



Resource mapping during a natural disaster: A case study on the 2015 Nepal earthquake



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ABSTRACT

Any major natural disaster, such as an earthquake, is accompanied by an urgent need for various types of resources in the disaster-affected region, which primarily includes medical resources, human resources, and infrastructural resources. How quickly this need for resources can be satisfied might critically determine the extent of damage and human casualties in the aftermath of the disaster. Hence, knowledge about what type of resources are usually needed in the aftermath of a disaster is important for responding organizations for planning formative solutions, to be better prepared to mitigate any upcoming disaster. The goal of this study is to curate the resource needs during a major disaster – the earthquake in Nepal and parts of India in April 2015. This work has been carried out in association with Doctors For You (DFY), a humanitarian organization of medical professionals who work in various disasters-affected regions. A large set of WhatsApp messages exchanged among DFY members who were working in the disaster-affected areas of Nepal was collected and analyzed to identify the different resource requirements and the corresponding delay in the mobilization of such resources. The study revealed detailed phase-wise requirement of various types of resources and also suggested that for several resources, there was a significant delay between the requirement and the actual availability of the resources. The acumens from this study will not only help disaster risk management in Nepal but also help in preparedness planning in other earthquake-prone regions of the world.

1. Introduction

The recent years have seen several major natural disasters such as earthquakes, floods, and hurricanes in various regions of the world. Any major natural disaster is accompanied by an urgent need for various types of resources in the disaster-affected region, such as medical resources (e.g., medicines, surgical instruments), human resources (e.g., doctors and nurses) and infrastructural resources (e.g., tents, alternative sources of electric power). How quickly such needs for resources can be satisfied might critically determine the extent of damage and human casualties in the aftermath of the disaster. Especially, for disasters in developing regions of the world, minimizing the delay in meeting resource requirements can go a long way towards controlling the effects of the disaster.

One potential way to efficiently meet the urgent resource

requirements in the aftermath of a disaster is to learn from prior disasters and develop knowledge about what type of resources are usually needed in the aftermath of a disaster. Such knowledge can help government agencies and other responding organizations for planning formative solutions, to be better prepared to mitigate any upcoming disaster. The present study aims to curate such knowledge through a case study on a major disaster in recent times.

On April 25, 2015, a severe earthquake struck Nepal with a magnitude of 7.8 M_w (Moment Magnitude scale). The devastating earthquake (also known as the *Gorkha Earthquake*), killed nearly 9000 people, injured almost 22,300 people and left more than 80,000,00 people in desperate need of assistance [27]. Furthermore, around 7,55,549 residential buildings, 4000 government offices, and 8200 school buildings were damaged due to this earthquake [27]. The earthquake shattered numerous susceptible portions of the country's

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infrastructure and debilitated the local health care system and social welfare institutions. Hence, the Nepalese government issued an urgent request for urban search and rescue (USAR) teams, foreign medical teams (FMTs), emergency shelters, and other life-saving assistance from the global community [1]. Afterward, several UN Organizations and international non-Governmental Organizations (NGO) like WHO, UNICEF, QRCS, CISAR and others moved to Nepal to provide humanitarian assistance.

Doctors For You (abbreviated as DFY) was one of the NGOs, actively involved in the relief operations in the aftermath of the Nepal earthquake. DFY is a pan-India humanitarian organization with international presence that focuses on providing medical care to the vulnerable communities during crisis and non-crisis situation [22]. DFY operated in the earthquake-struck regions of Nepal from April 27 to November 26, 2015. Some of the members of this team were involved in the ground activity in Nepal while the other members stayed at their home station in India, planning for resource deployment and other associated works [2]. The members of DFY formed a WhatsApp group to communicate among themselves and plan the relief operations. In this study, we analyze the WhatsApp messages exchanged among the medical personnel of DFY.

The data of WhatsApp messages exchanged among DFY personnel is a rich repository of both temporal and spatial information reported from the earthquake-struck regions of Nepal, and contains valuable information on what resources were required, how long it took to meet the resource requirements, what problems were being faced by the rescue workers, and so on. This data comprises discourse among medical experts. Accordingly, it contains a noteworthy amount of micro-level information about the requirement and availability of different medical resources (including various types of medicines and medical infrastructure). In analyzing this data, we address the following research questions:

1. What resources are usually required in the aftermath of an earthquake?
2. Considering that the post-disaster relief operations have various temporal phases, what resources are required at what points of time?

In our present study, we attempt to address the aforementioned questions taking the 2015 Nepal Earthquake as a case study. Additionally, we have also calculated the delay in mobilizing various resources after the Nepal earthquake.

