safe	
	N	Col %	N	Col %
Run Outside To Safe Place Within 5 Seconds	239	17%	566	40%
Run Outside To Safe Place Within 10 Seconds	426	30%	671	48%
Run Outside To Safe Place Within 15 Seconds	738	53%	855	61%
Drop Cover And Hold Under A Sturdy Table Or Desk	490	35%	201	14%
Drop Cover And Hold Where You Are / Were	528	38%	198	14%
Lie Down Next To Table Or Desk	460	33%	191	14%
Lie Down Next To A Sofa Or Hard Pieces Of Furniture	404	29%	176	13%
Stay In Bed (If You Had Been There At That Time)	592	42%	176	13%
Stand In Strong Doorway	628	45%	254	18%
Stand By Inner Wall Or Pillars	518	37%	188	13%
Move To Safer Home	258	18%	266	19%
Total	**1403**	**100%**	**1403**	**100%**

*Total out of people (1403) who were interviewed

Community Awareness Program Level Variables

- About 28% (137) of our sample households told us where they had learned about what to do during the shaking. Of this group, 38% learned from radio, and 37% from TV. The other sources of learning, in order of frequency were self, friends/relatives, internet, and parents, Fewer than 10% reported learning from Red Cross, posters, school children, ancestors/old people, government agencies, International Non-Governmental Organizations (INGOs), seeing other people do it, or traditional beliefs.
- Of the households in our sample 4% (18) of households representing 69 household members (in the VDC during the earthquake) knew of training programs available in the community or at school. Of the school programs, 33% were from the Nepal Red Cross Society, 67% from a variety of others, and 35% don't know.
- From these households (except one, with no children), 34 children and 11 adults participated in these programs and 22 individuals did not. In communities where awareness programs existed, participants in those programs were less likely to be injured or killed than those who did not participate. (However the sample size is too small for significance test to be valid).

Table 22: Where You Learned About What To Do During Shaking

Source	N	Col %
Radio	52	38%
TV	51	37%
Self	35	25%
School Teachers	24	18%
Friends/relatives	20	15%
Internet	15	10%
Parents	14	10%
Red Cross	11	8%
Posters	11	8%
School children	7	5%
Ancestors/old people	4	3%
Govt Agency	2	1%
I/NGOs	2	1%
Seeing other people	1	<1%
Traditional beliefs	1	<1%
Total	**137**	**100%**

Table 23: Community Awareness or Training Program for Disaster Risk Reduction and Preparedness

Someone in HH participated	N	Col %
Yes	17	4%
No	463	96%
Total	480	100%

Table 24: Awareness or Training Program for Disaster Risk Reduction and Preparedness at School

Awareness Program	N	Col %
Yes	17	4%
No	398	83%
Not applicable	65	14%
Total	65	14%

Table 25: School and Community Training Providers

Provider	N	Col %
Nepal Red Cross Society	6	33%
All others: World Vision, Aatma Nirbhar Kendre, ENPHO, Mahila Bikash, Plan International, USAID	12	67%
Total	**18**	**100%**

Table 26: Household Training Participation and Deaths and Injuries

Activity		Not Injured	Injured / Dead	Total
Adults and children participated	Count	11	0	11
	Row %	100%	0%	100%
	Col %	19%	0%	17%
Only children participated	Count	30	1	31
	Row %	97%	3%	100%
	Col %	52%	17%	48%
Available, but no one participated	Count	17	5	22
	Row %	77%	23%	100%
	Col %	29%	83%	34%
Total	Count	58	6	64
	Row %	91%	9%	100%
	Col %	100%	100%	100%
Compared to full sample population	Count Row %	849 (83%)	170 (17%)	1019 (100%)

(*Not part of statistical analysis) Pearson's Chi-squared value 7.134 2 df. Chi-square is significant at the .05 level
More than 20% of cells have expected cell counts less than 5. Chi-squared test may be invalid

Discussion

> *"In addition to providing information that is reliable, valid and current, messages must be formulated in ways that help audiences appreciate the uncertainties involved yet at the same time not be so confused by them that they decide against any action."* Kathleen Tierney (2004)

Major Variables Affecting Deaths and Injuries

The Characteristics of the Seismic Event ('The Earthquake')

- The location of this earthquake meant that the most proximate and worst-hit districts were primarily rural with low population densities.
- The timing of the earthquake, on a Saturday at mid-day meant that a large portion of the rural population was outdoors. No students were in school buildings, and few staff were in offices and institutional buildings. Even in the May 12 major aftershock, the schools were still closed and most people who had evacuated damaged buildings had not re-occupied them.
- The maximum felt intensities were IX (violent shaking), nonetheless, the shaking intensity of the Gorkha earthquake (observed through instruments in Kathmandu and the nearby region) was lower than expected. Moreover, the ground motion - low shaking intensity but high swaying movement (displacement and velocity), was uncharacteristic compared to most large earthquakes.
- This event was not the expected "big one," and the stored energy was not completely released (Science, 2015) The "big one" is still to come. The Gorkha earthquake was unusual in ways that are important to understand, in order to learn as much as possible in order to avert further destruction and suffering.
- It is important to convey a full understanding of earthquake shaking, why this one was unusual, and how the next ones may differ.

Built Environment ('The Buildings')

- The findings from this earthquake are mostly of relevance to people occupying *gārowālā* (stone and brick masonry) buildings in Nepal.
- The greater the degree of building damage, much greater is the likelihood of death. Totally collapsed buildings are the most lethal of all. Heavily damaged buildings that do not collapse are much less lethal, and buildings that have minor and/or even moderate levels of damage, are much less dangerous still. As a result, any and all well-considered measures to strengthen construction, including 'minimum retrofit' in order to prevent collapse, is the single most important thing that can be done to reduce earthquake deaths and injuries.
- Relevant findings related to reinforced concrete construction should be considered from Turkey (Kocaeli earthquake, 1999), where reinforced concrete construction is of a similar era, and with similar construction deficits. Findings from Turkey indicate that mitigation of risks by fastening building contents so that they move *with* the building and do not become hazardous projectiles reduces deaths and injuries.

Risk Mitigation Actions ('The Risk Reduction Actions')

- The evidence for building and maintaining earthquake resistant buildings is overwhelming. Indeed, poorly built buildings do kill people, and minimum retrofit and replacement are important solutions which are only incrementally costly if done during the normal course of construction, rather than an enormous burden in the context of disaster recovery.
- Clearly a large proportion of people have taken measures, or are planning to take measures that they hope will make their buildings safer. It is important for those taking measures for structural safety that they have a good understanding of how limited resources can be applied to incremental seismic-resistant design and construction measures for collapse-prevention and greater life-safety. It is not a foregone conclusion that they have sufficient knowledge to implement effective strengthening measures, or to assess when replacement might be a better use of resources. This must be a priority area for public education.
- Building non-structural elements and building contents are implicated in deaths and injuries. Public education can usefully emphasise knowledge and skills to identify and mitigate items that can slide and fall, to secure tall and heavy furniture, electronics and appliances, to keep exit pathways clear, fasten hanging objects, store heavy objects lower down, place beds away from windows, and use tempered glass and window coverings in high traffic areas.

Protective Actions ('The Behavior')

- Those who moved were 1.4x more likely to be injured or killed compared to all others. Those who remained in place were .7x less likely to be injured or killed compared to all others. Those who took cover were .5 x less likely to be injured or killed compared to all others. Thus the best guidance is to take protective cover during earthquake shaking, or to stay in place. Moving, and exiting are the most hazardous actions.
- The evidence of the youngest and oldest members of the household being most vulnerable, and people who were active and on their feet being less vulnerable suggests that people who are upright and alert compared to those sitting or lying down, are more aware of their surroundings at the onset of the event. They may be taking some subtle actions to protect themselves from danger. A reasonable hypothesis is that this immediate 'situational awareness' seems to be protective.
- As 26% of injuries were caused by falling, and 49% were from being struck by a falling object, and because the most fatal injuries were to head, neck and chest, the most important protective actions that people can take is to drop to their knees, to prevent falling, make themselves small, and cover their head, neck and chest. If they can be away from walls and under sturdy protection (eg. a solid table) or next to a low piece of furniture, that would offer protection.
- Because people can be injured both inside and outside a building, and because injuries during exiting are more frequent than injuries sustained when staying in place, exiting during shaking is advised only when early primary waves can be distinguished or when on the ground floor of an adobe or stone building with heavy roof and where the person can quickly exit to a safe place.
- It is difficult to assess the extent to which survivor perceptions about possible and safe behaviors

are accurate. The vast majority do not believe that they could have moved safely for protection.

- Recommended protective actions (during the shaking and immediately following) should be based upon what is feasible to do, what will prevent the most lethal injuries, and what will reduce the largest number of injuries.
- About half of the people (53%), they were able to move during the shaking in this particular event. However, it is extremely important that the public understands that the more usual characteristics of strong shaking may not permit as much control over movement. In other earthquakes those that experience the most intense shaking are unable to move where or how they might intend, and they are injured in the process of trying. Conversely, those who have the most ability to move, should do so carefully and mindful of hazards.
- Public education regarding protective action should help people to develop situational awareness. It is important to build understanding of both structural and non-structural hazards in the built environment, to discuss both *what* can be done and *why*, the potential *limits* to some actions, and the hazards associated with different behavior.
- Going back inside a building during earthquake shaking is not safe. Similarly entering heavily damaged buildings after the shaking is also unsafe.

Response Preparedness Skills and Provisions ('Response Preparedness')

- Readiness to engage in response preparedness is extremely high, with many households adopting safety measures. The main issue limiting household response preparedness is lack of access to effective knowledge and skills. The most effective and efficient way to reach the enormous population needing information is with the adoption of evidence- and consensus-based key messages, promoted through radio and television, consistently, repeatedly, and at a large scale (IFRC, 2012). The use of trusted sources and consistency of both informal and formal messaging are both important (Kirchenbaum et. al. 2017).

Implications for Future Earthquakes in Nepal

Limitations

- The unusual long period waves of this earthquake, and the low peak ground acceleration meant that it did not particularly affect poorly-constructed reinforced concrete and confined masonry buildings, in the way that more common earthquakes would.
- The findings from this research provide data on deaths and injuries from a large earthquake striking predominately in the rural and remote communities of Nepal. Such areas are characterized by highly fragile rubble stone and adobe brick housing construction built on steep, often unstable, slopes and ridgetops. Future seismic events that strike the hilly and mountain regions of Nepal may indeed result in heavy damage and collapse to similar construction types, such that the 2015 event provides some estimate of death and injuries from these buildings.
- However, even if future seismic events strike populated areas of the hilly and mountain regions, they may not strike at mid-day on a spring Saturday, the one day many rural people are in the

fields, children are out of school, and office workers are not at work. It is likely that in a future event, a much higher percentage of the population will be within fragile education facilities, homes, shops and places of work. Future events in these regions may strike at night when people are asleep and take longer to become situationally aware. Similarly, future events may strike in the winter where death and injuries may increase due to exposure to cold and inclement weather.

- Additional concerns arise when contemplating earthquakes that happen during the school and work day, or during the commute to and from school and work. It is important to use the lessons of other earthquakes, and extrapolate to imagine and avert consequences that were not seen in this earthquake.
- Of particular concern is the high probability of future seismic events occurring in the urban environment of the Kathmandu Valley. Much of the multi-storey reinforced concrete with infill construction found in the area has been constructed without adherence to seismic building codes, and is of notably poor construction quality. An event in the Valley is likely to result in much higher deaths, but also a different pattern of death and injuries. Whereas residents of one storey housing in rural and remote Nepal are more likely to be outside during an earthquake, residents in multi-storey, urban buildings are more likely be indoors throughout the shaking.

Applicable Findings from Causes of Deaths and Injuries in Earthquakes in Turkey

- Results of a study of the causes of deaths and injuries in the 1999 Kocaeli earthquake, and 2002 Afyon earthquakes in Turkey provide an important source of information for future earthquake impacts in Nepal (Petal, 2002 a & 2002b).
- The context of these earthquakes is similar to urban and peri-urban areas in the Kathmandu Valley due to the vulnerability of poorly-constructed reinforced concrete buildings, as well as the accumulation of more furniture, appliances and building contents found in higher-income urban dwellings. (The context also different significantly from the Gorkha earthquake, because it took place in the middle of the night when most people were asleep in bedrooms or living room). Of particular note:
- As in the Gorkha earthquake, in the Kocaeli, Turkey earthquake, most of the deaths and injuries were in buildings that were severely damaged (82%) vs. less damaged (18%). And head, neck and chest injuries were those most associated with fatalities.
- 38% of those who were injured or died were exiting the building or running downstairs at the time.
- Unlike the Gorkha earthquake: Many injuries sustained after the earthquake (17% in Kocaeli and 23% in Afyon) and should be considered avoidable.
- In Kocaeli, 26% of those injured were struck by a falling object, 20% were under a falling object, 19% cut or pierced by an object, and 18% fell.
- 87% of severe injuries and 88% of deaths had structural causes, 68% of light injuries had non-structural causes, and moderate injuries were nearly equally caused by structural and non-structural objects.
- Reflecting the differences between day time and night time earthquakes; in the Kocaeli earthquake, in the middle of the night, 47% of injuries were to legs, feet and toes, and 26% to

arms, hands and fingers (compared to 22% and 13% in the day-time, Afyon earthquake).

- Most of those who died, and most of those who survived uninjured in the Kocaeli earthquake, did so remaining in their beds.
- In the Afyon earthquake which took place 2.5 years after the Kocaeli earthquake, fewer than 23% of people had heard of structural safety measures, and only 10% had taken any structural safety measures. Almost half (45%) didn't think about their homes being vulnerable to earthquake damage, and only 22% thought their homes might experience heavy damage or collapse.
- These findings lead to several additional recommendations that seem equally applicable to Nepal.
    - Injuries can be caused by both non-structural and structural factors. So it is important to fasten tall and heavy furniture to the building so that it doesn't slide or topple.
    - Many injuries after an earthquake are avoidable. Keep shoes and flashlight by your bed, in case of a night-time earthquake.
    - During strong earthquake shaking, drop to the ground to avoid falling, make yourself small, get under a strong table or down low next to a sturdy and low piece of furniture, protect your head and neck, and hold on to your cover. Move away from tall and heavy furnishings and windows.

