RESEARCH REPORT – EXECUTIVE SUMMARY & RECOMMENDATIONS: CAUSES OF DEATHS AND INJURIES IN THE 2015 GORKHA (NEPAL) EARTHQUAKE

Causes of Deaths and Injuries in the 2015 Gorkha (Nepal) Earthquake : Executive Summary & Recommendations

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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.

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

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.