Though there have been several prior attempts to analyze resource requirements during disaster events (as discussed in Section 2), to our knowledge, no prior study has reported the requirement of resources, especially medical resources, in such detail as we do in this study. Further, since the data analyzed in this study was posted by medical experts who were actually present in the disaster-affected region, the insights obtained from the data are trustworthy and authoritative and can be reliably used to formulate strategies for coping with future disaster events.

Overall, the motivation of this study is to provide guidelines to government and non-government organizations about the requirements in the aftermath of an earthquake, which might help in better preparedness and resource mapping during future disaster events. Moreover, this study demonstrates that, if closed-group conversations among members of different responding agencies are collected and analyzed in real-time (i.e., during the disaster itself), such analyses can help in taking crucial and dynamic decisions regarding resource mobilization and allocation in an optimal way.

2. Related work

Different research communities including medical experts, urban scientists, computer scientists, etc. have carried out extensive research

on preparedness planning and hazard mitigation strategies in the area of disaster management. Out of these, most of the studies by medical experts and urban scientists have mostly depended on user surveys and user-experiences [7–13]. Hence, the amount of information analyzed in aforementioned studies is often limited by various human factors (e.g., how much detail the relief workers remember at the time of the survey).

However, in today's society, we are globally connected through the Internet such that disaster managers in all countries can be benefited from the use of crowdsourcing through various social media platforms [26]. Social media data has been used by computer scientists for extracting situational information during disaster events [14–18]. For instance, several recent studies have utilized thousands to millions of microblogs posted on the popular Twitter social media (twitter.com) for extracting situational information. The amount of information analyzed in these studies is huge, but the data obtained from social media is mostly noisy and too unreliable to formulate future strategies. The combined use of social media and Social Media Analysis Tools (SMAT) can increase the effectiveness of their social media on disaster preparedness and disaster risk reduction. However, there are several issues associated with the selection and use of SMAT like the language of the user, social media data, and SMAT interface, the cost of the tool and much more [24]. Moreover, it poses a huge challenge in identifying the most significant information to protect human lives from these social media posts [23].

In contrast to the prior studies, the present work relies on social media (WhatsApp) data crowd-sourced from medical experts who were actually present at the site of the disaster. Hence the data is much more reliable (e.g., compared to data obtained from public social media like Twitter), and contains a detailed description of resource requirements, as observed by the DFY members during the relief operations. To the best of our knowledge, no prior study has reported the requirements of resources after a disaster event, and the time frame within which these requirements were addressed, in such diminutive details as in this study.

Further, there have been few prior studies on various aspects of the relief operations after the 2015 Nepal earthquake. For instance, Yang et al. [3] focused on the medical rescues by CISAR (China International Search & Rescue Team) in Nepal. The rescue and treatment of pediatric patients by the Chinese Red Cross medical team during the Nepal earthquake has been analyzed by Wang et al. [4] Few studies have also been conducted on identifying damage patterns (e.g., damage to buildings) to reduce the future earthquake risks in Nepal [5,6]. Another study on the 2015 Nepal Earthquake indicates strong governance and political will plays an important role in disaster risk reduction efforts at the national level [25]. Nevertheless, these prior studies have neither used WhatsApp chat logs nor reported the medical resource requirements and the delay in addressing the requirements, which is the primary contribution of the present work.

3. Methodology

This section describes the data analyzed in this study, and the methodology adopted for cleaning and analyzing the data. On April 27, 2015 (two days after the earthquake struck Nepal) the members of DFY formed a WhatsApp group for intra-organizational interactions. Around 35 individuals contributed to this group and approximately 3500 messages were posted during the first 3 months after the disaster, i.e., from April 27 to July 30, 2015. These messages were collected and analyzed by us. All the messages were in English and have varying length. The average length of the messages was calculated as 7 words. Each message includes the mobile number from which the message was posted, the timestamp when the message was posted, and the message text.