Research Gaps and New Questions

The differing lethality rates across districts (Table 1) leads to some significant questions. Were deaths and injuries in Dolakha, Kavrepalanchok, and Ramechhap related to some specific activities rather than to building damage? If not, what is it about the construction in those two areas that made the buildings so much less lethal than in Rasuwa and Sindhupalchok? Could this information be helpful to reducing casualties?

The goals of earthquake epidemiology should go beyond casualty estimation and fatality prevention. Explicit outcomes should incude an evidence base for recommendations to the public regarding disaster risk reduction measures to be taken before earthquake onset, and guidance for behaviour during the shaking and effective response afterwards.

It is equally the responsibility of casualty researchers to measure the impacts of the mitigation and preparedness measures most widely promoted. Building popular understanding of structural awareness for seismic, wind, and flood safety should be embraced by public educators, rather than avoided.

Whilst non-governmental organizations and national RC Society made significant efforts to raise public awareness through field-based training, these messages did not seem to have an appreciable effect in the areas hardest hit by this earthquake. For the key elements of successful public awareness campaigns, it will be important to look to the radio and TV messages most remembered by the respondents, as well as to new strategies that might be considered (IFRC, 2011), and to engage in consultation and pre-testing with potential beneficiaries to gauge impact before scaling-up these efforts.

The effectiveness of public education outreach efforts in spurring adoption of household risk reduction and resilience measures, and the ultimate effectiveness of those measures in bringing about reduced deaths and injuries is equally important to track and study. Research gaps to be filled incude the impact of child-

centered education efforts on families, and means of leveraging cultural strengths and indigenous knowledge to strengthen public education.

A comprehensive and ongoing body of research requires impact studies of many earthquakes that differ with respect to location, time, secondary hazards, changes in construction technology, and the impact of household mitigation and community response-preparedness measures. Scientific sampling methods, and the use of standard classification schemes for building damage and injury typology, are vital to producing credible and comparable findings. People can be trained ahead of time to more accurately identify building damage levels as well as to differentiate between confusing injury types (e.g. bruises and crush injuries) by selecting from standard photographs.

The body of research presented provides a strong foundation for a clearer understanding of the most effective structural, non-structural, and behavioural measures that can be taken to mitigate the impacts of earthquakes. Future research must investigate the merits of specific protective actions and safer places that can be accessed during strong shaking. New issues to be addressed include concerns that 1) multi-storey buildings have an enormous amount of dangerous non-structural building materials (windows, cladding, etc) that are likely to fall on those in the immediate vicinity of buildings, 2) in high-occupancy venues such as stadia and theatres, assuming the tucked brace position (as for an airplane crash) is advised rather than simply 'drop, cover and hold,' and 3) that the extent to which orderly evacuation is practised is critical to life safety.

References

- **Akason, J.B., Olafsson, S., & Sigbjornsson, R. (2006).** *Perception and observation of safety during earthquake exposure: A case study*, Safety Science 44; 913-933.
- **Alexander, D.E. (2013).** Magni M. Mortality in the L'Aquila (central Italy) earthquake of 6 April 2009. PLoS Curr Dis. 2013 Jan 7:1-26.
- **Armenian, H.K., Noji, E..K, Oganesian, A.P. (1988).** *A case-control study of injuries arising from the earthquake in Armenia*, Bulletin of the World Health Organization. 1992;70(2):251.
- Association for the Advancement of Automotive Medicine (2008). *Abbreviated Injury Scale* (AIS) 2005–Update 2008.
- **Bissell, R.A., Pinet, L., Nelson, M., Levy, M. (2004).** Evidence of the effectiveness of health sector preparedness in disaster response, the sample of four earthquakes. Fam Community Health 27: 193-203.
- **Bhattarai, et. al. (2015).** Overview of the Large 25 April 2015 Gorkha, Nepal, Earthquake from Accelerometric Perspectives, Seis. Res. Lett., 86, 6, 1540-1548.
- **Birkmann, J. (2006).** Measuring vulnerability to promote disaster-resilient societies: Conceptual frameworks and definitions. Measuring vulnerability to natural hazards: Towards disaster resilient societies. 1:9-54.
- **Bilham, R. et al. (2001).** *Himalayan Seismic Hazard*, Science, 293, 1442-1444.
- **Bourque, L. B., Peek-Asa, C., & Mahue, M. (1997).** Health implications of Earthquakes: Physical and Emotional Injuries During and After the Northridge Earthquake. In World Health Organization (Ed.), Proceedings of the International Symposium on Earthquakes and People's Health: Vulnerability Reduction, Preparedness and Rehabilitation (Vol. Health Library for Disasters, pp. 11). Kobe, Japan: World Health Organization.
- **Centers for Disease Control (CDC) (2012).** *Community Assessment for Public Health Emergency Response (CASPER) Toolkit.* Second Edition. Atlanta (GA). http://emergency.cdc.gov/disasters/surveillance/pdf/casper_toolkit_version_2_0_508_compliant.pdf [Accessed Aug, 27, 2016]
- **Chan, Y.F., Alagappan, K., Gandhi, A., Donovan, C., Tewari, M., Zaets, S.B. (2006).** *Disaster management following the Chi-Chi earthquake in Taiwan*. Prehospital and disaster medicine. Jun 1;21(03):196-202.
- **Chou, Y.J., Huang, N., Lee, C.H., Tsai, S.L., Chen, L.S., Chang, H.J. (2004).** *Who is at risk of death in an earthquake?* American Journal of Epidemiology. 2004 Oct 1;160(7):688-95
- **Coburn, A.W., Hughes R.E. (1987).** *Fatalities, injury and rescue in earthquakes*. In 2nd Conference of the Development Studies Association (pp. 235-243). University of Geneva.
- **Department of Mines and Geology, GoN.** (2016). *Seismological Centers and Seismic Research*. Available from: http://www.dmgnepal.gov.np/index.php?option=com_content&view=article&id=98&Itemid=60 [Accessed June 9, 2016]
- **Doocy, S., Daniels, A., Packer, C., Dick, A., & Kirsch, T. (2013).** *The Human Impacts of Earthquakes: a Historic Review of Events 1980-2009 and Systematic Literature Review*. PloS Currents:

Disasters. http://currents.plos.org/disasters/article/the-human-impact-of-earthquakes-from-1980-2009-a-historical-review-of-events-1980-2009-and-systematic-literature-review/ [Accessed June 9, 2016]

- **Durkin, M.E., Murakami, H.O. (1988).** *Casualties, survival and entrapment in heavily damaged buildings*. In Proceedings of the Ninth World Conference on Earthquake Engineering 1988 Aug 2 (Vol. 8, pp. 977-982).
- **EERI (2016).** *EERI Earthquake Reconnaissance Team Report: M7.8 Gorkha, Nepal Earthquake on April 25, 2015 and its Aftershocks*. EERI. Oakland, CA.
- **EERI (2015).** *Nepal National Building Code (NBC): An Overview*. http://www.eqclearinghouse.org/2015-04-25-nepal/2015/05/05/nepal-national-building-code-nbc-an-overview/ [Accessed, Dec. 15, 2016]
- **Elliott J. (2012).** *Earthquake disasters and resilience in the global North: lessons from New Zealand and Japan*. The Geographical Journal. 2012 Sep 1;178(3):208-15.
- **Emspak, J. (2016).** *Nepal Quake Could Have Been Much Deadlier*, Scientists Say, Live Science. Aug 6, 2015. http://www.livescience.com/51779-nepal-earthquake-could-have-been-deadlier.html [Accessed Aug. 27, 2016]
- **FEMA (Apr 29, 2016 Draft)** Protective Action Validation Summary Report: Recommendations for Guidance and Messaging for the Public for 12 Natural Hazards. FEMA Individual and Community Preparedness Division (ICPD).
- **Galetzka, et. al. (2015).** Slip pulse and resonance of the Kathmandu basin during the 2015 Gorkha earthquake, Nepal. Science, 349, 6252, 1091-1095.
- **Geo-Hazards International (GHI) (2015).** Developing Messages for Protective Actions to Take During Earthquake Shaking. GHI. Palo Alto, CA.
- **GeoHazards International (1999).** *Kathmandu Initiative*. GHI, Palo Alto, CA. http://media.wix.com/ugd/08dab1_785a4085eba44f64996c178124b1a348.pdf [Accessed Aug. 27, 2016]
- **Goltz, J. (2006).** Initial Behavioral Response to a Rapid Onset Disaster: A Social Psychological Study of Three California Earthquakes. UCLA.
- **Goltz, J. & Bourque, L. (2017).** *Earthquake Ground Motion and Human Behavior: A Sociological Perspective*, International Journal of Disaster Risk Reduction, V21.
- **Goverment of Nepal (2015a).** *Nepal Earthquake 2015 Post Disaster Needs Assessment*. Kathmandu: National Planning Commission. www.preventionweb.net/publications/view/44973 [Accessed, 15 Dec. 2016]
- **Government of Nepal (2015b).** *Incident Report of Earthquake 2015*. https://web.archive.org/web/20150629024928/http://drrportal.gov.np/incidentreport [Accessed Aug. 27, 2016]
- **Government of Nepal (2011).** *Nepal Population and Housing Census 2011*. http://cbs.gov.np/wp-content/uploads/2012/11/VDC_Municipality.pdf [Accessed June 9, 2016] *2011 Nepal Census Data (areas affected by the 2015 Earthquake)*, Humanitarian Data Exchange, https://data.humdata.org/dataset/2011-nepal [Accessed Dec. 15, 2016]
- **Hand, E.** (2015). *Why the Nepal earthquake was far less damaging than feared,* Science. Aug 6, 2016. http://www.sciencemag.org/news/2015/08/why-nepal-earthquake-was-far-less-damaging-feared [Accessed Dec. 15, 2016]
- **Hogg, S.J. (1980).** Reconstruction following seismic disaster in Venzone, Friuli. Disasters. 1980 Jun

1;4(2):173-85.

- **International Federation of Red Cross and Red Crescent Societies (IFRC) (2012).** *Public Awareness and Public Education: Key Messages.* IFRC. Geneva. http://www.ifrc.org/PageFiles/103320/Key-messages-for-Public-awareness-guide-EN.pdf [Accessed Dec. 15, 2016]
- **International Federation of Red Cross and Red Crescent Societies (IFRC) (2011).** *Public Awareness and Public Education: A Guide*. IFRC. Geneva. http://www.ifrc.org/Global/Publications/disasters/reducing_risks/302200-Public-awareness-DDR-guide-EN.pdf [Accessed Dec. 15, 2016]
- **IRIS (2014).** Building resononance: the resonant frequency of different seismic waves.
- https://www.iris.edu/hq/inclass/animation/building_resonance_the_resonant_frequency_of_different_seismic_waves [Accessed Dec. 15, 2016]
- **IRIS & University of Portland (2010).** *Buildings and earthquakes – Which stands? Which falls?* http://www.iris.edu/hq/files/programs/education_and_outreach/retm/tm_100112_haiti/BuildingsInEQs_2.pdf [Accessed Dec. 15, 2016]
- **Jones, N.P. et al. (Ed.) (1990).** *Proceedings, International Workshop on Earthquake Injury Epidemiology for Mitigation and Response* (pp. 71-76). Baltimore, MD: U.S. Geological Survey, Reston, VA.
- **Kirschenbaum, Alan; Rapaport, Carmit; Canetti, Daphne (2017).** *The impact of information sources on earthquake* preparedness. IJDRR V 21, p.99-109.
- **Kohrt, B. A., & Hruschka, D. J. (2010).** Nepali Concepts of Psychological Trauma: The Role of Idioms of Distress, Ethnopsychology, and Ethnophysiology in Alleviating Suffering and Preventing Stigma. Culture, Medicine and Psychiatry, 34(2), 10.
- **Kohrt, B. A (2008).** Navigating Diagnoses: Understanding Mind–Body Relations, Mental Health, and Stigma in Nepal. Culture, Medicine and Psychiatry, 32(4),10.
- **Maps of World (2015).** *Earthquakes in Nepal.* http://www.mapsofworld.com/thematic-maps/earthquake/earthquake-in-nepal.html [Accessed Aug 27, 2016]
- **Mahue-Giangreco, M., Mack, W., Seligson, H., & Bourque, L. B. (2001).** Risk Factors Associated with Moderate and Serious Injuries Attributable to the 1994 Northridge Earthquake, Los Angeles, California. Annals of Epidemiology, 11(5), 347-357
- **National Society for Earthquake Technology (2012).** *Earthquakes.* http://www.nset.org.np/nset2012/index.php/menus/menuid-58/submenuid-137 [Accessed June 8, 2016]
- **Nepal Risk Reduction Consortium Communications Group** (2014). *Common Messages for Disaster Risk Reduction*
- **Nepal Risk Reduction Consortium (NRRC) (2013).** Flagship 4 Handbook: Nepal's 9 Minimum Characteristics of a Disaster Resilient Community.
- **Nepal Seismological Center (2016).** *Historical Earthquakes*. Available from: http://www.seismonepal.gov.np/index.php?linkId=56 [Accessed June 3, 2016].
- **Noji, E. K. (1997).** The Epidemiology of Earthquakes: Implications for Vulnerability Reduction, Mitigation and Relief. In World Health Organization (Ed.), Proceedings of the International Symposium on Earthquakes and People's Health: Vulnerability Reduction, Preparedness and

Rehabilitation (Vol. Health Library for Disasters, pp. 9). Kobe: World Health Organization.

- **Osaki Y, Minowa M. (2001).** Factors associated with earthquake deaths in the great Hanshin-Awaji earthquake, 1995. American Journal of Epidemiology. Jan 15;153(2):153-6.
- **Paton D, Bajek R, Okada N, McIvor D. (2010).** *Predicting community earthquake preparedness: a cross-cultural comparison of Japan and New Zealand*. Natural Hazards. 2010 Sep 1;54(3):765-81.
- **Peek-Asa, C., Ramirez, M., Seligson, H., & Shoaf, K. (2001).** A Population-based Case-Controlled Study of Seismic, Structural, and Individual Factors Associated with Earthquake-related Injury
- **Peek-Asa C, Ramirez M, Seligson H, Shoaf K. (2003).** *Seismic, structural, and individual factors associated with earthquake related injury*. Injury prevention. 2003 Mar 1;9(1):62-6.
- **Petal, M. (2014).** *Critical Reflections on Disaster Prevention Education*, Ch. 11 in Egner, H., Schorch, M., & Voss, M. (eds) Learning and Calamities: Practices, Interpretations, Patterns. Taylor & Francis, Routledge.
- **Petal, M. (2012).** *Ch 3. Earthquake Casualties Research and Public Education* in Robin J. Spence, Emily So and Charles Scawthorn Eds. Human Casualties in Natural Disasters: Progress in Modelling and Mitigation, Springer.
- **Petal, M. (2009).** Evidence-based Public Education for Disaster Prevention: The Causes of Deaths and Injuries in the 1999 Kocaeli Earthquake, VDM. Doctoral dissertation, UCLA, 2004.
- **Petal, M (2002a).** Research Report: Causes of Deaths and Injuries in the August 17th, 1999, 3:02 a.m. Mw 7.4, Kocaeli Earthquake. Boğaziçi University, Kandilli Observatory & Earthquake Research Institute.
- **Petal, M (2002b).** *Reconnaissance: Deaths and Injuries, Feb 6th 2002, 9:03 a.m. 6.0 Ms Afyon Earthquake.* Boğaziçi University, Kandilli Observatory & Earthquake Research Institute.
- **Petal, M. & Green, R., Kelman, I., Shaw, R. & Dixit, A. (2008).** *Community-based Construction for Disaster Risk Reduction*, in Lee Bosher Ed. Hazards and the Built Environment: Attaining Built-in Resilience, Routledge/Taylor & Francis, London.
- **Seligson, H. A., & Shoaf, K., I. (2002).** *Human Impacts of Earthquakes*. CRC Press.
- **Shapira S., Aharonson-Daniel L., Shohet I.M., Peek-Asa C, Bar-Dayan Y. (2015).** *Integrating epidemiological and engineering approaches in the assessment of human casualties in earthquakes.* Natural Hazards. 2015 Sep 1;78(2):1447-62.
- **Shoaf, K. I. (2002a).** Special Earthquake Report; Preliminary Observations on the Southern Peru Earthquake of June 23, 2001: Health Impacts of the Earthquake.36(11).
- **Shoaf, K. I. (2002b).** *Standardized Earthquake Injury Classification Scheme*, from www.ph.ucla.edu/cphdr/scheme.pdf [Accessed June 6, 2016]
- **Shoaf, K. I., Seligson, H. A., Peek-Asa, C., & Mahue-Giangreco, M. (2002a).** *Advancing the science of casualty estimation: A standardized classification scheme.* Paper presented at the 7th. National Conference for Earthquake Engineering, Boston, MA.
- **Shoaf, K. I., Seligson, H. A., Peek-Asa, C., & Mahue-Giangreco, M. (2002b).** *Enhancement of Casualty Models for Post-Earthquake Reponse and Mitigation*. 547-556.
- **Shoaf, K., Seligson, H., Ramirez, M., & Kano, M. (2003).** Fatality Model for Non-Ductile

Concrete Frame Structures Developed from Gölcük Population Survey Data. Presented to PEER.

- **Shoaf, K. I., Bourque, L. B., & Nguyen, L.H. (1996).** *Injuries sustained in the January 17, 1994 Northridge Earthquake.* Paper presented at the American Public Health Association, New York NY.
- **Schultz C.H., Koenig K.L., Noji E.K. (1996).** *A medical disaster response to reduce immediate mortality after an earthquake.* New England Journal of Medicine. Feb 15;334(7):438-44.
- **Spence, R., So, E., and Scawthorn, C. Eds. (2011).** *Human Casualties in Natural Disasters: Progress* in Modelling and Mitigation. Springer.
- **Spence R, So E. (2009).** *Estimating shaking-induced casualties and building damage for global earthquake events.* Cambridge, UK.: Cambridge Architectural Research Ltd.
- **Tang, B.; Chen, Q.; Chen, X.; Glik, D.; Liu, X.; Liu, Y.; Zhang, L. (2017).** *Earthquake-related injuries among survivors: A systematic review and qualitative synthesis of the literature*, IJDRR V21 p.159-167
- **Thomas, A. & Wodzin, E. (2008).** The Abbreviated Injury Scale, American Association for Automotive Medicine (AAAM), Des Plaines, IL 2008.
- **Tierney, K. (2004).** *Guidance for Seismic Safety Advocates: Communicating Risk to the Public and Other Stakeholders* in Alesch, D., P. May, R. Olshansky, W. Petak and K. Tierney. Promoting Seismic Safety: Guidance for Advocates. Buffalo, NY: Multidisciplinary Center for Earthquake Engineering Research
- **UNDP (2004).** *Reducing disaster risk: a challenge for development.* New York: Bureau for Crisis Prevention and Recovery, United Nations Development Programme.
- **UNDP/UN-Habitat (1994).** *Seismic Hazard Assessment and Risk Assessent for Nepal,* National Building Code Development Project, Kathmandu, Nepal.
- **Wang, L., Zhang, Y., Wan,g W., Shi, Z., Shen, J., Li, M., Xin, Y. (2009).** *Symptoms of posttraumatic stress disorder among adult survivors three months after the Sichuan earthquake in China.* Journal of traumatic stress. Oct 1;22(5):444-50.
- **Wikipedia (2016)** *CTV Building* https://en.wikipedia.org/wiki/CTV_Building [Accessed Dec. 15, 2016]
- **Wood, M. et. al (2011).** Communicating Actionable Risk for Terrorism and Other Hazards, Risk Analysis 10.1111
- **Wood, M. (2014).** Epidemiology of Deaths and Injuries During Earthquakes, GeoHazards International.
- **YouTube (2016).** *Earthquake Non-Structural Damage*, https://www.youtube.com/watch?v=vUH76D5D3xs and https://www.youtube.com/watch?v=DxTpLZJ6HrE and https://www.youtube.com/watch?v=iOUChaZN2w8 [Accessed Dec. 15, 2016]

Appendices

Appendix #1: Glossary of Terms (Source: from CDC, 2012)

Cluster—a small group of households, or occupied housing units, within a geographic unit (e.g., a block or block group) that is within the sampling frame being assessed.
Cluster sampling—a form of probability sampling in which respondents are drawn from a sample of mutually exclusive groups (i.e., clusters) within a total population.
Completion rate—a type of response rate; the number of completed interviews, with reporting units divided by the goal number of completed interviews. (See response rate).
Disaster—a serious disruption of the functioning of society, causing widespread human, material, or environmental losses and exceeding the local capacity to respond requiring external assistance.
Disaster epidemiology—use of epidemiology to assess the short- and long-term adverse health effects of disasters and to predict consequences of future disasters (See epidemiology).
Disaster-related health effects Direct—health effects caused by the actual physical forces or essential elements of the disaster. Indirect—health effects caused secondarily by anticipation of the disaster or by unsafe/unhealthy conditions that develop due to the effects of the disaster.
Eligible household—a household within a selected cluster that is selected at random for interview and in which at least one adult (18 years or older) lives.
Epidemiology—the quantitative study of the distribution and determinants of health-related events in human populations.
Household—a household includes all the individuals who occupy a housing unit as their usual place of residence.
Housing unit—a house, an apartment, [temporary shelter], a group of rooms, or a single room that is intended to be occupied as separate living quarters.
Probability weight—a factor/value applied to each element in a sample in order to adjust for differences in the likelihood of selection. This is a value assigned to each household (i.e., each interview) that represents the inverse probability of its selection from the sampling frame, given the sampling design. Results calculated by use of the probability weight are representative of the entire sampling frame.
Proportion—a type of ratio in which the numerator is included in the denominator A proportion, or ratio of a part to the whole, is usually expressed as a decimal (e.g., 0.2), a fraction (e.g., 1/5), or a percentage (e.g., 20%).
Random number—a number selected by chance.
Random sample—probability sampling in which a subset of individuals (a sample) is chosen from a larger set (a population or sampling frame) randomly and entirely by chance, in such a way that each individual has the same probability of being chosen at any stage during the sampling process. See sampling.
Representative sample—a sub-group representing the total population, or sampling frame.
Response rate—the number of completed interviews divided by the total number of housing units sought or attempted. See contact rate, completion rate, and cooperation rate.

Sampling—the selection of a subset of individual observations within a population of individuals intended to yield some knowledge about the population of concern; sampling can be random or non-random, and representative or non-representative. See also random sampling, stratified sampling, systematic sampling, and target sampling.
Sampling design—the specification of the sampling frame, sample size, and the system for selecting and contacting individual respondents from the population.
Sampling frame—the entire population within the selected assessment area from which a sample is drawn. The sample is a subset of the larger sampling frame.
Stratified sample—a sample selected by grouping members of the population into relatively homogeneous subgroups and then applying random or systematic sampling within each stratum. See sampling.
Systematic random sample—a sample in which the target population is arranged according to an ordering scheme, with elements of it then selected at regular intervals through that ordered list. See sampling.
Target sample—a type of non-probability sample in which sample elements are chosen on the basis of some non-random characteristic (e.g., choosing the most severely damaged homes for interviews). See sampling.
Weight—the inverse of the probability that a given household will be included in the sample due to the sampling design. The weight is the total number of housing units (HUs) in the sampling frame divided by the number of clusters selected (e.g., 30), multiplied by the number of interviews completed within the cluster.

Weight = $\frac{\text{Total number of housing units in sampling frame}}{\text{(the number of housing units interviewed within cluster)*(number of clusters selected)}}$

Appendix #2: Variables

Hazard Level Variables:

- **Earthquake characteristics:** Magnitude, depth, shaking intensity

Individual Level Variables:

- **Demographic characteristics:** Age. Gender. Marital Status. Occupation. Caste/ethnicity. Disability. Family Income. Education.

Injury Level Variables:

- **Parts of body injured:** Body region affected and anatomical structure will be identified by naming and pointing to schematic diagram of body regions. (1. Head , 2. Face, 3. Neck, 4. Thorax, Chest, 5. Abdomen 6. Spine, Back 7. Arms, Hands 8. Legs, feet 9. Pelvis, Buttocks, Shoulders, Other)
- **Injury severity:** The descriptions and criteria below are based on Dr. Kimberley Shoaf, UCLA School of Public Health, Center for Public Health and Disasters. (See Appendix #5)
- **Time to treatment:** entrapment, and length of hospitalization.
- **Time of injury:** during, after shaking
- **Location at time of injury:** indoors (room, floor), outdoors (location)
- **Cause of Injury:** structural, non-structural, other
- **Position / Behavior / Movement during shaking**: Movement: stayed where I was, sat down, stood up, attempted to move but could not, got down on my knees, got under table or desk, walk, run, jump, crawl, other. Moved where: other people in same room, other people in different room, under furniture, outside, balcony, doorway, inside, other
- Medical care sought

Built Environment Level Variables:

- **Type of area:** Rural. Peri-Urban. Urban. Dense Urban.
- **Building Function:** eg. home, work, school, shop
- **Slope of land:** Flat. Moderate. Steep.
- **Relationship to other buildings:** Detached. Very close. Touching.
- **Corner position:** Corner / Middle
- **Building type**: Building types for Nepal have been categorized for research purposes by international team from National Society for Earthquake Technology, and Risk RED (2015). Photo prompts are used here to determine buiding type.
    1. Gārowālā (traditionally stone with mud mortar)
    2. Pillarwālā (confined masonry or reinforced concrete)
    3. Kath/Katch (bamboo)
    5. Mixed
- Building Features

Year of construction: #, don't know
Era of construction: <1934, 1934-1989, 1990-2010, 2011-Present
N.B. These date ranges were selected for the following reasons: The year 1934 corresponds to the last 'great' earthquake in the Kathmandu Valley. The year 1988 is when the Bihar earthquake in eastern Nepal spurred the adoption of earthquake resistant building codes. The year 2011 corresponds to the most recent earthquake in Nepal. (Whilst the Nepal National Building Code was adpted in 2003 and was first legally enforced in 2005 it was felt that these dates in history may have had more impact on structural awareness.
Buiding type: load-bearing (gārowālā), RC (pillarwālā), wood/bamboo (kath), mixed
Sub-types: Load-bearing (stone walls, mud walls, fired brick walls)/(cement mortar, mud mortar). RC (brick infill walls, block infill walls, stone infill walls)
 # Storeys
Roof type: concrete slab, CGI, tile, slate, thatch
Floor type: concrete slab, reinforced concrete with brick infill, wood/bamboo, mud
Pillars: *(photo prompts here)* (on each floor): yes, no, don't know
Roof material: *(photo prompts here)* metal sheet, thatch, earth/mud, timber truss, concrete slab, tile, stone, other, don't know

- Other building vulnerability factors:
  If load bearing (walls connected by bands, wood floor, lintel band, roof band)
  If RC (pillars from top to bottom)
  If wood/bamboo (with or without mud)
- Measures taken for structural safety
  Replaced heavy roof with lighter weight material (CGI, thatch etc).
  Shored walls of any part of the building.
  Bracing added to walls
  Ring Beams around building
  Other
- Structural and non-structural causes of injuries and deaths:
  A. Structural elements of building
  wall, column, beam, ceiling, roof, staircase, partition wall, balcony, door, window
  B. Non-structural element of the building
  tiles/sinks/tubs, lighting fixtures, false ceiling, parapet/awning, ladder, porch roof, pipes
  C. Building contents
  low furniture, high furniture, refrigerator or large appliance, office equipment, water heater/ fan/heater/cooler/ac, factory equipment, agricultural equipment, office equipment, hanging light, standing lamp, prayer alcove or statuary, large TV, small TV or appliance, signage, hot item, picture frame or glass
  D. Outdoor objects

grain stacks, hay stack, wood pile, garden stakes, billboard, electricity points, electrical wires, telephone or electrical poles, telecommunications tower, statuary or columns, tree, water tank, satellite dish, animals, other

- **Building damage level** (See Appendix #4 for Building Damage Chart and photos)
  Five building damage level are defined, based on ATC-13, 2002. These are illustrated by a set of photographs showing each damage level (for all construction types), based on the schematic example below. Respondent ability to correctly identify damage level of buildings in their environment, based on these sets of photos will be pre-tested for reliability.

Mitigation and Preparedness Level Variables:

- Risk assessment measures:
- **Response preparedness measures:** taken before, taken after, intended, useful
- Response skills:
- **Response provisions:** These are aligned to both the NRRC's consultation with public and community education programs, in order to support effectiveness studies.