The flow of our work is illustrated in Fig. 1. The set of messages was initially cleaned and pre-processed by scripts written using the Python programming language. The images and videos shared during the

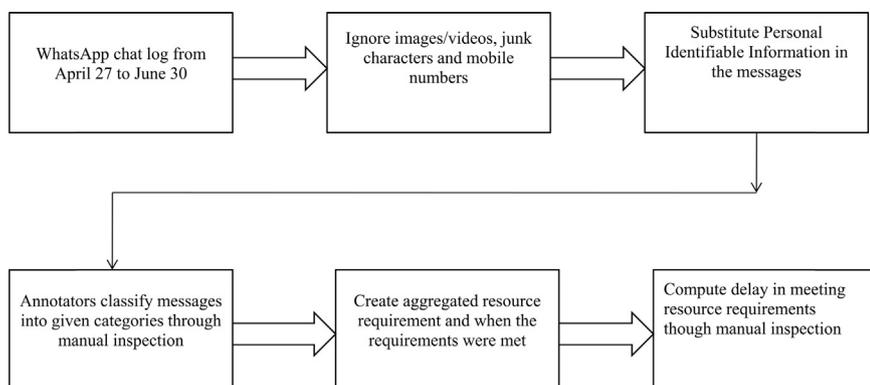


Fig. 1. Steps Involved in the Proposed Work.

conversations were ignored, and we focused on the textual content of the messages. Personal Identifiable Information (PII) in the messages was replaced to conserve the privacy of the DFY members, e.g., the mobile numbers were substituted by a common < Mobile > tag, and names of members (if any) in the message text were substituted by identifiers.

The sanctified set of messages was then given to three human volunteers for annotation. The annotators are graduates having proficiency in English language and have prior experience of annotating documents related to disaster situations. The volunteers were first instructed to identify the various types of information contained in the messages, and then classify the messages into different categories according to the type of information contained in individual messages. The volunteers identified the presence of the following five categories of information: (1) Requirement of resources (2) Potential availability of resources from outside Nepal (3) Information about resources being available within Nepal, (4) Grievances and problems being experienced by the members who were at the disaster-struck areas in Nepal, and (5) Non-Situational messages which typically do not contain any kind of situational information about resources or problems (e.g., personal messages, conversational content). Some examples of different categories of messages and the number of pertinent messages in each category are illustrated in Table 1.

Furthermore, the annotators also noted that most of the messages were related to three types of resources, namely (i) medical resources, such as medicines and surgical equipment, (ii) infrastructure resources, such as tents and generators for setting up make-shift hospitals, and (iii) human resources, like doctors and nurses.

Next, the volunteers were again asked to study the messages categorized as (1) Requirement of resources, and (3) Availability of resources within Nepal, and to estimate the delay in availability of the resources. Corresponding to the initial request for a particular resource, say Ventilators (e.g., *Ventilators & Digital X-rays needed for Hospitals*), the

volunteers inspected each message in the category (3) to check for first actual availability of that resource within Nepal (e.g., *Forth truck with Xray machines n Clean delivery kits crossed the border. It will reach Kathmandu by evening today*). Then the time gap between the initial request and the first actual availability of the resource is computed using the timestamp information of the messages. Some examples of such matching request and availability messages are demonstrated in Table 2.

3.1. Temporal phases of disaster relief

As stated earlier, one of the objectives of this work is to analyze the temporal aspects of the resource requirements, such as what resources are required at what stage of the relief operations. Various nomenclatures are used to designate different phases of disaster recovery. For example, several UN agencies recognize stages of disaster relief as Acute phase (4–6 weeks), Transition phase (6–12 weeks) and Rehabilitation phase (after 3 months). For this study, the guidelines set down by the American Red Cross are followed [19], which recognizes that during the first 3 months after a disaster, the relief operations transit through the following (overlapping) stages: *Heroic Phase* (that occurs immediately after a disaster strikes), *Honeymoon Phase* (from about a week to six months after the disaster), and *Disillusionment Phase* (that begins couple of months after the disaster). In this study, the timeline of requirements and availability of resources are analyzed in terms of these phases identified by the American Red Cross.

3.2. Limitations of the study

It should be noted that the WhatsApp messages analyzed in this study were *not* primarily meant to report the requirement/availability of resources. Rather, the primary motivation of the WhatsApp conversations was intra-group communication among the DFY members.

Table 1
Example of some WhatsApp messages corresponding to different categories, and number of messages in each category (as identified by annotators).

Category	Example Messages	Number of Messages
Requirement of resources	Water purifier and chlorine tablets needed immediately We need Physiotherapy n Occupational therapist also....as reflected in WHO report	82
Potential availability	< Mobile > DrUrmi Physiotherapist from Mumbai sunny include her in roster she is ready to move for 1month period Tents are available in Delhi. Sai Tents & Exports, New Delhi Contact no- < Mobile > < Mobile >	55
Information about resources being available within Nepal	10 filters in trisuli hospital n six filters in field hospital Forth truck with Xray machines n Clean delivery kits crossed the border. It will reach Kathmandu by evening today	58
Grievances and problems	Heavy rains n storms destroyed our camp n roads are also bad now. We have to decide our strategy for coming monsoon. We hv to do one Skype call or hangout tonight at 10 pm. Only problem is electricity.since 4 days	53

Table 2
Example of some resource request messages and corresponding matching availability messages identified by the annotators.