Response Level Variables:

- **Perceptions of efficacy and safety of recommended actions:** respondents will be asked whether a variety of recommended actions were possible, and would have been safe
- Entrapment & search and rescue
- Medical Response

Community Awareness Program Variables:

- Availability and participation of household members in disaster awareness or preparedness training programs in school or community.

Appendix #3: Research Design Details

Cluster sampling using purposive method was adopted to select the study sample. Five of the seven hardest-hit districts with the highest number of fatalities, and highest numbers of damaged buildings were selected in order to cover a range of urban, peri-urban, and rural settings. Figure 3 presented below shows the overall sampling procedure.

The selected districts were:

i. Kathmandu district
ii. Bhaktapur district
iii. Sindhupalachok district
iv. Kavrepalanchok district
v. Nuwakot district

Selection of Wards

Altogether, one ward each from 10 VDCs/Municipalities/Metropolitan Cities identified as hardest hit, or with the highest numbers of fatalities were purposively selected from above mentioned five districts. Outliers caused by very high fatalities in one or two high occupancy building collapses in these areas were eliminated during sampling. The main criteria for selection of wards were accessibility, and sufficient density (for efficient data collection from at least 3 households per day per field researcher). Wards were eliminated if they were inaccessible by road, dangerous to access, had insufficient density for efficient data collection from at least 3 households per day per field researcher, or did not permit daily return to a regional hub. In Nuwakot, ward was selected for the presence of community-disaster risk reduction and public awareness outreach programs of the Nepal Red Cross Society.

Selection of Households

Based on social mapping with local key informants, a list of households, accessible by road, was prepared. This ensured that every sampling frame consisted of at least 100 households; if inadequate, adjoining wards were merged. From this list, every second household was selected until fifty households were identified. Substitutions of 'next building' were made where building was uninhabited, or when no inhabitants could be found after third visit.[5] In dense urban areas where several families occupy a single structure, field researchers/supervisors selected 'household' based on those sharing a meal. In multi-unit buildings, units were counted top floor down, clockwise on each floor. For each household, the target was to interview, or to obtain separate survey responses from each member of the household, including for children (by adults).

[5] The methodology below is one that was used: http://un.org.np/sites/default/files/report/tid_188/Internal-Migration-March2005.pdf
"They are selected along a transect line from the center to the periphery of the cluster identified by spinning a bottle at its center point. First, the total number of households – defined as people sharing a meal – along the transect line is established by visiting each building along the line. Secondly, that number is divided by the required sample to reach at the sampling interval with which households along the line are selected for interview. If necessary, the exercise is repeated till the sample size requirement is met."

Criteria for Sample Selection

Only those persons who were present inside the VDC during the 25 April Nepal Earthquake were considered as participants (subjects) of this study. If the eligible person was under the age of 18, unavailable or dead, proxy interviews were performed with other household members who were present with the individual at the time of the earthquake.

Data Collection

Five field supervisors and 22 data enumerators were recruited for the purpose of the data collection. The field data collection team included individuals with experience in interviewing and data collection in other similar surveys. They were intensively trained on survey objectives, methodology, tools and techniques, psychosocial support and Save the Children's child safeguarding policy. A one-day field trial was also conducted to ensure the clarity and consistency of the tool, uniformity in understanding about the survey among the field researchers and their familiarity with the tablet. Data collection was done over the course of two weeks.

At household level, survey questions were nested to provide unique subject ID and household ID. The most well informed subject (household head in most of the cases in this survey) reported on household demographic questions on behalf of the household. Similarly, interviews were attempted for every individual who was present at the time of the earthquake by either self or proxy, based on their availability. Capable adult informants (respondents) had provided the information they were confident about, on behalf of any absent member/s of the household (subject/s), including some deceased, and on behalf of children under the age of 18. Children over the age of 14 were present during the interview, in some instances, at the discretion of parent or guardian who had already participated in the survey. Field researchers/supervisors visited a single household up to 2 additional times as needed to seek responses from all household members.

Since people are not inclined to share personal details without some circumspection, more personal questions about education level, caste, and family income, were placed at the very end of the questionnaire to be answered after a relationship had been well-established. It was the aim of the team that respondents will find that sharing the details of their experience, and contributing to future risk reducation to be a positive experience.

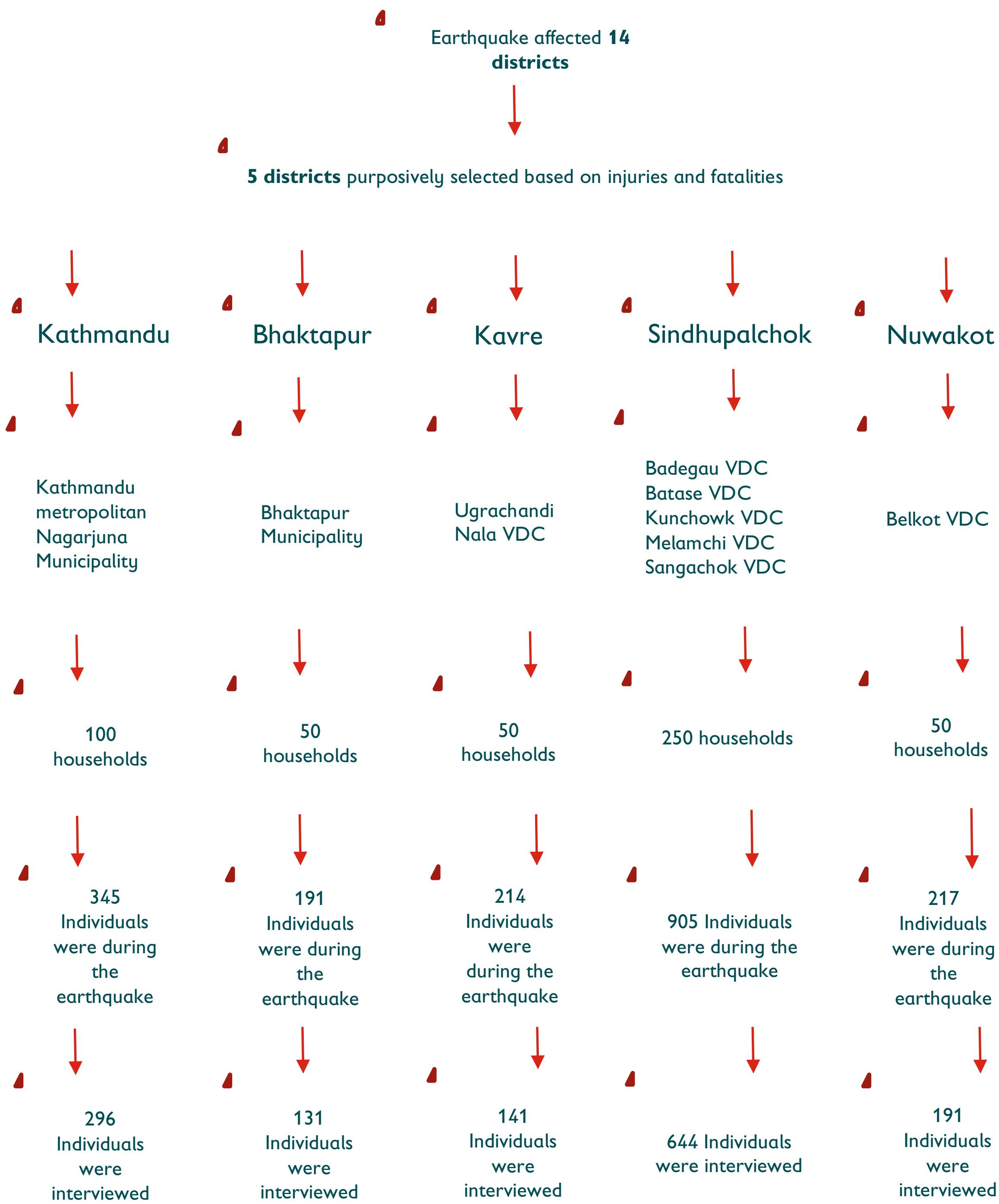


Figure 3: Sample Frame

Data Quality Assurance

The survey questionnaire was pretested, reframed and retranslated.

Data Quality

Validity
Reliability
Integrity

Survey Activities

-Design of survey, tools and methods by experts in the relevant field
-Pretesting of survey tools and techniques
-Qualified and experienced field researchers
-Intensive training and field trial for FRs to ensure the proper and uniform understanding
-Field monitoring and supervision
-Real time data monitoring from timely uploaded data
-Data coding, editing and cleaning by experienced Data Management Officer and timely checked by the Data Analyst

Figure 4: Data Quality Assurance Procedures

Data Management and Analysis

Overall data management was carried out by experienced Data Management Officer and Data Analyst. Cleaning of data and resolution of anomalies and errors took place as soon as the data were collected. Certain level of outliers and consistency were checked by the Tablet program. Data was kept in a password-protected computer with access by only the Data Analyst and Data Management Officer. None of information that could possibly track the respondents was kept. The movement of the dataset was done through encrypted memory stick. A detailed data analysis plan was developed and executed by the PI and Data Management team. Descriptive analysis was performed along with bivariate analysis to assess association between deaths/injuries and the various groups of variables.

Appendix #4: Building Damage Levels Categorization and Appraisal

Building Damage Level Appraisal

When subjects were asked questions about the damage level of the building they were in at the time of the April 25th earthquake, they were asked to identify the building damage level based on rough visual identification using the the chart below, with standard building damage levels identified in Nepal. Photographs of buildings of different construction types and damage levels were assembled from and triangulated by several Nepali engineers. These were assembled into the "flipchart" below. Enumerators offered the respondents photos of one level of damage lower and higher (as shown below), to assist respondents in disambiguating and selected the nearest damage level.

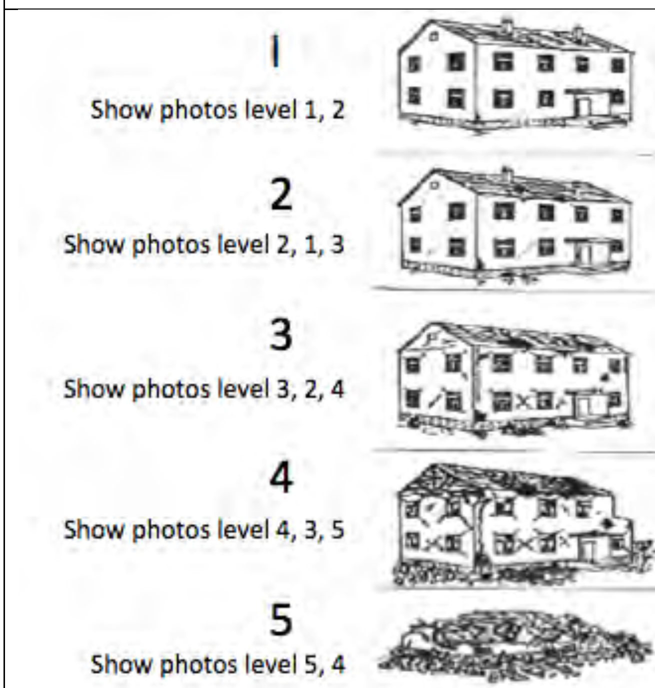
<table>
<tr><th>Damage Level Appraisal Diagram</th><th>Corresponding Damage Level</th><th>Habitability</th></tr>
<tr><td rowspan="5">
</td><td>None / Slight</td><td rowspan="2">Repairable</td></tr>
<tr><td>Light / Moderate</td></tr>
<tr><td>Moderate / Heavy</td><td rowspan="3">Not Repairable</td></tr>
<tr><td>Very Heavy</td></tr>
<tr><td>Total Collapse</td></tr>
</table>

Figure 5: Building Damage Level Schematic Chart

Validation of Building Damage Level Appraisal

In order to provide clues as to the efficacy of having respondents identify building damage levels of the buildings they were in at the time of the earthquake, a testing method was piloted to see the how accurately respondents using the chart and photos would mirror the building damage levels assessed by engineers. Students Dipesh Pulara and Om Dhakal of Tribhuvan University, supervised by Dr. Beth Pratt-Situala undertook a study to find out how accurate average individuals would be in:

- identifying construction type of buildings in view, and from memory

- identifying building damage level of visible buildings, using the flipchart diagram and photos to dissambiguate
- identifying building damage level of familiar buildings not visible (i.e. using memory)

The students surveyed 58 people in four locations selected on the basis of a range of building damage levels, construction types, and rural and urban locations. Passersby were invited to participate, making an effort to invite a range of ages, genders and education levels. The areas selected were *Sankhu* (a highly-damaged rural area with lots of gārowālā and a few pillarwālā buildings, *Gongabu* buspark is a highly damaged urban area with mostly pillarwālā buildings and is highly damaged area, *Bhimdhuinga* (a village near Ramkot) is a moderately damaged peri-urban locality with nearly equal numbers of gārowālā and pilllarwala buildings, and *Chalnakhel* is a less-damaged rural area where virtually all buildings are gārowālā.

Gender	Male 54%	Female 46%	
Ages	18-30 31%	30-50 41%	>50 28%
Education level	Primary and below 29%	Middle school 50%	High school and above 21%

Figure 6: Map showing Shankhu, Chalnakhel, Gongabu and Bhimdhunga

Three buildings were visible buildings and three other well-known buildings in the area were selected and photographed. Three qualified structural engineers, agreed on the construction type and damage level based based on a standard pictograph used in Nepal (See Appendix #4 and #9). These were deemed to be the "correct answers". None of the buildings selected were Damage Levels 1 or 5, which were taken to be by and large self-evident. Respondents were asked questions about the 3 buildings that were clearly visible, and the three that were not visible. Respondents identified building type with 70% accuracy. They identified 42% of visible buildings and 40% of buildings from memory exactly the same as the engineers had. They identified almost all of the building damage level within 1 damage level above or below the engineers' response. Nonetheless, the respondents in the urban locations tended to assess the visible damage level lower than the engineers (especially in the case of pillarwālā buildings), and the non-visible buidings as more damaged than the engineers.