Resource Name	Request Message	Actual Availability Message
X-ray	Ventilators & Digital X-rays needed for Hospitals	Forth truck with Xray machines n Clean delivery kits crossed the border. It will reach Kathmandu by evening today
Water purifier/filter C-arm	Water purifier and chlorine tablets needed immediately ... if we place the order for C-arm tomorrow morning then how long it will take in delivery at Delhi	10 filters in trisuli hospital n six filters in field hospital C-Arm Machine reached katmandu. It is at Thapathali. Have to get clearence from them.

Hence, the DFY members did not explicitly write about some facts that were possibly obvious to all members from the context, such as exact location of different members. These observations are missing in our analysis. Specifically, since the location of the DFY members were not known, a spatial analysis could not be performed.

Also, the observations made in this study are limited to the information contained in the messages exchanged among the DFY members, and do *not* reflect an exhaustive picture of the relief efforts in the aftermath of the Nepal earthquake. For instance, since DFY is based in India, the members reported most of the potential availability of resources from places in India (where presumably they have most of their contacts) and not from other countries. Hence, the observations in this study should be considered as indicative, and not exhaustive.

Nevertheless, the WhatsApp conversations analyzed in this study have a large amount of detailed information, from which the requirement and availability of various types of resources could be inferred. We believe that the observations stated in the subsequent sections have ample scope to help improve disaster preparedness and mitigation strategies in future.

4. Phase-wise requirement and availability of resources

We commence with the phase-wise requirements and availabilities of the three types of resources, namely, medical resource, human resource, infrastructure resource. We have considered two facets of availability – (i) *potential availability* (i.e. reports of some resource being potentially obtainable from outside Nepal, or being despatched from outside Nepal), and (ii) *actual availability* (i.e. reports of some resource

being actually available within Nepal). Tables 3–5 exemplify the requirements of the three types of resources and their potential and actual availabilities in the different phases of the relief operations. From these tables, it can be understood which resources were needed within the first seven days after the earthquake and which resources were needed at later points of time. Additionally, it can be seen from the tables what resources were potentially available at different phases in the timeline, and what time lag was there between the requirement and actual availability of different resources.

It can be noted that some of the resources occur both as required and available during the same phase. This is because, while the resources had become available at some location within Nepal, it was still unavailable (required) at some other locations. Also, the potential availability of most of the resources is indicated from places in India – this is probably because the DFY members have most of their contacts in India.

4.1. Medical resources

Since the conversations analyzed in this study were among medical personnel, it is intuitive that most of the information will be about medical resources, such as medicines, surgical instruments, etc. (illustrated in Table 3). While reporting the medical requirements, instead of specifying exact brand names of medicines, we have classified the medicines considering the essential medicine classification of the World Health Organization [20,21]. Further, for generic medicines and support infrastructure, some supplementary classifications have been introduced in discussion with DFY members.

Table 3
Timeline wise classification of medical resources.

Time Line	Requirements	Potential Availability (From outside Nepal)	Availability (Within Nepal)
Heroic Phase April 28–May 03	Anesthetics, Oxytocics and Antioxytocics, Medicines affecting the blood, Ventilators, Spinal needles, Cord clamps, Labor room equipment, Supplementary foods, Digital X-rays, Implants, Surgical appliances, Water purifier/filter	From India: Vitamins and Minerals, Anti-Infective Medicines, Reproductive Health Kits, Implants, Implants Fixator, Plasters, generic medicines (Mumbai) Location unidentified: Ventilators, Digital X-Ray, consumable drugs and implants (through Direct Relief, USA)	Makeshift / mobile hospitals, Tent for open field OPD
Honeymoon phase May 04–May 31	Anti-Infective Medicines, Gastrointestinal Medicine, Medicines affecting the blood, Vitamins, and Minerals, Disinfectant, Medicines for diseases of joints, ambulances, telemedicine, Muac strip, Baby food, Ortho equipment, Ventilators, C-Arm Machine	From India: Medicines(Mumbai), Stethoscope(Delhi), BP App and Glucometers (Delhi), Ventilators, implant, X-ray machine, Telemedicine Unit (Madurai)	Anti-Infective Medicines (e.g., IV Fluids), Medicines Affecting The Blood (e.g., iron supplement), Disinfectants (e.g., chlorine tablets), Delivery kits, Gastrointestinal Medicine (e.g., ORS), Ventilators, Water Filters, Stethoscope, BP App, Field Nurse, Psychosocial care and support units, Field Hospital
Honeymoon + Disillusionment Phase June 01–July31	Gastrointestinal Medicine, Anti-Infective Medicines, Hygiene, Dressing & Delivery Kits, Inhalers, Dermatological Medicines (topical), First aid kit, Medicines affecting the blood, Antiallergics, Medicines for pain and palliative care, Post-traumatic stress disorder medicine, Delivery and Preterm Infants Care Unit, Vitamins & Minerals, Cough Syrup, BP apparatus, Zytee Gel, Glucometers, head torch	From India: C-Arm Machine (Delhi)	Water Filters, ECG machine, head torch, Stethoscope, BP App Glucometers, C-arm