Appendix #5: Injury Severity Categorization and Parts of Body Injured

Three injury levels were defined; minor, moderate, and severe, as follows:

Table 27: Injury Severity Categories

Simplified Injury Severity Categories	Injury description
1. Minor (corresponds to AIS* 1. Minor)	minor cuts bruises sprain or strain superficial injury head injury, if untreated burns - red, no blister breathing difficulty - due to dust inhalation (untreated)
2. Moderate (corresponds to AIS 2. Moderate and 3. Serious)	upper extremity fracture lower extremity fracture cuts in soft tissue open wounds dislocation of joints head, skull or brain injury (treated by non-medical unit) injury to blood vessels, bleeding crushing injury (only) burns - red, with blisters, wet, breathing difficulty - due to dust inhalation (treated by non-med unit)
3. Severe (Corresponds to AIS 4. Severe, 5. Critical, and 6. Maximum)	head, skull or brain injury (treated by medical unit) neck/torso fracture pelvic fracture internal injury uncontrolled bleeding crushing with kidney problems or failure burns - charred, white or dry injury to nerves, spinal cord poisoning drowning breathing difficulty - due to dust inhalation (treated by medical ur

Source: The Abbreviated Injury Severity Score (AIS) 2008,
designed by the Association for the Advancement of Automotive Medicine
(http://www.aaam.org/about-ais.html) and Shoaf 2002a)

For illustration of part of body injured, and differentiation of minor vs. crush injuries, please see Appendix #9.

Appendix #6: Research Findings – Additional Tables

EARTHQUAKES IN NEPAL:

Table 28: Significant Earthquakes in Nepal since 1900

Location	Date	Year	Time / Day	Magnitude	Deaths
Nepal / Tibet (Xizang province)	Aug 28	1916	06:39 Thur	7.7	3,500
Nepal / India (Bihar)	Jan 15	1934	08:43 Mon	8.4	10,600
Nepal / India	June 27	1966	10:41 Mon	6.3	80
Nepa / India (Pithoragarh)	July 29	1980	14:58 Tues	6.5	200
Nepal (Kathmandu) / India (Bihar)	Aug 20	1988	23:09 Sat	6.6	1,091
Nepal / India (Sikkim)	Sept 18	2011	06:29 Sun	6.9	111
Nepal (Gorkha)	Apr 25	2015	11:56 Sat	7.8	8,698
Nepal (Dolakha)	May 12	2015	12:50 Tue	7.3	213

Sources: Government of Nepal 2015 (National Centers for Environmental Information; Humanitarian Data Exchange.)

- **POPULATION DEMOGRAPHICS:**

Gender distribution

The gender distribution of household members in the VDC was 44% male and 56% female. The reason for this unexpected inequality is likely that in these rural locations, male members of the family may either live elsewhere, or travel a significant distance for livelihood pursuits and therefore either not be living in household or not be present in the same local VDC during the earthquake. Similarly, the gender distribution of the subjects for whom data was collected was population was 42% (583) male and 58% (820) females.

Marital status

Of the surveyed population 57% (802) were married, 36% (508) were never married, 6% (82) widowed, <1% (6) divorced and <1% (5) don't know.

Main source of income

The main source of household income overall was Farming/Livestock 61% (308), Business/Shop owner 11% (55), Service Worker 7% (24), Skilled daily worker 7% (33) government employee 5% (23), foreign employment 4% (20), all others 5% (27) .

Education level

The highest education level obtained by our subjects was as follows:

Table 29: Education Level Distribution

Education Level	N (1403)	%
Illiterate (including pre-school)	317	23%
Below primary	338	24%
Primary	346	25%
Secondary	193	14%
College	116	8%
University	39	3%
Not Applicable	54	4%
Total	1403	100%

Age distribution

The distribution of ages of those with survey responses was as follows:

Table 30: Distribution of Subject Ages

Age Groups	Ages	N	%
Pre school	0-3 years	48	3%
	4-6 years	57	4%
School age	7-14 years	184	13%
	15-19 years	139	10%
20s-30s	20-29 years	251	18%
	30-39 years	193	14%
40s-50s	40-49 years	197	14%
	50-59 years	143	10%
60s +	60-69 years	99	7%
	70+	92	7%
TOTAL		1403	100%

Household Income

Table 31: Household Source of Income (Main Employment)

Current Occupation	N	%
Agriculture	498	36
Student	403	29
Work in home	215	15
Employed	82	6
Self-employed	81	6
Children under 5 years	45	3
All others	81	6
TOTAL	1403	100

Caste/ethnicity

The caste of household members in our sample, compared to that in the 3m population of 5 districts:

Table 32: Caste / Ethnicity of Subjects

Caste	N	% in sample	% in 3m population of 5 districts
Brahmin	309	22	21
Tamang	277	20	19
Newar	253	18	21
Sanyasi	225	16	16
Kshettri	134	10	18
Danuwar	69	5	<1%
Thakuri	51	4	1%
Dalit	40	3	<1%
All others	45	3	3%
TOTAL		100%	

Source: Government of Nepal, 2011

- **RESEARCH FINDINGS:**

Individual Level Variables:

Table 33: Gender, Injury, and Death

Gender		Not Injured	Injured / Dead	Total
Male	N	729	90	819
	Row (%)	89%	11%	100%
	Column (%)	45%	40%	44%
Female	N	898	138	1036
	Row (%)	87%	13%	100%
	Column (%)	55%	61%	56%
Total	N	1627	228	1855
	Row (%)	88%	12%	100%
	Column (%)	100%	100%	100%

Pearson's Chi-squared value 2.306 1 df – not significant

Table 34: Gender and Severity of Injury

Gender		Minor	Serious / Critical	Total
Male	N	40	31	71
	Row (%)	56%	44%	100%
	Column (%)	34%	45%	38%
Female	N	78	38	116
	Row (%)	67%	33%	100%
	Column (%)	66%	55%	62%
Total	N	118	69	187
	Row (%)	63%	37%	100%
	Column (%)	100%	100%	100%

Pearson's Chi-squared value 2.249 1 df – not significant

Table 35: Age, Injury and Death

	Not Injured		Injured		Dead		Injured / Dead		Total	
	N	Row %	N	Row %	N	Row %	N	Row %	N	Col %
0-3 years	66	83%	4	5%	10	12%	14	18%	80	4%
4-6 years	82	91%	2	2%	6	7%	8	9%	90	5%
7-14 years	265	94%	13	5%	5	2%	18	6%	283	15%
15-19 years	168	89%	19	10%	1	<1%	20	11%	188	10%
20-29 years	312	90%	34	10%	1	<1%	35	10%	347	19%
30-39 years	207	87%	29	12%	1	<1%	30	13%	237	13%
40-49 years	204	88%	24	10%	4	2%	28	12%	234	13%
50-59 years	142	84%	26	16%	1	1%	27	16%	169	9%
60-69 years	96	82%	18	15%	3	3%	21	18%	117	6%
70+	85	76%	21	19%	6	6%	27	24%	112	6%
Total	1627	88%	191	10%	39	2%	228	12%	1855	100%

N.B. Signficance testing was done comparing Not Injured to Injured / Dead
Pearson's Chi-squared value 34.403 9 df. This is significant at the .0001 confidence level

Table 36: Education Level, Injury and Death

Education Level		Not injured	Injured / Dead	Total
Illiterate	N	264	53	**317**
	Row (%)	83%	17%	**100%**
	Column (%)	23%	29%	**23%**
Pre-school / Primary	N	601	83	**684**
	Row (%)	88%	12%	**100%**
	Column (%)	51%	46%	**51%**
Secondary / College / University	N	304	44	**348**
	Row (%)	87%	13%	**100%**
	Column (%)	26%	24%	**26%**
Total	**N**	**1169**	**180**	**1349**
	Row (%)	**87%**	**13%**	**100%**
	Column (%)	**100%**	**100%**	**100%**

Pearson's Chi-squared value 4.136 2 df – not significant

Built Environment Level Variables:

Table 37: Injury Rates by Building Damage Category

Level of Damage			Not Injured	Injured	Dead	Total
Habitable	None / Light / Moderate	N	423	37	0	460
		Row %	92%	8%	0%	100%
		Column %	51%	35%	0%	47%
Uninhabi-table	Very Heavy / Total Collapse	N	402	114	14	530
		Row %	76%	22%	3%	100%
		Column %	49%	76%	100%	54%
	Total	N	825	151	14	990
		Row %	83%	15%	1%	100%
		Column %	100%	100%	100%	100%

Pearson's Chi-Square value: 49.095 2 df. This is significant at the .00 level
(Those who could not identify building damage level were excluded)

Table 38: Range of Floors of Buildings (in or near) and Deaths or Injuries

Number of Floors	Indoors		Outdoors near a building		Total		Not Injured		Injured/Dead		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
1 floor	62	8%	18	9%	**80**	**8%**	73	9%	7	4%	**80**	**8%**
2 floor	320	40%	69	35%	**389**	**39%**	317	38%	72	44%	**389**	**39%**
3 floor	294	37%	97	49%	**391**	**39%**	324	39%	67	41%	**391**	**39%**
4 floor and up	126	16%	14	7%	**140**	**14%**	121	14%	19	12%	**140**	**14%**
Total	**802**	**100%**	**198**	**100%**	**1000**	**100%**	**835**	**100%**	**165**	**100%**	**1000**	**100%**

Table 39: Place at Time of Earthquake and Deaths or Injuries

Location		Not Injured	Injured / Deceased	Total
Indoors	N	661	148	809
	Row (%)	82%	18%	100%
	Column (%)	54%	78%	58%
Outdoors near a building	N	187	20	207
	Row (%)	90%	10%	100%
	Column (%)	15%	11%	15%
Outdoors near another structure	N	36	6	42
	Row (%)	86%	14%	100%
	Column (%)	3%	3%	3%
Not in or near any structure	N	329	16	345
	Row (%)	95%	5%	100%
	Column (%)	27%	8%	25%
Total	N	1213	190	1403
	Row (%)	86%	14%	100%
	Column (%)	100%	100%	100%

Table 40: Home vs Other Places and Injury and Death

Home / Away	Not injured		Injured / Dead		Total	
	N	Percent	N	Percent	N	Percent
Family House	197	35%	24	**57%**	**221**	**37%**
Others	358	65%	18	**43%**	**376**	**63%**
Total	555	100%	42	100%	597	100%

Pearson's Chi-squared value 7.848 1df This was significant at the .005 level.

Table 41: **Struck by Structural and Non-Structural Building Elements and Severity of Injury**

Structural / Non-Structural	Minor		Serious/Critical		Total	
	N	Col %	N	Col %	N	Col %
Structural Elements	73	90%	48	94%	121	92%
Non-structural Elements	24	30%	21	41%	45	34%
Total	81		51		132	

Pearson's Chi-squared value 2.511 2df. This was not significant

The elements are not mutually exclusive. Some people were struck by both, therefore total exceeds 100%.

Table 42: **Struck by Building Elements and Building Contents, and Severity of Injury**

Building (All) Elements vs. Building Contents	Minor		Serious/Critical		Total	
	N	Col %	N	Col %	N	Col %
The Building	81	99%	51	94%	132	97%
Building Contents	13	16%	16	30%	29	21%
Total	82		54		136	

Pearson's Chi-squared value 5.827 2df. This was significant at the .054 level

The elements are not mutually exclusive. Some people were struck by both, therefore total exceeds 100%.

Table 43: **Damage to Contents and Deaths and Injuries**

Damage to contents	Not Injured			Injured / Dead			Total	
	N	Col %	N	Col %	N	Col %	N	Col %
No (none or very little)	218	92%	25%	20	8%	12%	238	23%
Yes, some damage	282	89%	33%	34	11%	20%	316	31%
Yes, lots of damage	339	75%	40%	115	25%	68%	454	44%
Don't know	16	94%	2%	1	6%	1%	17	2%
Total	855	83%	100%	170	17%	100%	1025	100%

Pearson's Chi-squared value 45.773 3df. This was significant at the .001 level

Mitigation and Preparedness Level Variables:

Table 44: Reasons for Not Taking Household Risk Reduction & Preparedness Measures After

Reasons for not taking household risk reduction and preparednesss measures after	N	%
I don't know what to do	52	53%
I am too busy	15	15%
I'm too old / too young / not capable / disabled	11	11%
I know it is important to prepare but didn't care much	11	11%
I couldn't afford to	9	9%
Not applicable (House totally destroyed)	9	9%
I don't think it would make a difference	8	8%
It is god's will whether I live or die, preparedness doesn't matter	8	8%
I don't want to	7	7%
Total	**98**	**100%**

Table 45: Sources of Information about Preparedness

Source of information about preparedness	N	%
Radio	239	60%
Friends/Family	234	59%
TV	209	52%
NGO or community-based organization	69	17%
Newspaper	62	16%
At work/ from colleagues	36	9%
Learned through own experience of earthquake	28	7%
At school/college	20	5%
Internet/Social Media	17	4%
Government	17	4%
Red Cross	13	3%
Awareness programmes (Drama)	2	1%
From past generation	2	1%
Not Applicable	2	1%
No response	1	0%
Community people	1	0%
Total	**400**	**100%**

Injury Level Variables:

Table 46: Emotional Injuries Impact by Age

	Pre-school / school age	20s-30s	40s-50s	60+	Total
None	12	28	18	6	64
Some impact	47	86	78	37	248
Moderate impact	19	37	32	17	105
Severe impact	6	20	18	9	53
Total	84	171	146	69	470

Pearson's Chi-Square 4.618 9df - not significant

Table 47: Emotional Injuries Impact by Gender

Emotional Injuries		Gender		Total
		Male	Female	
None	Count	31	33	64
	Row (%)	48%	52%	100%
	Column (%)	19%	11%	14%
Some impact	Count	81	167	248
	Row (%)	33%	67%	100%
	Column (%)	49%	55%	53%
Moderate impact	Count	31	74	105
	Row (%)	30%	70%	100%
	Column (%)	19%	24%	22%
Severe impact	Count	24	29	53
	Row (%)	45%	55%	100%
	Column (%)	14%	10%	11%
Total	Count	167	303	470
	Row (%)	36%	64%	100%
	Column (%)	100%	100%	100%

Pearson's Chi-Square 9.400 3df Significant at the .05 level

Appendix #7: 10 Common Messages in Nepal – 2014 (excerpted from NRRC, 2014).

10 Key Common Messages for Multi-Hazards

1) Being prepared starts with you. Be prepared and know what to do when disaster strikes. Taking simple steps can save your life.