Table 4
Timeline wise classification of human resources.

Time Line	Requirements	Potential Availability (From outside Nepal)	Availability (Within Nepal)
Heroic Phase April 28–May 03	Gynecologists, Anesthesiologists, Emergency Medicine Specialists, Physiotherapists, Orthopedic surgeons, and consultants, Occupational Therapists	From India: Orthopedic surgeons, Anesthetists (Pune), Physiotherapists (Mumbai), Emergency medicine Specialists (Delhi), Orthopedic consultants (Pune)	Emergency staff, public health team, Gynecologists, Paramedics, Nurses, field hospital staff
Honeymoon phase May 04–May 31	Physiotherapists, Anesthesiologists, Psychologists, Gynecologists	Location unidentified: Psychologists	Emergency Medicine Specialists, Gynecologists, Trauma Counselors, Field Nurses
Honeymoon + Disillusionment Phase June 01–July 31	Emergency medicine specialists, Nurses, MBBS Doctors, Support Staff, Pediatricians, Gynecologists, Anesthetists	From India: Pediatricians (Mumbai) Location unidentified: Orthopedic specialists, Gynecologists	Nurses, Mental Health Team, Gynecologists

Table 5
Timeline wise classification of infrastructure resources.

Time Line	Requirements	Potential Availability (From outside Nepal)	Availability (Within Nepal)
Heroic phase April 28–May 03	Tents, GPS Device, Generators in hospitals	From India: Tarpaulin sheets, Tents (Delhi), GPS device (Delhi) Location unidentified: Tents distributed by private group	Few tents
Honeymoon phase May 04–May 31	Drinking water, alternative power resources, power banks		Few tents (OPD and normal)
Honeymoon + Disillusionment Phase June 01–July 31	Toilets, Cooking supports lacking, Sleeping Bags	From India: power banks (Delhi)	

Throughout the heroic phase (immediately after the earthquake), there was a huge requirement of appliances primarily associated with surgical support and orthopedics like x-ray, implant, implant fixator, plasters, spinal needles, and anesthetics. Moreover, "Anti-Infective-Medicines" were also required for quick recovery of surgical patients.

Also, during the Heroic and Honeymoon phases, resources like cord clamps, labor room equipment, "Oxytocic and anti-oxytocic" were in demand for ante-natal care, safe delivery and post-partum care of pregnant women. According to UNICEF, three-fourths of the pregnant women in Nepal were anemic, therefore, the necessity of "Medicines affecting the blood", i.e., drugs like Iron-folic acid tablets and calcium tablets were essential to avert maternal deaths. The demand of ventilators was also manifest, especially in Heroic Phase, as a large number of trauma patients from several earthquakes affected regions of Nepal were in need of ventilator support at tertiary care hospitals.

In the Honeymoon Phase, infection of the skin, gastrointestinal tract, and respiratory tract were the common ailments. Thus the requirement of "Anti-Infective Medicines", "Gastrointestinal Medicines" and "Inhalers" was evident. Moreover, due to multiple aftershocks, major water bodies were contaminated. Consequently, "Disinfectants" like chlorine tablet or chlorine solution were needed to disinfect the water to prevent the apparent spread of diarrhoeal diseases.

A couple of months after the disaster, in the Disillusionment Phase, several *aftershock earthquakes* struck Nepal. Therefore, First Aid kits and "Medicines for Pain and Palliative Care" were still in demand for dealing with fresh injuries due to aftershocks. Moreover, "Post-traumatic Stress Disorder Medicines" were entailed to improve the mental health of the victims as well as volunteers, since several team members of DFY, as well as earthquake victims, could not sleep peacefully at night due to the trauma of aftershocks. A wide range of medicines and kits were also essential during this phase, including Hygiene Kits, Inhalers, Delivery Kits, Dressing Kits, "Dermatological Medicines", "Medicines Affecting The Blood", "Antiallergics", Delivery and Preterm Infants Care Unit, and so on. Also note that there was a regular demand for delivery kits in all phases, as a large number of pregnant women were affected by this earthquake. From Table 3, it can also be observed that in the Heroic phase, several medicines, kits, equipment like Anti-infective medicines, ventilators were potentially available from

different locations in India, but not actually available within Nepal. There was a huge gap between the requirement and actual availability of resources in this phase. Most of the medical resources (like Anti-infective medicines, Medicines affecting the blood, Ventilators and many more) became actually available in the Honeymoon phase.