2) Are you ready? **Prepare a disaster action plan with your family**. **Agree** on a **meeting point outside** in a safe open space. **Plan escape routes** in case the main door is blocked. **Keep a whistle** on you at all times. **Identify safe places** that are accessible, keep copies of information on any special needs you have, medications being taken and any allergies or sensitivities.

3) **Have an emergency bag** ready for your family. This **should contain** essential items you will need immediately after a disaster. Contents: a **torch** and **batteries**, a **small radio**, enough dry **food** such as beaten rice or instant noodles for one day, a plastic bottle of drinking **water**, a bottle of Piyush **chlorine drops** for purifying drinking water, a basic **medical kit**, and photocopies of your **ID cards**. Store the bag in a safe place that is easily reached.

4) **Carry a whistle** with you at all times to attract attention in an emergency. Blow the whistle if you are trapped or injured by an earthquake, flood, or landslide. You can also blow the whistle if you are attacked. A whistle can be heard far away and it can save your voice.

5) **Always defecate in proper toilets or latrines** to prevent the spread of water-borne diseases such as diarrhoea. If you cannot use a latrine, **bury your faeces in the ground**. **Do not defecate on open ground or near water sources**.

6) Dangerous diseases such as cholera are transmitted through dirty and polluted water. **Make water safe to drink by boiling it**. Boil water for at least five minutes before you drink it, even if it looks clear and clean. Stay safe from diseases that are transmitted through dirty and polluted water.

7) After a disaster, family members may be split apart and lose contact with each other. **Make sure children and the elderly can remember or keep a document, official or handwritten, with them at all times that provides their name, address, and family contact information and mobile telephone number if available.** This information will help make sure children and elderly can be reunited with their family after a disaster.

8) Disaster can happen at any moment. **Never leave your stove, lit cigarettes, or candles unattended.** **Turn off and unplug electrical appliances when not in use** to protect from fire before, during, or after disasters like earthquakes or floods.

9) **Learn basic first aid skills and be prepared for an emergency**. First aid skills will help you treat yourself and your family from minor injuries. Maintain and refresh those skills at least every three years.

10) **Ensure you and your family follow proper building codes** when constructing a home for disaster safety and to protect it from collapse due to an earthquake. A building code compliant home can save lives and property.

10 Key Common Messages for Earthquakes

1. What to Expect? When an earthquake strikes, expect the ground to shake, buildings, bridges, and power lines to collapse and glass to shatter. **Keep calm when you feel the ground shake**, do not panic.

2. Are you ready**? Prepare an earthquake action plan with your family**. **Agree** on a **meeting point outside** in a safe open space. **Plan escape routes** in case the main door is blocked. **Keep a whistle** on you at all times.

3. **Have an emergency bag ready for your family**. This **should contain essential items** you will need immediately after a **flood** or **landslide**. Contents: a **torch** and **batteries**, a **small radio**, enough **dry food** such as beaten rice or instant noodles for one day, a plastic bottle of drinking **water**, a bottle of Piyush **chlorine drops** for purifying drinking water, a basic **medical kit** and **photocopies** of your **ID cards**. Store the bag in a safe place that is easily reached.

4. **Carry a whistle with you at all times to attract attention** in an emergency. Blow the whistle if you are trapped or injured by an earthquake, flood or landslide. You can also blow the whistle if you are attacked. A whistle can be heard far away and it can save your voice.

5. Build safely: **Follow proper building codes when constructing your home** for fire safety and to protect it from collapse due to an earthquake. A building code compliant home can save lives and property.

6. In your home, school, or workplace, **learn and practise the safety position** which you should adopt in an earthquake. This is called **Drop, Cover, and Hold On**. Drop down low to make yourself small. Then cover your head and neck with your arms. These two actions will help to protect you from falling objects. If there is strong furniture nearby such as a table, hold on to it. This will also help to protect you. Once you have assumed this safety position, stay where you are until the shaking stops.

7. After an earthquake, communication networks may be down or overloaded. **Use text message instead of calling to prevent network outage.**

8. **If trapped, keep calm, and use your whistle to signal to others**. Using a whistle saves energy and protects you from breathing in rubble and dust. If you do not have a whistle, knock on a hard surface to draw attention to your location.

9. Learn first aid: **Learn basic first aid skills and be prepared for an emergency.** First aid skills will help you treat yourself and your family from minor injuries. Maintain and refresh those skills at least every three years.

10. Are you ready? Shaking during an earthquake may cause loose objects to fall. Falling objects may injure or kill. **Protect yourself and your family from injury by securely screwing or chaining heavy objects such as shelves, cupboards, flower pots, water tanks, and mirrors to the wall or floor.**

Appendix #8: Survey Questionnaire – Epidemiological Study on Causes of Deaths and Injuries in Gorkha Earthquakes, 2015

Identification and Call Record			
ID1	District		☐☐
ID2	VDC/Municipality		☐☐
ID3	Ward		☐☐
ID4	Settlement/(Tole)		☐☐

Informed Consent

Namaste! My name is ______________________ I am working for Health Research and Social Development Forum (HERD) located at Kathmandu. HERD is a non-profit, non-governmental organization. This organization has been conducting various programmes and research in the health and social sector for the Ministry of Health and Population and other agencies. Currently, we are conducting an epidemiological study of the causes of deaths and injuries in the April 25th Nepal Earthquake for Save the Children.

The main objective of this study is to identify the causes of injuries and deaths in the April 25th Earthquake (and subsequently) in order to provide a scientific basis for education and training of the Nepali public in basic disaster preparedness and mitigation. In order to do so, I would like to collect some information from you and your family members. Our interview usually takes about 30 to 40 minutes. Your responses will be kept confidential and none of the information revealing your identity will be disclosed. You may or may not take part in the study. You may skip answering any question in case of difficulty and I will go on to the next question or you can stop the interview at any time. Your views will be extremely important and will contribute to help Save the Children and improve its response.

May I begin the interview now? Yes ☐ No ☐

INTERVIEWERS VISITS RECORD		
1st Interview Date ☐☐/ ☐☐ /15 DD / MM	2nd Interview Date ☐☐/ ☐☐ /15 DD / MM	3rd Interview Date ☐☐/ ☐☐ /15 DD / MM
Name of interviewer	………………………..	
Signature	………………………...	
1st Result ☐	2nd Result ☐	3rd Result ☐

**Result code*

Interview completed……..…..……………………………………………………1
No one met in the house: need to go for 2nd interview……...……………………….2
No one met in the house: need to go for 3rd interview……...……………………….3
Refused to give interview……………..……………………………………………….4

START INFORMALLY • WARM UP QUESTIONS • LISTEN TO STORY (& GRIEVANCES)

SECTION 1 : Household Member Characteristics

(HH ID#)

Q.N.	Household members inside and outside the VDC	
1	At the time of the earthquake on April 25th how many people in your household were in this VDC and how many were in another VDC? ***# inside is the target number of surveys to be collected for this household***	
1A	Number inside this VDC	
1B	Number outside this VDC	

Q.N. 2	**Household Roster**						
	Please list all the household members who were in this VDC, at the time of the April 25th earthquake. For each person listed please indicate whether they have any of the challenges BEFORE and SINCE the earthquake.						
	2A	2E	2B	2C	2D	3	4
INDV#	**Name**	**Relation to Current HH head**	**Sex**	**Age**	**Status**	**Challenges BEFORE the earthquake**	**Challenges SINCE the earthquake**
		1=Self/HH head; 2=Spouse; 3=Son/daughter; 4=Daughter-in-law; 5=Grandchild; 6=Parent; 7=Parent-in-law; 8=Co-wife; 9=Brother/Sister; 10=Other relative /Guest	*(Male=1; Female=2; Other=3)*		*(Injured=1; Deceased=2; Neither=3)*	*None=1; Chronic health-2; Physical or sensory disability=3; Cognitive disability=4; Mental health problem=5*	*Deceased because of earthquake=0; None=1; Chronic health-2; Physical or sensory disability=3; Cognitive disability=4; Mental health problem=5; Deceased for other reasons since earthquake=9*
			1 2 3		1 2 3	1 2 3 4 5	0 1 2 3 4 5 9
			1 2 3		1 2 3	1 2 3 4 5	0 1 2 3 4 5 9
			1 2 3		1 2 3	1 2 3 4 5	0 1 2 3 4 5 9
			1 2 3		1 2 3	1 2 3 4 5	0 1 2 3 4 5 9

SECTION 2 : Household Member's Earthquake Location and Experience

Q.N.	Identification details	Response/Categories	Code	Skip
5	Name of the subject ***Select individual from hh roster, of who you are going to take the information***			
5B	Is the subject older than 18 years? ***Do not need to ask; check from the household roster***	Yes... No	1 2	
8A	Was the subject with any other household member(s) during the EQ?	Yes... No	1 2 →	 5C
8B	If yes, who? ***Select individual(s) from hh roster***			
5C	Is the subject OR the next best household member present AND given verbal consent for the interview? ***Note: If the subject is under 18 years, is hospitalized, deceased, or unavailable, the "next best household member" is an adult hh member who is able to provide the best information on behalf of the subject***	Yes and consent given.............................. No………………………………………. Yes, BUT consent not given……….	1 2 3	 End
5D	What is the relationship between the respondent and subject? ***Should be an individual from the roster who is older than 18 years***	Self……………………………………. Spouse………………………………. Son/daughter (older than 18 years) Daughter-in-law…………………….. Grandchild (older tam 18 years)….. Parent………………………………. Parent-in-law…………………………. Co-wife………………………………. Sibling (older than 18 years)………. Other relative /Guest………………..	1 2 3 4 5 6 7 8 9 96	
5F	Who is the respondent providing answers for the subject ***Select an individual from hh roster***			

Q.N.	Identification details	Response/Categories	Code	Skip
*If the subject and respondent are **<u>NOT</u>** the same, make sure you are collecting information on the SUBJECT*				
Built Environmental Level				
7	What is the address or location where you were at, at the time of the Baisakh 12th (April 25th) earthquake? ***(This is location info for the respondent, and any others identified in Q. 8B)***			
7D	Ward number			
7E	Tole			
7F	Village or Neighbourhood			
7G	Street name			
6B	Was the area you were in Rural, Peri-Urban, Urban or Very dense urban?	Rural .... Peri-Urban.................... Urban.................... Very dense urban	1 2 3 4	
6C	Were you in a flat/terrace, slightly sloped or steep place?	Flat .... Terrace .... Slight slope .... Steep	1 2 3 4	
5A	Where were you at the time of shaking?	Indoors .... Outdoors near a building.................... Outdoors near another structure .... Not in or near any structure	1 2 3 4	
5E	If you were with another household member during the earthquake, have questions 6B-23 already been answered?	Yes.................... No....................	1 → 2	24
6A	What type of building/structure were you IN, NEAR or AROUND at the time of shaking? ***Probe to know exactly what the primary purpose of the building was***	Single family house.................... Apartment or Condo building .... Hostel (of school, college, army) .... School/ college .... Shop .... Office .... Factory.................... Warehouse .... Temple.................... Health center or hospital.................... Mass gathering place, Cinema hall Tower (which people can climb) .... Bridge/Road .... No building/structure .... Other....................	1 2 3 4 5 6 7 8 9 10 11 12 13 14 96	 24
9A	How many floors were there in this building? ***Basement / G/1/2/3/4/…./attic*** ***Remember to count the basement and buigal (attic)***			
9B	How is the building in relationship to the nearest building?	Detached .... Very close.................... Touching.................... Don't know	1 → 2 3 8 →	9E 9E
9D	What was the position of the building?	Corner.................... Middle .... Don't know	1 2 8	
9E	Were there any shops or wide open places on the ground floor or storey?	Yes.................... No .... Don't know	1 2 8	

No.	Question	Response	Code	Skip to
10	Do you know roughly when the building was constructed?	<1934 1934-1988 1989-2010 2011-present Don't know	1 2 3 4 8	
11A	Is this your family's own building, or one that you know well?	Family building Well known building Not a well-known building	1 2 3	11C
11B	Was the building covered in plaster?	Yes No Don't know	1 → 2 8 →	19 19
11C	Had any measures been taken to strengthen the building?	Yes, Replaced heavy roof with lighter weight roof Yes, Shored walls Yes, Bracing added to walls Yes, Ring beams around building No Don't know Other	1 2 3 4 5 8 96	
12	Please identify the type of building or structure that you were in or near ***For MIXED buildings, select multiple***	Gārowālā Pillar wala Kath/Kachcha (wood/bamboo) Don't know	1 → 2 → 3 → 8 →	13A 14A 15 21
13A	If Gārowālā, what type of wall did it have?	Stone Mud Fired/baked brick Don't know	1 2 3 8	
13B	If Gārowālā, what type of mortar did it have?	Pakka (cement) Mato jodai (mud) Don't know	1 2 8	
13C	If Gārowālā (load bearing) ***Use flipchart diagram***	**Yes**	**No**	**Don't know**
	Were walls connected by bands?	1	2	8
	Was there a wood floor?	1	2	8
	Was there a lintel band?	1	2	8
	Was there a sill band?	1	2	8
	Was there a roof band?	1	2	8
14A	If Pillarwālā, how were the walls constructed? ***Use flipchart diagram***	Brick infill wall Block infill Stone infill Don't know	1 2 3 8	
14B	If Pillarwālā, did all beams go all the way around building? ***Use flipchart diagram***	Yes No Don't know	1 2 8	
14C	If Pillarwālā, did all columns go all the way from top to bottom? ***Use flipchart diagram***	Yes No Don't know	1 2 8	
15	If Kath, was it with mud?	With mud Without mud Don't know	1 2 8	
17	What was the roof type? ***Use flipchart diagram***	Dhalan wala (concrete) Jasta pata (CGI) Jhingati (tile) Dhunge chana (slate) Kar/babiyo (thatch) Terrace (dhalan concrete) Don't know	1 2 3 4 5 6 8	
18	What was the floor type?	Dhalanwala (RCC reinforced concrete slab)	1 2	