4.2. Human resources

The requirements and availabilities of human resources are summarized in Table 4. In the Heroic Phase, since a considerable fraction of the occupant medical personnel were themselves affected by the earthquake, there was a huge requirement of doctors and medical personnel. Primarily, to deal with earthquake-related injuries and maternal death, Orthopedic Surgeons, Anesthetists, Gynecologists, and Emergency Medicine Specialists were essential. The need of Occupational Therapists was also experienced for helping people come out of trauma ensuing from the disaster.

In the Honeymoon Phase, mainly Psychologists and Physiotherapists were required, along with Gynecologists. In the Disillusionment Phase, Pediatricians and Gynecologists were sought, along with Emergency Medicine Specialists, Nurses, Anesthetists, and other Support Staff.

In all phases of the disaster relief, we observed that for several types of human resources, both requirement and availability were reported (e.g., Gynecologists were both required and available in different phases). However, the number of resources available was much lesser than what was required for each category. Also, human resources were deployed in only a few locations (e.g., Kathmandu, the capital city of Nepal), whereas there were unfulfilled requirements at several remote locations.

4.3. Infrastructure resources

Table 5 states the requirement and availability of some infrastructure resources. In the Heroic Phase and Honeymoon Phase, there was a huge demand for tents for the shelter of the affected people. Additionally, tents were also needed to create makeshift Out Patient Departments (OPD). However, there was a huge scarcity of tents,

especially in the Heroic and Honeymoon phases. In fact, the Nepal Government had to procure tents from the local market to provide shelter to the affected community.

In all three phases, there was a requirement of alternative power sources for hospitals (e.g., generators, power banks, solar power, etc.) since the earthquake had affected the electric supply network at different places. Furthermore, since the electricity supply was interrupted, mobile phones were getting discharged quickly. Most of such resources like power banks and GPS devices were potentially available only from the major cities of India; hence there was a significant delay in the resources becoming actually available in Nepal.

4.4. Delay in mobilization of resources during different phases of relief

Till now, we have given an extensive description of the phase-wise requirement and availability of resources, as observed from the WhatsApp chat log of DFY members. It was also evident from the messages that, for certain resources, there was a significant delay between the point of time when the requirement was first perceived and the point of time when the resource finally became available in Nepal. Table 6 summarizes the delay in the availability for some of the medical resources, for which significant delay of more than one week was observed. The dataset also suggests that efforts for mobilizing the resources were almost instantaneous; for example, on April 30 ventilators were sought, and through Disaster Recovery Institute (DRI), the process of acquiring ventilators initiated within three days. However, there was a large delay of the order of 2–3 weeks before ventilators actually became operational. For other resources like implants and ORS, the delay was relatively low (one week).

The reason behind the delay is largely associated with several administrative issues as evident from the chat-log. Thus, it might help to list down the critical human resources, equipment and medicine requirements, especially those whose availability was excessively delayed, so that inter-regional, as well as international collaborations, might be strengthened to enable quicker availability in case of future disaster events.

It is to be noted that the calculation of delay in Table 6 is completely dependent on the WhatsApp messages exchanged among the DFY member, and no supplementary data has been considered to validate this delay. Hence the delays stated are to be treated more as indicative, rather than conclusive figures.

Table 6
Summarization of delay for few medical resources.

Resources	Requirement Identification Date	Potential Availability Date	Actual Availability Date (within Nepal)	Delay
Ventilator	April 30: First requirement observed May 01: Requirement persists, required models are specified May 06: Urgent requirement, chance of airlifting inquired	May 03: Efforts of mobilizing started through DRI May 04: Quotations called May 08: Potential availability announced May 10: Declared to be fitted in next consignment	May 24: Ventilators in use at Tribhuvan teaching hospital	More than three weeks
Digital x-ray	May 01: First requirement observed	May 03: Efforts of mobilizing started through DRI	May 15: Available at Katmandu	Two weeks
Implant	May 03: First requirement observed	May 03: Efforts of mobilizing started through DRI	May 10: Available at Katmandu Airport, but not cleared immediately	One week
Water purifier/filter	May 01: First requirement observed		May 31: Released by customs at airport June 07, 08: Available at few places like Trisuli, Nuwakot	More than two weeks
Reproductive health kit	April 28: First requirement observed		May 15: Available at Katmandu	Two weeks
ORS	May 03: First requirement observed		May 10: Available at Katmandu	One week
Psychologist/occupational therapist	May 03: First requirement observed May 06: Requirement persists		May 16: 2–3 trauma counselors available	Two weeks