		Dhalan ra rod (reinforced concrete brick infill)... Kath/bamboo with mud (wood/bamboo)..... Mato/Mud... Don't know... Other...	3 4 8 96	
19	Which of these pictures best matches the damage level of the building that you were in or near? ***Use flipchart diagram***	None-slight... Light/moderate (repairable)... Moderate/Heavy (not repairable)... Very heavy... Total collapse... Don't know...	1 2 3 4 5 8	
20	Was there damage to any of the contents of the building? (eg: furniture, television, equipment)	No (none or very little)... Yes, some damage... Yes, lots of damage... Don't know...	1 2 3 8	
21	***If the person was indoors in Q5A*** Where were you indoors during the EQ?	Shop/store... Office... Factory... Temple or Mass assembly... Bedroom... Living room/salon... Kitchen... Toilet or Bathroom... Porch... Balcony... Buigal (attic)... Staircase... Barn... Cinema... Other indoor locations...	1 2 3 4 5 6 7 8 9 10 11 12 13 14 96	
22	***If the person was indoors in Q5A*** Which floor were you in?	Basement... Ground... 1st floor... 2nd floor... 3rd floor... 4th floor... Attic... Don't know (proxy)... Other...	1 2 3 4 5 6 7 8 96	
23	***If the person was outdoors or not in or near any structure in Q5A*** Where were you outdoors during the EQ?	Field/Farm... Road... Sidewalk... Square... Bus... Car... Motorbike... Bicycle... Outdoor assembly place... Forest... Don't know (proxy)... Other outdoor location...	1 2 3 4 5 6 7 8 9 10 98 96	
24	What were you doing just before the April 25th earthquake started?	Lying down... Standing up... Sitting down... Cooking... Bathing... Toileting... Walking... Running... Riding/Driving... Caring for children... Caring for animals...	1 2 3 4 5 6 7 8 9 10 11	

		Don't know (proxy)	98	
		Other	96	
25	When the shaking started, what was the first thing you did?	Stayed in same place	1	
		Sat down	2	
		Stood up	3	
		Moved	4	
		Tried to move but could not	5	
		Don't know (proxy)	98	
		Other	96	
26	Did you move at all while the ground was still shaking?	Yes	1	
		No	2	
		Don't know (proxy)	8	30
27	Where did you try to move?	Other people in the same room	1	
		Other people in the different room	2	
		Under furniture	3	
		Next to furniture	4	
		Downstairs	5	
		Upstairs	6	
		Outside	7	
		Inside	8	
		Balcony	9	
		Against wall	10	
		Corner	11	
		Under beam	12	
		Doorway	13	
		Other	96	
28	How far did you move? ***Probe from where to where.***	<1m	1	
		1-3m	2	
		4-10m	3	
		10-20m	4	
		>20m	5	
29	How did you move?	Walked	1	
		Ran	2	
		Crawled	3	
		Jumped	4	
		Other	96	
30	Did you take particular position during the shaking?	Drop, Cover, Hold on	1	
		Under bed	2	
		Next to strong furniture	3	
		Holding pillar	4	
		Doorway	5	
		Against wall	6	32
		Lie on the floor	7	
		Press floor with thumbs	8	
		Triangle of life*(only if they mention this phrase)	9	
		Other	96	
		Don't know (proxy)	98 →	34
31	If "Drop, Cover, Hold", what position was this?	On knees	1	
		Squatting	2	
		Other	3	
32	Could you please demonstrate ***Ask if they are willing***	....		
33	From where have you learned about what to do during shaking?	School teachers	1	
		School children	2	
		Red Cross	3	
		Junior Red Cross	4	
		Save the Children	5	
		NSET	6	
		Television	7	
		Radio	8	
		Internet	9	

		Posters	10	
		Parents	11	
		Government agency	12	
		Friends or relatives	13	
		Don't know (proxy)	98	
		Other	96	
34	Were you trapped at all (in either earthquake)?	Yes	1	
		No	2	
		Don't know (proxy)	8	37
35	For how long were you trapped? ***Only mention time in hours. If the answer is in days, convert into hours.***			
36	Who rescued you?	Self	1	
		People nearby	2	
		Professional rescuers	3	
		Don't know (proxy)	98	

Q.N.	Identification details	Response/Categories	Code	Skip
Structural and Non-structural causes of injuries and deaths				
37	Did you have any physical injuries, even minor cuts and bruises, as a result of the two earthquakes or aftershocks?	Yes... No ... Don't know... Don't know (proxy)...	1 2 8 98	 49
38	When were you injured?	During the April 25th EQ ... During May 12th EQ ... During an aftershock of the April/May EQ... Just after the April 25th or after May 12th EQ... During search and rescue ... During clean-up ... Other...	1 2 3 4 5 6 96	
39	What were you doing when you were injured?	Staying where I was... Drop, Cover and Hold... Going inside a building... Exiting building ... Running down stairs ... Waiting for search and rescue ... Waiting for medical aid... Caring for animals ... Don't know (proxy)... Other...	1 2 3 4 5 6 7 8 98 96	
40	How were you injured? ***Multiple answers possible.***	Cutting or piercing object... Struck by falling object... Stuck under a falling object ... Fire (burn) ... Fire (smoke inhalation) ... Falling ... Stampede (people) ... Jumping from window or balcony ... Exposure to heat or cold Submersion in water... Firearm or explosive Electrical current Transportation accident... Livestock Poisoning Self-inflicted Other...	1 2 3 4 5 6 7 8 9 10 11 12 13 15 16 17 96	

41	What were the objects that injured you?	***Structural element of the building***		
		Was not injured by structural elements	0	
	Probe to differentiate the elements	Wall	1	
		Column	2	
	Multiple answers possible.	Beam	3	
		Ceiling	4	
		Door	5	
		Roof	6	
		Staircase	7	
		Partition wall (light weight)	8	
		Balcony	9	
		Window	10	
		Non-structural element of the building		
		Was not injured by non-structural elements	0	
		Tiles, sinks, tubs	1	
		Lighting fixtures	2	
		False ceiling	3	
		Parapet/awning	4	
		Ladder	5	
		Porch roof	6	
		Pipes	7	
		Building contents		
		Was not injured by building contents	0	
		Low furniture	1	
		High furniture	2	
		Refrigerator or large appliance	3	
		Office or health center equipment.	4	
		Fan/ Heater / Cooler/ AC/ Water heater..	5	
		Factory equipment	6	
		Agricultural equipment	7	
		Hanging light	8	
		Standing lamp	9	
		Gumba (Prayer alcove) or statuary	10	
		Large TV	11	
		Small TV	12	
		Appliance	13	
		Hoarding board (signage)	14	
		Hot item	15	
		Picture frame (or glass)	16	
		LPG cylinder (canister)	17	
		Outdoor objects		
		Was not hit by outdoor objects	0	
		Grain stacks (Bhakari)	1	
		Hay stacks (kunyu)	2	
		Wood pile	3	
		Garden stakes (thankra)	4	
		Hording board (Billboard)	5	
		Electricity points	6	
		Electrical wires	7	
		Telephone/electrical poles	8	
		Telecommunications tower	9	
		Statuary or columns	10	
		Tree	11	
		Water tanks	12	
		Satellite dish	13	
		Animals	14	
		Other	96	
Injury severity				

42	What part(s) of your body was/were injured? ***Use flipchart diagram.***	Head Neck Face Shoulder Back Arms Hand/fingers Chest Abdomen Pelvis/Buttocks Legs Feet/Toes Don't know (proxy) Other	1 2 3 4 5 6 7 8 9 10 11 12 98 96	
43	What were your injuries exactly? ***Use flipchart diagram to distinguish between bruise, crushing injury, and injury to blood vessels.***	Fracture Dislocation Sprain Superficial injury (bruises and abrasions) Deep wounds (Open cuts/wounds) Head injury (blunt force trauma) Crushing injury Abdominal injury (spleen, liver, kidneys) Burns Poisoning Injury to spinal cord Facial injuries (cuts, broken nose…) Foreign body in eye, ear, nose, throat Dental injuries (teeth, jaw) Chest injury (lungs, sternum, collar bone) Amputation Don't know (proxy) Other (Specify)	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 98 96	
44	Did you seek any treatment for your injury?	Yes, immediately.. Yes, later.. No .... Not applicable (died immediately)…….	1 2 3 9	 49
45	Where did you seek treatment? ***Multiple answers possible.***	Local remedy.. Community response team .... Medical unit (polyclinic, private doctor, outdoor clinic).. Health clinic .... Public hospital... Private hospital .... Other	1 2 3 4 5 6 96	
46	If you went for treatment, how did you get there?	Walked by self .... Carried on foot by others....................... Bicycle .... Motorcycle .... Tuk Tuk... Bus.. Car .... Ambulance .... Helicopter……………………………..	1 2 3 4 5 6 7 8 9	
47	How long did it take you to get there?	Days: Hours: Minutes:		
48	Were you hospitalized/ in a rehabilitation facility or are still being hospitalized/ in a rehabilitation facility?	Was not hospitalized or in a rehabilitation facility .... Was hospitalized/ in a rehabilitation facility Still being hospitalized/ in a rehabilitation facility	1 2 3	→ 49 → 48A → 48B
48A	Approximately how many days were you there?	Days:		

48B	Enter date of hospitalization/ checking into a rehabilitation facility	Month (04-11): Day (01-31):	
48C	And enter today's date	Month (08-11): Day (01-31):	
49	What about emotional injuries? Would you say that you had any emotional injuries- even minor ones like feeling sad, worried, nervous/anxious, and irritable- as a result of this earthquake?	Yes 1 No 2 Don't know (proxy) 8 Not applicable (died immediately) 9	55
50	How would you describe the emotions that you felt for more than a month, or that you continue to feel?		
51	What impacts have these had on your work, study or family life or relationship?	None 1 Some impact. 2 Moderate impact 3 Severe impact 4	
52	Do you feel that your symptoms are:	Already better 1 Slowly getting better 2 Staying the same 3 Getting worse 4	
53	Did you seek any help for these emotional effects?	Yes 1 No, but planning to 2 No, **not** planning to 3 →	55
54	If so, where did you/will you seek help? ***Multiple answers possible.***	Self-help 1 Family member(s) 2 Friend(s) 3 Spiritual advisor (eg: priest, guru) 4 Medical provider 5 Mental health provider 6 None 7 Other 96	

Mitigation, Preparedness and Response level

55 These are some of the things that people have been told to do during an earthquake. **If you were indoors,** please consider each of the following items and identify first whether it would have been possible for you to take any of these actions, and second, would it be safe?

		Possible					**Safe**				
	Actions	**Yes**	**No**	**Don't know**	**Don't know** (proxy)	**Not applicable**	**Yes**	**No**	**Don't know**	**Don't know** (proxy)	**Not applicable**
55A	Run outside to safe place within 5 seconds	1	2	8	98	99	1	2	8	98	99
55B	Run outside to safe place within 10 seconds	1	2	8	98	99	1	2	8	98	99
55C	Run outside to safe place within 15 seconds	1	2	8	98	99	1	2	8	98	99
55D	Drop cover and hold under a sturdy table or desk	1	2	8	98	99	1	2	8	98	99
55E	Drop cover and hold where you are / were	1	2	8	98	99	1	2	8	98	99
55F	Lie down next to table or desk	1	2	8	98	99	1	2	8	98	99
55G	Lie down next to a sofa or hard pieces of furniture	1	2	8	98	99	1	2	8	98	99
55H	Stay in bed (If you had been there at that time)	1	2	8	98	99	1	2	8	98	99
55I	Stand in strong doorway	1	2	8	98	99	1	2	8	98	99
55J	Stand by inner wall or pillars	1	2	8	98	99	1	2	8	98	99
55K	Move to safer home	1	2	8	98	99	1	2	8	98	99

Ask only to the household head (or acting household head)				
56	Is the SUBJECT the household head OR acting household head? ***Do not need to ask; check from the roster***	Yes No Acting household head	1 2 → 3	 62
56A	Do you remember whether your community had any awareness or training program for disaster risk reduction and preparedness?	Yes No	1 2 →	 56C
56B(1)	If so, did you or another household member participate?	Yes, just one adult household member participated Yes, more than one adult household member participated Yes, both adult(s) and child/ children in our household participated Only child/children participated No	1 2 3 4 5	
56C	Do you know if your children's school had any awareness or training program for disaster risk reduction and preparedness?	Yes No Not applicable	1 2 9	 58
56B	If you know the name of the organization that led this program, please specify: (School's name, NRC, NSET, Plan International, Save the Children, UNICEF, UNDP ...)			
57	If so, did you or another household member participate?	Yes, just one adult household member participated Yes, more than one adult household member participated Yes, both adult(s) and child/ children in our household participated Only child/children participated No	1 2 3 4 5	

58	What kind of preparedness measures had you taken before the April 2015 earthquake?	**Measures taken before EQ**	**If done, was it useful or effective?**	**If not done, would it have been useful or effective?**
	Actions	**Yes (1) No (2) Don't know (8) Not Applicable (9)**	**Yes (1) No (2)**	**Yes (1) No (2)**
58A	Have a family safety plan at home	1 2 8 9	1 2	1 2
58B	Have emergency/disaster plan at work	1 2 8 9	1 2	1 2
58C	Have emergency/disaster plan at school	1 2 8 9	1 2	1 2
58D	Building strengthening measures [reftrofit]	1 2 8 9	1 2	1 2
58E	New construction for hazard resistance	1 2 8 9	1 2	1 2
58F	Secure tall furniture or equipment	1 2 8 9	1 2	1 2
58G	Learn first aid	1 2 8 9	1 2	1 2
58H	Learn how to put out small fire	1 2 8 9	1 2	1 2
58I	Learn how to organize post-disaster response	1 2 8 9	1 2	1 2
58J	Flashlights	1 2 8 9	1 2	1 2
58K	First aid kit	1 2 8 9	1 2	1 2
58L	Extra batteries	1 2 8 9	1 2	1 2
58M	Store water	1 2 8 9	1 2	1 2
58N	Store food	1 2 8 9	1 2	1 2
58O	Battery-operated radio	1 2 8 9	1 2	1 2