5. Problems observed and experienced by the relief workers

Apart from depicting the need and availability of resources, the dataset includes several problems that were experienced by the relief workers. Table 7 summarizes various primary and auxiliary problems faced and observed by the DFY members. These include contamination of water sources, problems in transportation, problems due to lack of electricity, and difficulties due to aftershock (e.g., reconstructed roads getting damaged again, the psychological impact on DFY volunteers as they were not able to sleep peacefully or frequent sleep cycle interruptions due to aftershocks). We have classified these problems into three categories namely *Clinical and technological*, *Natural*, *Administrative*.

5.1. Clinical and technological problems

Clinical problems are typically directly related to medicines and medical resources. From Table 7 it is clear that shortage of expert medical personnel (like Gynecologists, Anesthetists) was the most critical issue experienced in each phase of disaster relief. Especially, Gynecologists were sought to take care of pregnant women and Emergency Medicine Specialist to take care of critically injured and traumatized victims. The core reason behind this shortfall is definitely the absence of local doctors in designated postings since the local medical personnel also got severely affected by the earthquake.

There were also technological problems related to communication and power. For instance, the electric power supply was intermittent, leading to problems in running of medical appliances and quick discharging of mobile phones. Internet connectivity was also disrupted.

5.2. Natural problems

The relief workers faced numerous difficulties due to the *Natural* problems, such as aftershock earthquakes, heavy rains, water contamination and landslides. There were also outbreaks of several diseases like diarrhea. Further, electricity was unavailable and heavy rainfall caused solar power to be intermittent. Additionally, post-earthquake, the vulnerability of the road infrastructure often delayed the supply critically.

5.3. Administrative problems

In Nepal, Government bodies were in the top tier of the disaster risk reduction (DRR) pyramid, which were controlling the relief operations

Table 7
Observations and assessment of problems experienced during the relief operation.

Time Line	Clinical & Technological	Natural	Administrative
Heroic Phase April 28- May 03	<ul style="list-style-type: none"> ● Pregnant women require ante-natal and post-partum care, safe delivery services ● Local doctors, including orthopedics not traceable at designated postings ● Gynecologists, female doctors -not been able to land at airport 	<ul style="list-style-type: none"> ● Outbreaks of diarrhea (WHO report) 	<ul style="list-style-type: none"> ● Relief material stagnating at airport, reproductive health kits not able to land ● No waivers for earthquake relief material on commercial flights ● No organized distribution of resources even in Kathmandu ● Lack of co-ordination between Govt. and NGOs ● Government under emergency taking all tents from local population ● Medicine should be approved by Ministry ● From India, generic medicines with minimum one-year expiry date approved by Nepal Government ● Foreign medical teams (FMTs) on hold by the Government, need to tie up with local NGO who has pre-approval from Government
Honeymoon phase May 04–May 31	<ul style="list-style-type: none"> ● Anesthetist unavailable ● Shortage of doctors ● In Katmandu: communication obstructed, houses destroyed, all shops closed, network congestion, no electricity, mobiles getting discharged ● Internet connection disrupted ● No electricity in remote places 	<ul style="list-style-type: none"> ● Heavy rainfall, landslide: airport closed, roads damaged, government health posts damaged ● Poor water quality, water contaminated, scarcity of drinking water ● Effects of aftershocks: Runway damaged, airport closed for larger aircraft, rebuilt roads severely damaged, only 2-wheelers usable in some places ● OPD tents waterlogged ● Camps destroyed due to storm and heavy rain ● Solar power is intermittent due to monsoon 	<ul style="list-style-type: none"> ● Problems at Kathmandu airport: air cargo seized, implants not cleared ● Custom clearance problems for donated materials ● High delay in location-wise distribution of medicines and other supplies ● Combination medicines restricted by Government ● Local partnership issues creating obstruction in organizing health camp ● Doctors canceled by Ministry ● Procured medicines, equipment should be approved by Government ● Too many permissions needed from Ministry ● Lack of co-operation from different departments of Government
Honeymoon + Disillusionment Phase June 01–July 31	<ul style="list-style-type: none"> ● District hospitals need support 	<ul style="list-style-type: none"> ● Hindrance in relief work & distribution due to transportation problem ● Heavy rains continue, tents flooded ● Danger of short-circuiting 	

[25]. The Council of Ministers was positioned at the top, followed by the Ministry of Home Affairs (MoHA), followed by the Department of Urban Development and Building Construction (DUDBC). International organizations like International Federation of Red Cross and Red Crescent, United Nations Development Programme (UNDP), DFY resided in lower tiers of DRR pyramid [25]. Accordingly, Government protocols and policies had a significant influence over the disaster management operations as well as DRR.

Several administrative problems were reported, such as “Foreign medical teams (FMTs) on hold by the Government” or “Too much permission needed from Ministry”. Additionally, international NGOs were required to tie up with local NGOs who have pre-approval from Government. However, several local NGOs did not have a good reputation [25]; hence international NGOs were not always ready to tie up with them. Thus, one of the major constraints reported in the messages was a lack of organized distribution of resources, especially during the Heroic Phase. Moreover, various coordination and approval related grievances were reported in the dataset, which was said to have hindered the operations in the Honeymoon Phase. For instance, protocols and approval mechanisms for several medicines and equipment delayed their supply.

5.4. Problem mitigation policies

In this study, we attempted to analyze the medical and infra-structural resource gaps that emerge post an event like the Nepal earthquake. It was also observed that there were several governmental policy gaps regarding the handling of aid and resources, some of which are illustrated in Table 7 as *Administrative* problems.

While an integrated policy framework is needed to address the national and international logistic management for the supply of resources, a systematic planning mechanism should be formulated to take note of the infrastructural gaps that might form critical bottlenecks, especially in the Honeymoon and Disillusionment phases. For example, lack of electricity and tents might hinder operationalization of temporary health camps; therefore, standby provisions might be crucial. It might be noted at this point that, although solar energy can be an alternative, during Nepal Earthquake, it was monsoon and heavy rainfall (seasonal conditions) affected this alternative accordingly (as stated in Table 7).

These observations indicate typical problems that can be faced by any medical team working in an area affected by an earthquake and can potentially help medical teams / Government agencies to be more prepared for such problems. For instance, it is not only sufficient to dispatch medical resources and medical personnel, but also alternative power sources need to be arranged so that hospitals can operate even

without electricity. Again, the relief workers themselves might get affected by stress and trauma, hence their well-being and counseling have to be arranged as well. Further, if the earthquakes and landslides destroy the physical communication links (as was the case in Nepal), virtual communications (e.g., mobile and Internet communication) become critical. In such scenarios, the relief workers get worried about their mobiles getting discharged as well as irregular Internet connectivity.

Thus, the observations from this study can aid in formulating strategies for disaster management at both local and national levels, for provisioning of medical, human, infrastructure and other resources, while strategizing for minimizing property and life loss.

6. Conclusion

This post hoc study analyzes a dataset of WhatsApp messages exchanged among members of ‘Doctors For You’ in the aftermath of the Nepal earthquake in April 2015. In contrast to prior works which rely on crowd-sourced data from online social media like Twitter / Facebook, the data in this study is more reliable since it is obtained from medical experts who are known to have been present at the disaster site. The main contributions of the study are (i) identification of the requirements of various resources, and (ii) studying how quickly the requirements of different resources could be met, during different phases of the disaster. Additionally, several auxiliary problems faced by the relief workers are also curated. While the observations regarding delays in resource mobilization are specific to the particular disaster, the identification of resources that are needed after an earthquake is generalizable to other disasters of a similar nature (especially in similar geographical regions).

The study demonstrates that real-time (i.e., actually during the disaster) analysis of such data would aid decision makers in forming resource mapping strategies dynamically. It can be noted that several off-the-shelf natural language processing algorithms are available which can be leveraged to automate the analysis process in real-time to provide prompt results. These results could then assist disaster management authorities in assessing the requirement, allocating resources, providing logistic support in real time, which in turn will reduce the loss of human life during disasters.

This study is not meant to criticize the delay in the mobilization of resources; rather, the primary motivation is to identify the resource requirements, which in turn can contribute to better disaster planning and mitigation in future. Principally, this paper emphasizes on the events that would enable Nepal Center for Disaster Management (NCDM) in the phase-wise mapping of resources. As a preparedness strategy, this resource mapping might enable them to procure life-saving resources as well as generic resources in a more efficient manner in future. It is also hoped that the observations in this study would help authorities in not only Nepal but also other earthquake-prone regions to better prepare for resource mapping during similar disasters in future.

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