58P	Emergency kit and tools	1 2 8 9	1 2	1 2	
58Q	Community or school level Hazard, Vulnerability and Capacity Assessment.	1 2 8 9	1 2	1 2	
58R	Moved to safer home	1 2 8 9	1 2	1 2	
58S	Other	Yes... No		1 2 →	59
58S(1)	Please specify				
58S(2)	Was it useful or effective OR would it have been useful or effective?	Was useful/effective Would have been useful/ effective		1 2	
57B	What was the reason for you or your family not taking any steps to prepare for an earthquake?	I didn't know what to do.......................... I didn't think it would make a difference...... I couldn't afford to.................................... I didn't have time / I meant to but didn't get around to it.. It didn't seem important.......................... I didn't believe it was a threat............... I'm too old / too young / not capable / disabled It is god's will whether we live or die, preparedness doesn't matter Others (specify)		1 2 3 4 5 6 7 8 96	
59	What kind of preparedness measures have you considered or taken since the April and May earthquakes? ***Note: Skip to Q61A if the respondent answers not taking any preparedness measures.***	**Measures taken since the earthquake** Yes, measure taken=1 Yes, intend to take this measure=2 No, do not intend to take this measure=3 Not applicable=9			
59A	Have a family safety plan at home	1 2 3 9			
59B	Have emergency/disaster plan at work	1 2 3 9			
59C	Have emergency/disaster plan at school	1 2 3 9			
59D	Building strengthening measures [reftrofit]	1 2 3 9			
59E	New construction for hazard resistance	1 2 3 9			
59F	Secure tall furniture or equipment	1 2 3 9			
59G	Learn first aid	1 2 3 9			
59H	Learn how to put out small fire	1 2 3 9			
59I	Learn how to organize post-disaster response	1 2 3 9			
59J	Flashlights	1 2 3 9			
59K	First aid kit	1 2 3 9			
59L	Extra batteries	1 2 3 9			
59M	Store water	1 2 3 9			
59N	Store food	1 2 3 9			
59O	Battery-operated radio	1 2 3 9			
59P	Community or school level Hazard, Vulnerability and Capacity Assessment.	1 2 3 9			
59Q	Move to safer home	1 2 3 9			
59R(a)	Are there any other preparedness measures you took or intend to take?	Yes .... No		1 2 →	60
59R(b)	Please specify any other preparedness measure and state whether you have taken the measure or intend to take the measure				

60	Where did you learn about the preparedness activities that you have taken or intend to take?	TV	1	
		Radio	2	
		Newspaper	3	
		Internet/Social Media	4	
		Friends/Family	5	
		At school/college	6	
		At work/ from colleagues	7	
		Red Cross	8	
		Government	9	
		Another NGO or community-based organization	10	
		Other (specify)	96	
61	Are you planning to take these measures? (Mentioned above)	Yes	1	
		No	2	
		Maybe	3	
60A	What else do you think would have been useful?			
61A	***Note: Only ask this question if the respondent has not taken any measures in Q59.*** If you have not taken any risk reduction or preparedness measures after the earthquake, what is the main reason? (select one)	I am too busy	1	
		I don't think it would make a difference	2	
		I couldn't afford to	3	
		I don't want to	4	
		I don't know what to do	5	
		I am already prepared enough	6	
		I'm too old / too young / not capable / disabled	7	
		It is god's will whether I live or die, preparedness doesn't matter	8	
Now I would like to ask some final questions about you and your family.				
62	What is your marital status?	Never married	1	
		Married	2	
		Widowed	3	
		Divorced	4	
63	What caste/ ethnicity do you belong to?	Kshettri	1	
		Brahmin	2	
		Newar	3	
		Gurung	4	
		Magar	5	
		Tamang	6	
		Kirant	7	
		Sanyasi	8	
		Sherpa	9	
		Limbu	10	
		Madeshi	11	
		Rai	12	
		Tibetan	13	
		Dalit	14	
		Prefer not to say	15	
		Other	96	
64	What is your current occupation	Self-employed	1	
		Work in home	2	
		Employed	3	
		Student	4	
		Not employed	5	
65	What is your highest education level attained?	Below primary	1	
		Primary	2	
		Secondary	3	
		College	4	
		University	5	
Ask Q66 – Q74 only if the respondent is the household head (or acting household head) and their situation BEFORE the April earthquake				

66	Main source of family income?	Government employee Service worker employee (incl. NGO) Tourism employee Business/Shop Farming/Livestock Foreign employment Fisherman Trades Skilled daily wages Unskilled daily wages (incl. porter) Guide Other	1 2 3 4 5 6 7 8 9 10 11 96	
67	Do people in your family own any land?	Yes No	1 2	
67A	Do you feel that your socio-economic level has increased, decreased or stayed roughly the same since the earthquake?	Increased………………………….. Decreased………………………… Stayed roughly the same………… Don't know (proxy)……………….	1 2 3 98	
68	What is the main source of drinking water in your house?	Piped into dwelling………………… Piped to house compound………. Public tap/standpipe……………… Rain water………………………… Spring water ………..…………….. River/dam/lake/pond/stream/canal/irrigation channel ………………... Stone tap/source water …………. Other (specify) …………………….	1 2 3 4 5 6 7 96	
69	What is the main toilet facility used by your household? (**One** only) ***Enumerators should observe***	Flush to piped sewer system ……. Flush to septic tank……………….. Pit latrine with slab ………………. Pit latrine without slab/open pit….. Composting toilet ………………… Bucket toilet……………………….. No facility/bush/field……………… Other (specify) …………………….	1 2 3 4 5 6 7 96	
69A	Does your household have the following things? *(Please observe also)*	**Yes**	**No**	
69B	Electricity	1	2	
69C	Solar	1	2	
69D	Radio	1	2	
69E	Television	1	2	
69F	Refrigerator	1	2	
69G	Mobile Phone	1	2	
69H	Telephone (Other than Mobile Phone)	1	2	
69I	Sofa	1	2	
69J	Cupboard *(Daraj)*	1	2	
69K	Computer	1	2	
69L	*Dhiki/Jato*	1	2	
69M	Bicycle	1	2	
69N	Motorcycle	1	2	
70	Four wheeler	1	2	
71	What types of cooking fuel do you use? *(multiple responses are possible)*	Firewood…………………………… Kerosene…………………………… Gas cylinder……………………….. Bio-gas…………………………….. Electricity…………………………… Other specify………………………	1 2 3 4 5 96	

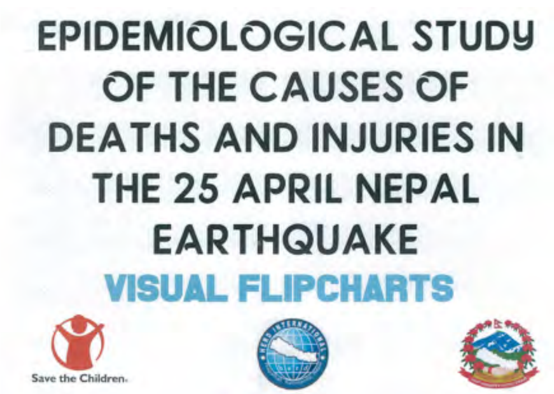
72	What is the major material used in the floor of the house?	Covered with clay/dung…..………… 1 Parketing colored wood………….. 2 Simple non colored wood……….. 3 Tile/Marble………………………… 4 Cement…………………………….. 5 Other (Specify)…………………….. 96	
73	What is the major material used in the roof of the house?	Thatch/palm leaf/reed/grasss…… 1 Bamboo…………………………… 2 Planks/wood……………………….. 3 Tiles/stones………………………. 4 Tin/Metals………………………….. 5 Calamine/cement fibre…………… 6 Cement Dhalan…………………… 7 Other (Specify)…………………….. 96	
74	What is the major material used on the walls of the house?	Cane/Palm/trunks/Bamboo……… 1 Burnt brick and clay……………… 2 Unburnt brick and clay…………… 3 Bamboo and clay………………….. 4 Stone and clay…………………….. 5 Plywood…………………………… 6 Brick and Cement…………………. 7 Stone and cement………………… 8 Cement Block……………………… 9 Other (Specify)…………………….. 96	

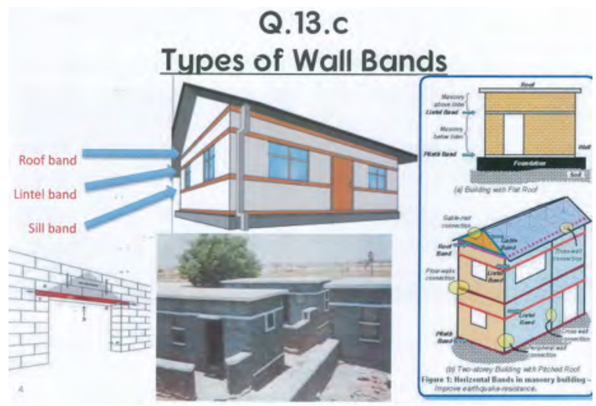
Please share the information package with the family.

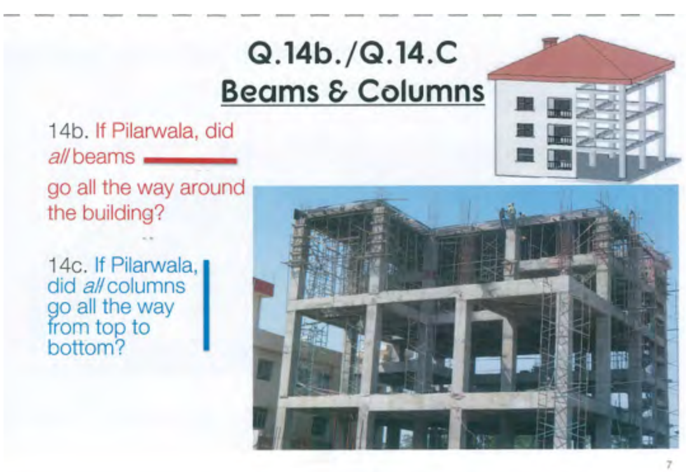
Appendix #9: Survey Visuals Flipchart – Sample pages

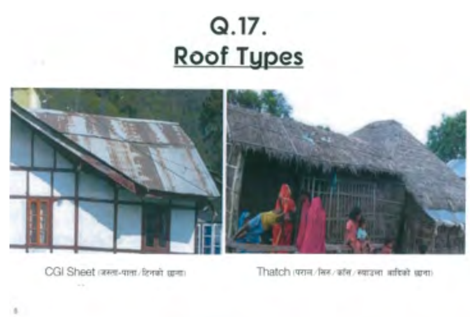
Enumerators carried with them a flipchart of visual references in order to support accuracy in answering questions about:

1. Construction type
2. Building damage level
3. Part of body injured
4. Minor injuries vs. crush injuries



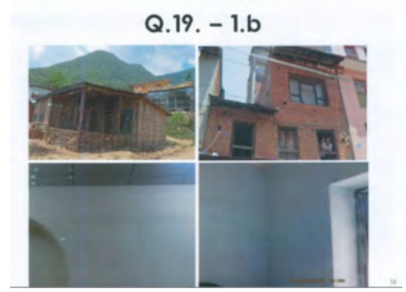




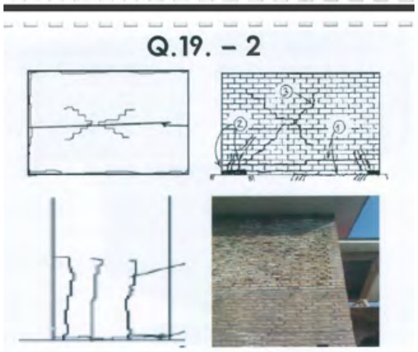



Q.19. Building damage levels for quick selection
1
कति पनि क्षति नभएको वा एकदमै कम क्षति भएको
(० - १%)
2
हल्का/मध्यम (मर्मत गर्न मिल्ने)
(१ - ३०%)
3
मध्यम/धेरै (मर्मत गर्न नमिल्ने
(३० - ६०%)
4
निकै क्षति भएको
(६० - १००%)
5
पूर्ण रुपमा ध्वस्त भएको
(१००%)

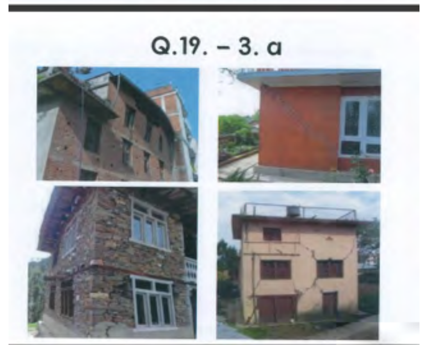

Q.19. – 1.a


Q.19. – 1.b


Q.19. – 2:B


Q.19. – 2


Q.19. – 3


Q.19. – 3. a

Q.19. – 3. b

Q.19. – 3. c

Q.19. – 4

Q.19. – 4.a

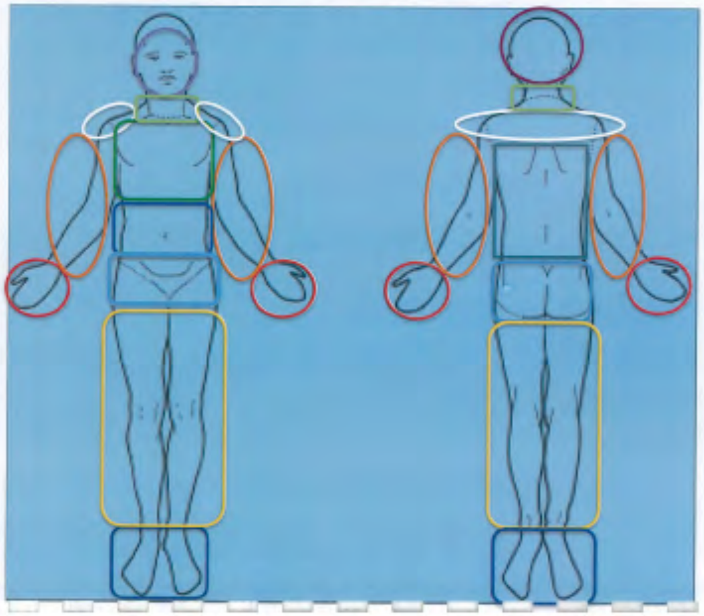
Q.19. – 4.b

Q.19. – 4.c

Q.19. – 5

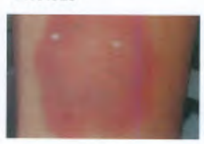
Q.19. – 5.a

Q.42.
Parts of body injured



Q.43.
Superficial and Crushing Injuries

BRUISES



SCRATCH

ABRASION

CRUSHING INJURIES

SUPERFICIAL CUT

39